Oracle® XML DB

Developer's Guide

11*g* Release 1 (11.1)

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This manual describes Oracle XML DB. It includes guidelines and examples for storing, generating, accessing, searching, validating, transforming, evolving, and indexing XML data in Oracle Database.

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Oracle XML DB Developer's Guide, 11*g* Release 1 (11.1)

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Preface

This manual describes Oracle XML DB, and how you can use it to store, generate, manipulate, manage, and query XML data in the database.

After introducing you to the heart of Oracle XML DB, namely the `XMLType` framework and Oracle XML DB repository, the manual provides a brief introduction to design criteria to consider when planning your Oracle XML DB application. It provides examples of how and where you can use Oracle XML DB.

The manual then describes ways you can store and retrieve XML data using Oracle XML DB, APIs for manipulating `XMLType` data, and ways you can view, generate, transform, and search on existing XML data. The remainder of the manual discusses how to use Oracle XML DB repository, including versioning and security, how to access and manipulate repository resources using protocols, SQL, PL/SQL, or Java, and how to manage your Oracle XML DB application using Oracle Enterprise Manager. It also introduces you to XML messaging and Oracle Streams Advanced Queuing `XMLType` support.

This Preface contains these topics:

Audience

Oracle XML DB Developer's Guide is intended for developers building XML Oracle Database applications.

An understanding of XML, XML Schema, XQuery, XPath, and XSL is helpful when using this manual.

Many examples provided here are in SQL, PL/SQL, Java, or C. A working knowledge of one of these languages is presumed.

Documentation Accessibility

Our goal is to make Oracle products, services, and supporting documentation accessible, with good usability, to the disabled community. To that end, our documentation includes features that make information available to users of assistive technology. This documentation is available in HTML format, and contains markup to facilitate access by the disabled community. Accessibility standards will continue to

evolve over time, and Oracle is actively engaged with other market-leading technology vendors to address technical obstacles so that our documentation can be accessible to all of our customers. For more information, visit the Oracle Accessibility Program Web site at

http://www.oracle.com/accessibility/

Accessibility of Code Examples in Documentation

Screen readers may not always correctly read the code examples in this document. The conventions for writing code require that closing braces should appear on an otherwise empty line; however, some screen readers may not always read a line of text that consists solely of a bracket or brace.

Accessibility of Links to External Web Sites in Documentation

This documentation may contain links to Web sites of other companies or organizations that Oracle does not own or control. Oracle neither evaluates nor makes any representations regarding the accessibility of these Web sites.

TTY Access to Oracle Support Services

Oracle provides dedicated Text Telephone (TTY) access to Oracle Support Services within the United States of America 24 hours a day, seven days a week. For TTY support, call 800.446.2398.

Related Documents

For more information, see these Oracle resources:

- *Oracle Database New Features Guide* for information about the differences between Oracle Database 11*g* and the Oracle Database 11*g* Enterprise Edition and the available features and options. This book also describes features new to Oracle Database 11*g* release 1 (10.1).
- *Oracle Database XML Java API Reference*
- *Oracle XML Developer's Kit Programmer's Guide*
- *Oracle Database Error Messages*. Oracle Database error message documentation is available only as HTML. If you have access to only printed or PDF Oracle Database documentation, you can browse the error messages by range. Once you find the specific range, use the search (find) function of your Web browser to locate the specific message. When connected to the Internet, you can search for a specific error message using the error message search feature of the Oracle Database online documentation.
- *Oracle Text Application Developer's Guide*
- *Oracle Text Reference*
- *Oracle Database Concepts.*
- *Oracle Database Java Developer's Guide*
- *Oracle Database Advanced Application Developer's Guide*
- *Oracle Streams Advanced Queuing User's Guide*
- *Oracle Database PL/SQL Packages and Types Reference*

Many of the examples in this book use the sample schemas, which are installed by default when you select the Basic Installation option with an Oracle Database

installation. Refer to *Oracle Database Sample Schemas* for information about how these schemas were created and how you can use them yourself.

Printed documentation is available for sale in the Oracle Store at

http://oraclestore.oracle.com/

To download free release notes, installation documentation, white papers, or other collateral, please visit the Oracle Technology Network (OTN). You must register online before using OTN; registration is free and can be done at

http://www.oracle.com/technology/membership/

If you already have a username and password for OTN, then you can go directly to the documentation section of the OTN Web site at

http://www.oracle.com/technology/documentation/

For additional information, see:

- http://www.w3.org/XML/Schema – XML Schema
- http://www.w3.org/2001/XMLSchema – XML Schema
- http://www.w3.org/TR/xmlschema-0/ – XML Schema: primer
- http://www.w3.org/TR/xmlschema-1/ – XML Schema: structures
- http://www.w3.org/TR/xmlschema-2/ – XML Schema: data types
- http://www.oasis-open.org/cover/schemas.html – XML Schema
- http://www.xml.com/pub/a/2000/11/29/schemas/part1.html – XML Schema
- http://xml.coverpages.org/xmlMediaMIME.html – media/MIME types
- http://www.w3.org/TR/xptr/ – XPointer
- http://www.w3.org/TR/xpath – XPath 1.0
- http://www.w3.org/TR/xpath20/ – XPath 2.0
- http://www.zvon.org/xxl/XPathTutorial/General/examples.html – XPath
- *XML In a Nutshell*, by Elliotte Rusty Harold and W. Scott Means, O'Reilly, January 2001, http://www.oreilly.com/catalog/xmlnut/chapter/ch09.html
- http://www.w3.org/TR/2002/NOTE-unicode-xml-20020218/ – Unicode in XML
- http://www.w3.org/TR/REC-xml-names/ – namespaces
- http://www.w3.org/TR/xml-infoset/ – information sets
- http://www.w3.org/TR/xslt – XSLT
- http://www.oasis-open.org/cover/xsl.html – XSL
- http://www.zvon.org/HTMLonly/XSLTutorial/Books/Book1/index.html – XSL
- http://www.w3.org/2002/ws/Activity.html – Web services
- http://www.ietf.org/rfc/rfc959.txt – RFC 959: FTP Protocol Specification

- ISO/IEC 13249-2:2000, Information technology - Database languages - SQL Multimedia and Application Packages - Part 2: Full-Text, International Organization For Standardization, 2000

Note: Throughout this manual, "**XML Schema**" refers to the XML Schema 1.0 recommendation, `http://www.w3.org/XML/Schema`.

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

Code Examples

The code examples in this book are for illustration only. In many cases, however, you can copy and paste parts of examples and run them in your environment.

Standard Database Schemas

Many of the examples in this book use the standard database schemas that are included in your database. In particular, database schema `OE` contains XML purchase-order documents in `XMLType` table `purchaseorder`, and XML documents with warehouse information in `XMLType` column `warehouse_spec` of table `warehouses`.

The purchase-order documents are also contained in Oracle XML DB Repository, under the repository path `/home/OE/PurchaseOrders/2002/`. The XML schema that governs these documents is file `purchaseorder.xsd`, at repository location `/home/OE/purchaseorder.xsd`. An XSL style sheet that is used in some examples to transform purchase-order documents is file `purchaseorder.xsl`, at repository location `/home/OE/purchaseorder.xsl`. This XML schema and style sheet can also be found in Appendix A, "Oracle-Supplied XML Schemas and Examples".

See Also:

- *Oracle Database Sample Schemas* for information about database schema `HR`
- *Oracle Database Sample Schemas* for information about database schema `OE`

Pretty Printing of XML Data

To promote readability, especially of lengthy or complex XML data, output is sometimes shown pretty-printed (formatted) in code examples.

Query Explain Plans

Some of the code examples in this book present query explain plans. These are for illustration only. Running examples presented here in your environment will likely result in different explain plans from those presented here.

Reminder About Case Sensitivity

When examining the examples in this book, keep in mind the following:

- SQL is case-insensitive, but names in SQL code are implicitly uppercase, unless you enclose them in double-quotes.
- XML is case-sensitive. You must refer to SQL names in XML code using the correct case: uppercase SQL names must be written as uppercase.

For example, if you create a table named `my_table` in SQL without using double-quotes, then you must refer to it in XML code as "`MY_TABLE`".

Syntax Descriptions

Syntax descriptions are provided in this book for various SQL, PL/SQL, or other command-line constructs in graphic form or Backus Naur Form (BNF). See *Oracle Database SQL Language Reference* for information about how to interpret these descriptions.

What's New In Oracle XML DB?

This section describes the new features and functionality, enhancements, APIs, and product integration support added to Oracle XML DB for Oracle Database 11*g* Release 1 (11.1).

Oracle Database 11*g* Release 1 (11.1) New Features in Oracle XML DB

Binary XML

Binary XML is a new storage model for abstract data type `XMLType`, joining the existing storage models of structured (object-relational) and unstructured (`CLOB`) storage. Binary XML is XML-Schema aware, but it can also be used with XML data that is not based on an XML schema. See "XMLType Storage Models" on page 1-15.

See Also:

- *Oracle Database Advanced Application Developer's Guide* for an overview of `XMLType` data stored as binary XML
- *Oracle Database SQL Language Reference* for information about creating `XMLType` tables and columns stored as binary XML
- *Oracle Database XML Java API Reference* for information about manipulating binary XML data using Java
- *Oracle Database XML C API Reference* for information about manipulating binary XML data using C

XMLIndex

A new index type is provided for `XMLType`: `XMLIndex`. This can greatly improve the performance of XPath-based predicates and fragment extraction for `XMLType` data, whether based on an XML schema or not. The new index type is a (logical) domain index that consists of underlying physical table(s) and secondary indexes. See Chapter 5, "Indexing XMLType Data".

Note: The `CTXSYS.CTXXPath` index is *deprecated* in Oracle Database 11g Release 1 (11.1). The functionality that was provided by `CTXXPath` is now provided by `XMLIndex`.

Oracle recommends that you replace `CTXXPath` indexes with `XMLIndex` indexes. The intention is that `CTXXPath` will no longer be supported in a future release of the database.

See Also:

- *Oracle Database Reference* for information about new view `XIDX_USER_PENDING`
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XMLINDEX`

XMLType OCTs Now Use Heap Storage Instead of IOTs

You can store collections of XML elements as ordered collection tables (OCTs). OCTs now use heap storage, by default. In prior releases, OCTs were index-organized tables (IOTs), by default. A new XML schema registration option, `REGISTER_NT_AS_IOT`, forces the use of IOTs.

> **See Also:** "Controlling How Collections are Stored for Object-Relational XMLType Storage" on page 3-19

Default Value of XML Schema Annotation storeVarrayAsTable Is Now true

In prior releases, the default value of XML schema annotation `storeVarrayAsTable` was `false`; the default value is now `true`. This means that, by default, an XML collection is now stored as a set of rows in an ordered collection table (OCT). Each row corresponds to an element in the collection. With annotation `storeVarrayAsTable = "false"`, the entire collection is instead serialized as a varray and stored in a LOB column.

Using `storeVarrayAsTable = "true"` facilitates efficient queries and updates on members of a collection, as well as the creation of B-tree indexes on a collection.

> **See Also:** "Controlling How Collections are Stored for Object-Relational XMLType Storage" on page 3-19 for more information about storing XML collections object-relationally

Repository Events

Applications can now register listeners with handlers for events associated with Oracle XML DB Repository operations such as creating, deleting, and updating a resource. See Chapter 30, "Oracle XML DB Repository Events".

See Also:

- *Oracle Database XML Java API Reference* for new Java methods
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XEVENT`
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_RESCONFIG`
- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XDBRESOURCE`

Support for Content Repository API for Java (JCR: JSR-170)

Oracle XML DB now supports Content Repository API for Java (JCR) and the JSR-170 standard. You can access Oracle XML DB Repository using the JCR APIs. See Chapter 31, "Using Oracle XML DB Content Connector".

> **See Also:** *Oracle Database XML Java API Reference* for new Java methods

New Repository Resource Link Types

You can now create weak folder links to represent Oracle XML DB Repository folder-child relationships. Hard links are still available, as well. See "Link Types" on page 21-6.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XDB`
- *Oracle Database SQL Language Reference* for updates to function `under_path`

Support for WebDAV Privileges and New Oracle XML DB Privileges

All WebDAV privileges are now supported by Oracle XML DB Repository. In addition, there are some new Oracle XML DB-specific atomic privileges. See Chapter 27, "Repository Resource Security".

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_NETWORK_ACL_ADMIN`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_TCP`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_INADDR`

Web Services

You can now access Oracle Database through Web services. You can write and deploy Web services that can query the database using SQL or XQuery, or access stored PL/SQL functions and procedures. See Chapter 33, "Using Native Oracle XML DB Web Services"

In-Place XML Schema Evolution

In many cases, you can now evolve XML schemas without copying the corresponding XML instance documents. See Chapter 9, "XML Schema Evolution".

See Also: *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XMLSCHEMA`

Support for Recursive XML Schemas

Oracle XML DB now performs XPath rewrite on some queries that use '`//`' in XPath expressions to target nodes at multiple or arbitrary depths, even when the XML data conforms to a recursive XML schema. See "Support for Recursive Schemas" on page 8-23

See Also: *Oracle Database PL/SQL Packages and Types Reference* for updates to PL/SQL package `DBMS_XMLSCHEMA`

Support for XLink and XInclude

Oracle XML DB now supports the XLink and XInclude standards. See Chapter 23, "Using XLink and XInclude With Oracle XML DB".

Support for XML Translations

You can now associate natural-language translation information with XML schemas and corresponding instance documents. This includes support for standard attributes `xml:lang` and `xml:srclang`. See "XML Translations" on page 6-17.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_XMLTRANSLATIONS`

Support for Large XML Nodes

The previous 64K limit on text nodes and attribute values has been lifted. Text nodes and attribute values are no longer limited in size to 64K bytes each. New streaming push and pull APIs are available in PL/SQL, Java, and C to provide virtually unlimited node sizes. See "Large Node Handling Using DBMS_XMLDOM" on page 12-12 for information about handling large nodes in PL/SQL and "Handling Large Nodes Using Java" on page 14-17.

> **See Also:**
>
> - *Oracle Database SQL Language Reference* for information about creating `XMLType` tables and columns stored as binary XML
> - *Oracle Database XML Java API Reference* for information about new Java methods
> - *Oracle Database PL/SQL Packages and Types Reference* for information about new PL/SQL package `DBMS_SDA` and updates to PL/SQL package `DBMS_XMLDOM`

Unified Java API

The Java XML APIs in Oracle XML DB and Oracle XDK have been unified.

> **See Also:**
>
> - *Oracle XML Developer's Kit Programmer's Guide*
> - *Oracle Database XML Java API Reference*, package `oracle.xml.parser.v2`

Oracle Data Pump Support for XMLType

Oracle Data Pump is now the recommended way to import and export `XMLType` data. See Chapter 36, "Exporting and Importing XMLType Tables".

Support for XMLType by Oracle Streams and Logical Standby

Oracle Streams and logical standby now support `XMLType` stored as `CLOB`. Both XML schema-based and non-schema-based XML data are supported.

> **See Also:**
>
> - *Oracle Streams Concepts and Administration*
> - *Oracle Data Guard Concepts and Administration*
> - *Oracle Database Utilities*
> - *Oracle Database Reference* for information on views `DBA_STREAMS_UNSUPPORTED` and `DBA_STREAMS_COLUMNS`

Oracle XDK Pull-Parser API (XML Events, JSR-173)

You can use the new Oracle XML Developer Kit (XDK) pull-parser API with Oracle XML DB. See "Using the Oracle XDK Pull Parser With Oracle XML DB" on page 15-9.

See Also:

- *Oracle Database XML C API Reference* for information about new C methods and types
- *Oracle XML Developer's Kit Programmer's Guide*

XQuery Standard Compliance

Oracle XML DB support for the XQuery language has been updated to reflect the latest version of the XQuery standard, W3C XQuery 1.0 Recommendation.

See Also:

- *Oracle XML Developer's Kit Programmer's Guide*
- `http://www.w3.org` for information about the XQuery language

Fine-Grained Access to Network Services Using PL/SQL

New atomic privileges are provided for access control entries (ACEs). These privileges are used for fine-grained PL/SQL access to network services.

SQL/XML Standard Compliance and Performance Enhancements

Oracle XML DB support for the SQL/XML standard has been updated to reflect the latest version of the standard. This includes support for standard SQL functions `XMLExists` and `XMLCast`. See "Querying XMLType Data with SQL Functions" on page 4-4 and "Generating XML Using SQL Functions" on page 17-2.

See Also: *Oracle Database SQL Language Reference* for information about new SQL/XML functions `XMLExists` and `XMLCast`; as well as updates to functions `XMLQuery`, `XMLTable`, and `XMLForest`.

XML-Update Performance Enhancements

The performance of SQL functions used to update XML data has been enhanced for XML schema-based data that is stored object-relationally. This includes XPath rewrite for SQL functions `updateXML`, `insertChildXML`, and `deleteXML`.

XQuery and SQL/XML Performance Enhancements

XQuery and SQL/XML performance enhancements include treatment of the following:

- User-defined XQuery functions
- XQuery prolog variables
- XQuery `count` function applied to the result of using a SQL/XML generation function
- Positional expressions in XPath predicates
- XQuery computed constructors
- SQL/XML function `XMLAgg`

XSLT Performance Enhancements

The performance of XSLT transformations using SQL function `XMLTransform` and method `transform()` has been enhanced.

Part I

Oracle XML DB Basics

Part I of this manual introduces Oracle XML DB. It contains the following chapters:

- Chapter 1, "Introduction to Oracle XML DB"
- Chapter 2, "Getting Started with Oracle XML DB"
- Chapter 3, "Using Oracle XML DB"

1

Introduction to Oracle XML DB

This chapter introduces the features and architecture of Oracle XML DB. It contains these topics:

Features of Oracle XML DB

Oracle XML DB is the name for a set of Oracle Database technologies related to high-performance XML storage and retrieval. It provides native XML support by encompassing both SQL and XML data models in an interoperable manner.

Oracle XML DB includes the following features:

- Support for the World Wide Web Consortium (W3C) XML and XML Schema data models and standard access methods for navigating and querying XML. The data models are incorporated into Oracle Database.
- Ways to store, query, update, and transform XML data while accessing it using SQL.
- Ways to perform XML operations on SQL data.
- A simple, lightweight XML repository where you can organize and manage database content, including XML, using a file/folder/URL metaphor.
- A storage-independent, content-independent and programming language-independent infrastructure for storing and managing XML data. This provides new ways of navigating and querying XML content stored in the database. For example, Oracle XML DB Repository facilitates this by managing XML document hierarchies.

- Industry-standard ways to access and update XML. The standards include the W3C XPath recommendation and the ISO-ANSI SQL/XML standard. FTP, HTTP(S), and WebDAV can be used to move XML content into and out of Oracle Database. Industry-standard APIs provide programmatic access and manipulation of XML content using Java, C, and PL/SQL.
- XML-specific memory management and optimizations.
- Enterprise-level Oracle Database features for XML content: reliability, availability, scalability, and security.

Oracle XML DB can be used in conjunction with Oracle XML Developer's Kit (XDK) to build applications that run in the middle tier in either Oracle Application Server or Oracle Database.

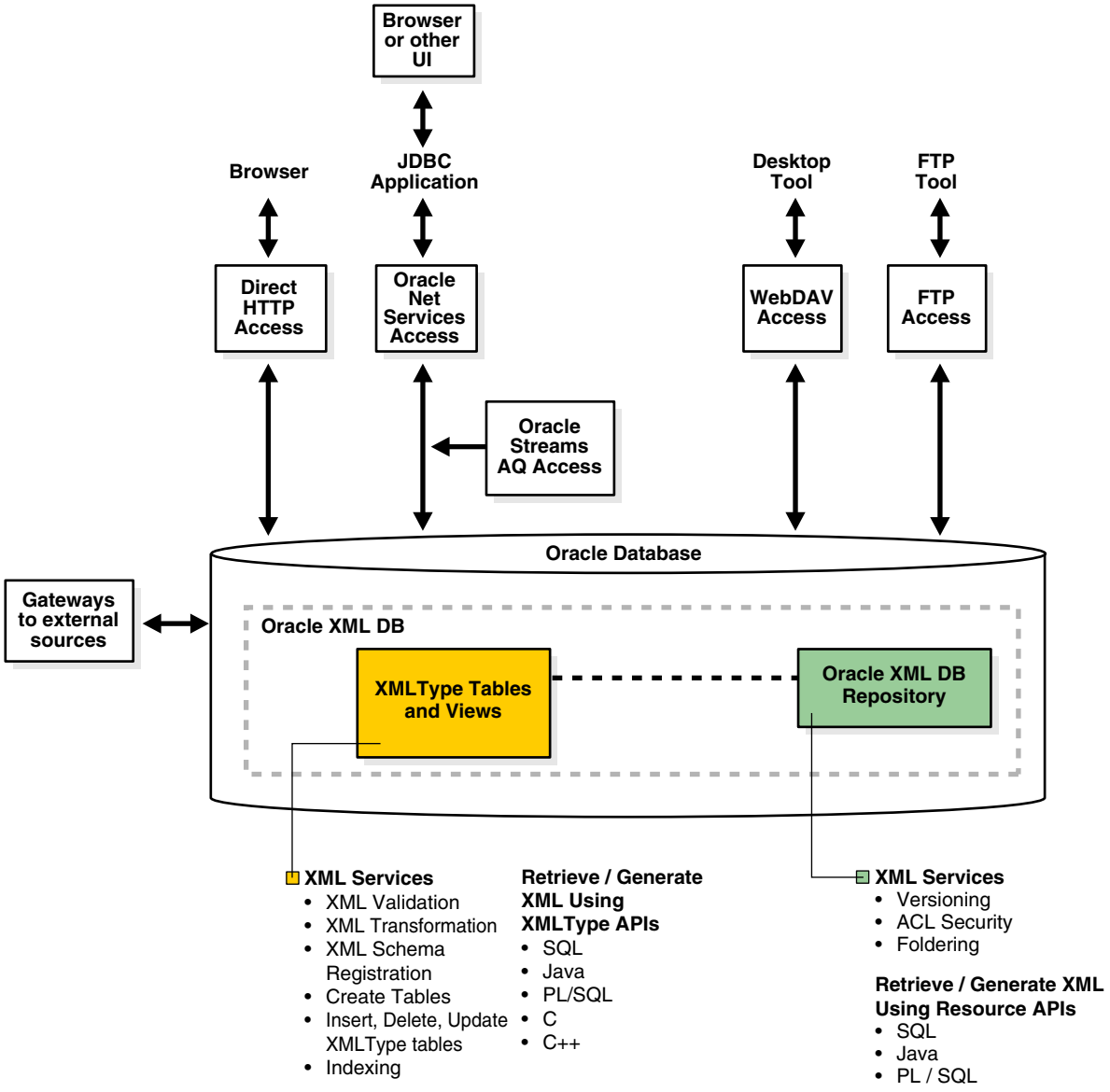
See Also: *Oracle XML Developer's Kit Programmer's Guide*

Oracle XML DB Architecture

Figure 1–1 and Figure 1–2 show the software architecture of Oracle XML DB. The two main features are:

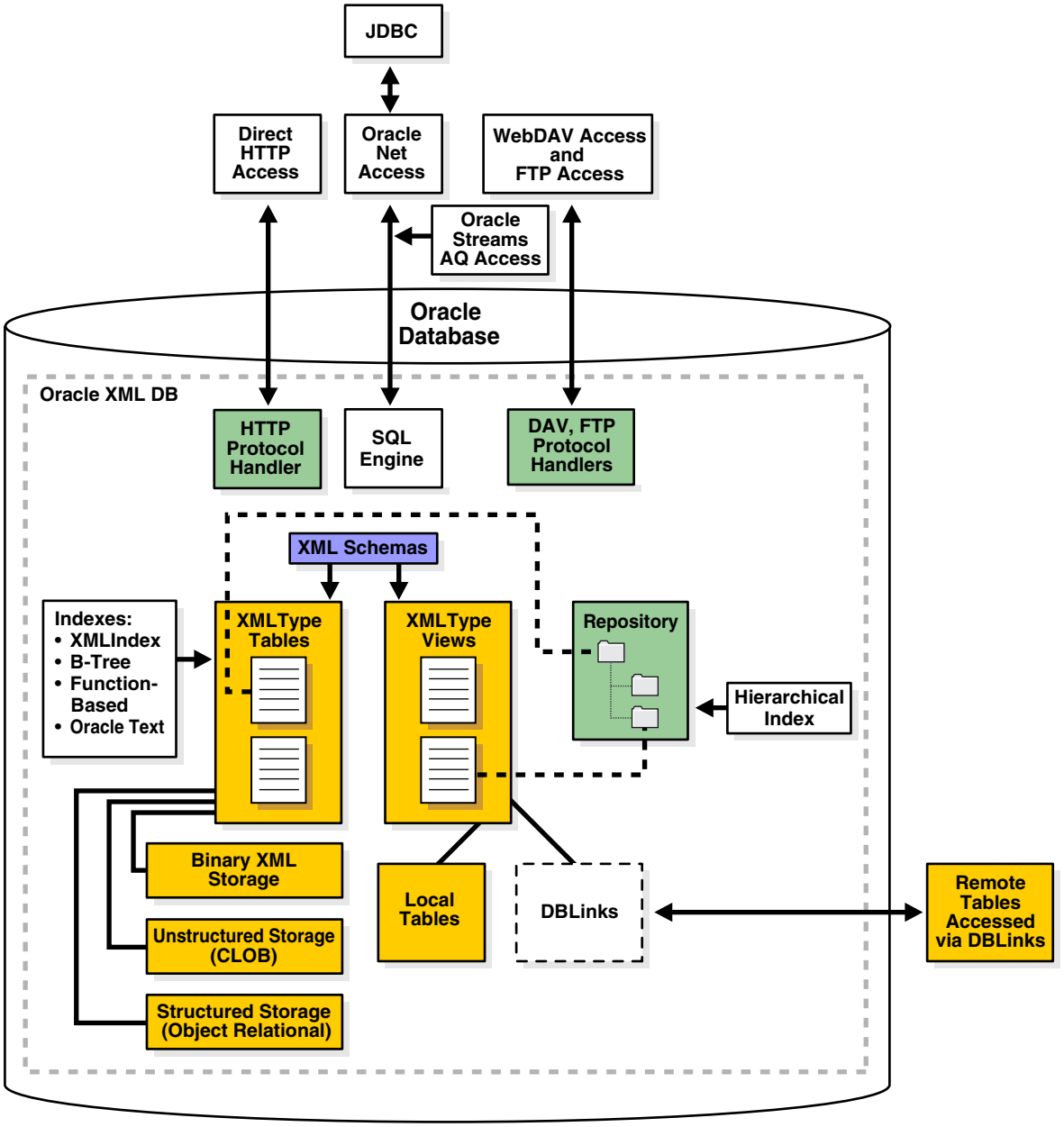
- Storage of `XMLType` tables and views
- Oracle XML DB Repository

Figure 1–1 XMLType Storage and Oracle XML DB Repository



****

Figure 1–2 XMLType Storage



XMLType Storage

Figure 1–2 shows `XMLType` storage in Oracle XML DB.

When XML schemas are registered with Oracle XML DB, a set of default tables are created and used to store XML instance documents associated with the XML schema. These documents can be viewed and accessed in Oracle XML DB Repository.

Data in `XMLType` views can be stored in local or remote tables. Remote tables can be accessed through database links.

`XMLType` tables and views can be indexed using `XMLIndex`, B-tree, function-based, and Oracle Text indexes.

You can access data in Oracle XML DB Repository using any of the following:

- HTTP(S), through the HTTP protocol handler
- WebDAV and FTP, through the WebDAV and FTP protocol server
- SQL, through Oracle Net Services, including Java Database Connectivity (JDBC)

Oracle XML DB supports XML data messaging using Oracle Streams Advanced Queuing (AQ) and Web Services.

See Also:

- Part II, "Storing and Retrieving XML Data in Oracle XML DB"
- Chapter 28, "Using Protocols to Access the Repository"
- Chapter 37, "Exchanging XML Data with Oracle Streams AQ"

APIs for XML

Table 1–1 lists the reference documentation for the PL/SQL, C, and C++ Application Programming Interfaces (APIs) that you can use to manipulate XML documents and data. The main reference for PL/SQL, C, and C++ APIs is *Oracle Database PL/SQL Packages and Types Reference*.

See Also: *Oracle Database XML Java API Reference* for information about Java APIs for XML

Table 1–1 APIs Related to XML

API	Documentation	Description
`XMLType`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "XMLType", *Oracle Database XML C API Reference*, and *Oracle Database XML C++ API Reference*	PL/SQL, C, and C++ APIs with XML operations on `XMLType` data – validation, transformation.
Database URI types	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "Database URI TYPEs"	Functions used for various URI types.
`DBMS_METADATA`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_METADATA"	PL/SQL API for retrieving metadata from the database dictionary as XML, or retrieving creation DDL and submitting the XML to re-create the associated object.
`DBMS_RESCONFIG`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_RESCONFIG"	PL/SQL API to operate on a resource configuration list, and to retrieve listener information for a resource.
`DBMS_XDB`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB"	PL/SQL API for managing Oracle XML DB Repository resources, ACL-based security, and configuration sessions.
`DBMS_XDB_ADMIN`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_ADMIN"	PL/SQL API for managing miscellaneous features of Oracle XML DB, including the `XMLIndex` index on the Oracle XML DB Repository.
`DBMS_XDBRESOURCE`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDBRESOURCE"	PL/SQL API to operate on repository resource metadata. > and contents
`DBMS_XDBT`	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDBT"	PL/SQL API for creation of text indexes on repository resources.

Table 1–1 (Cont.) APIs Related to XML

API	Documentation	Description
DBMS_XDB_VERSION	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDB_VERSION"	PL/SQL API for version management of repository resources.
DBMS_XDBZ	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XDBZ"	Oracle XML DB Repository ACL-based security.
DBMS_XEVENT	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XEVENT"	PL/SQL API providing event-related types and supporting interface. .
DBMS_XMLDOM	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLDOM"	PL/SQL implementation of the DOM API for XMLType.
DBMS_XMLGEN	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLGEN"	PL/SQL API for transformation of SQL query results into canonical XML format.
DBMS_XMLINDEX	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLINDEX	PL/SQL API for XMLIndex.
DBMS_XMLPARSER	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLPARSER"	PL/SQL implementation of the DOM Parser API for XMLType.
DBMS_XMLQUERY	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLQUERY"	PL/SQL API providing database-to-XMLType functionality. (Where possible, use DBMS_XMLGEN instead.)
DBMS_XMLSAVE	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLSAVE"	PL/SQL API providing XML- to-database type functionality.
DBMS_XMLSCHEMA	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLSCHEMA	PL/SQL API for managing XML schemas within Oracle Database – schema registration, deletion.
DBMS_XMLSTORE	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XMLSTORE"	PL/SQL API for storing XML data in relational tables.
DBMS_XSLPROCESSOR	*Oracle Database PL/SQL Packages and Types Reference*, Chapter "DBMS_XSLPROCESSOR"	PL/SQL implementation of an XSLT processor.

Catalog Views Related to XML

Table 1–2 lists the catalog views related to XML. Information about a given view can be obtained by using the SQL command DESCRIBE. Example:

```
DESCRIBE USER_XML_SCHEMAS
```

Table 1–2 Catalog Views Related to XML

Schema	Description
USER_XML_SCHEMAS	Registered XML schemas *owned* by the current *user*
ALL_XML_SCHEMAS	Registered XML schemas *usable* by the current *user*
DBA_XML_SCHEMAS	Registered XML schemas in Oracle XML DB
USER_XML_TABLES	XMLType tables *owned* by the current *user*

Table 1–2 (Cont.) Catalog Views Related to XML

Schema	Description
ALL_XML_TABLES	XMLType tables *usable* by the current *user*
DBA_XML_TABLES	XMLType tables in Oracle XML DB
USER_XML_TAB_COLS	XMLType table columns *owned* by the current *user*
ALL_XML_TAB_COLS	XMLType table columns *usable* by the current *user*
DBA_XML_TAB_COLS	XMLType table columns in Oracle XML DB
USER_XML_VIEWS	XMLType views *owned* by the current *user*
ALL_XML_VIEWS	XMLType views *usable* by the current *user*
DBA_XML_VIEWS	XMLType views in Oracle XML DB
USER_XML_VIEW_COLS	XMLType view columns *owned* by the current *user*
ALL_XML_VIEW_COLS	XMLType view columns *usable* by the current *user*
DBA_XML_VIEW_COLS	XMLType view columns in Oracle XML DB

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Views RESOURCE_VIEW and PATH_VIEW

Oracle XML DB views RESOURCE_VIEW and PATH_VIEW provide SQL access to data in Oracle XML DB Repository through protocols such as FTP and WebDAV. View PATH_VIEW has one row for each unique path in the repository; view RESOURCE_VIEW has one row for each resource in the repository.

The Oracle XML DB resource API for PL/SQL, DBMS_XDB, provides query and DML functions. It is based on RESOURCE_VIEW and PATH_VIEW.

See Also:

- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"
- *Oracle Database Reference* for more information about view PATH_VIEW
- *Oracle Database Reference* for more information about view RESOURCE_VIEW

Overview of Oracle XML DB Repository

Oracle XML DB Repository is a component of Oracle Database that is optimized for handling XML data. The Oracle XML DB repository contains **resources**, which can be either **folders** (directories, containers) or files. Each resource has these properties:

- It is identified by a *path* and *name*.
- It has *content* (data), which can be XML data but need not be.
- It has a set of **system-defined metadata** (properties), such as Owner and CreationDate, in addition to its content. Oracle XML DB uses this information to manage the resource.
- It might also have **user-defined metadata**: information that is not part of the content, but is associated with it.

- It has an associated **access control list** that determines who can access the resource, and for what operations.

Although Oracle XML DB Repository treats XML content specially, you can use Oracle XML DB Repository to store other kinds of data, besides XML; you can use the repository to access any data that is stored in Oracle Database.

See Also:

- Part V. "Oracle XML DB Repository"
- Chapter 28, "Using Protocols to Access the Repository" for information about accessing XML data in `XMLType` tables and columns using external protocols
- Chapter 29, "User-Defined Repository Metadata"

Accessing and Manipulating XML in the Oracle XML DB Repository

You can access data in Oracle XML DB Repository in the following ways (see Figure 1–1):

- Using SQL, through views `RESOURCE_VIEW` and `PATH_VIEW`
- Using PL/SQL, through the `DBML_XDB` API
- Using Java, through the Oracle XML DB resource API for Java

XML Services

Besides supporting APIs that access and manipulate data, Oracle XML DB Repository provides APIs for the following services:

- Versioning – Oracle XML DB uses the `DBMS_XDB_VERSION` PL/SQL package for versioning resources in Oracle XML DB Repository. Subsequent updates to a resource create a new version (the data corresponding to previous versions is retained). Versioning support is based on the IETF WebDAV standard.
- ACL Security – Oracle XML DB resource security is based on access control lists (ACLs). Each resource in Oracle XML DB has an associated ACL that lists its privileges. Whenever resources are accessed or manipulated, the ACLs determine if the operation is legal. An ACL is an XML document that contains a set of access control entries (ACEs). Each ACE grants or revokes a set of permissions to a particular user or group (database role). This access control mechanism is based on the WebDAV specification.
- Foldering – Oracle XML DB Repository manages a persistent hierarchy of folder (directory) resources that contain other resources (files or folders). Oracle XML DB modules, such as protocol servers, the schema manager, and the Oracle XML DB `RESOURCE_VIEW` API, use foldering to map path names to resources.

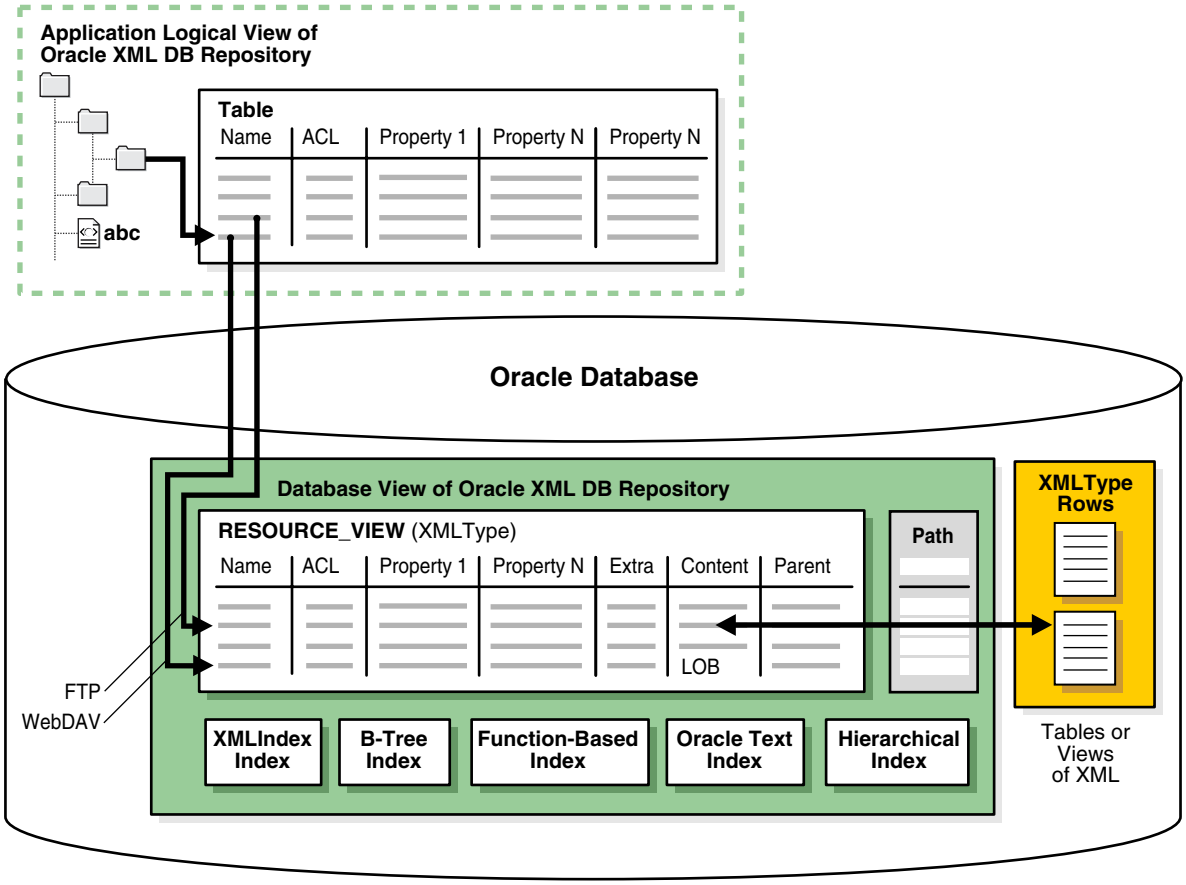
Oracle XML DB Repository Architecture

Figure 1–3 describes the Oracle XML DB Repository architecture. You can access the repository in SQL, for example, using the `RESOURCE_VIEW` API. In addition to the resource information, the `RESOURCE_VIEW` also contains a `Path` column, which holds the paths to each resource.

See Also:

- Chapter 21, "Accessing Oracle XML DB Repository Data"
- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"

Figure 1–3 Oracle XML DB Repository Architecture



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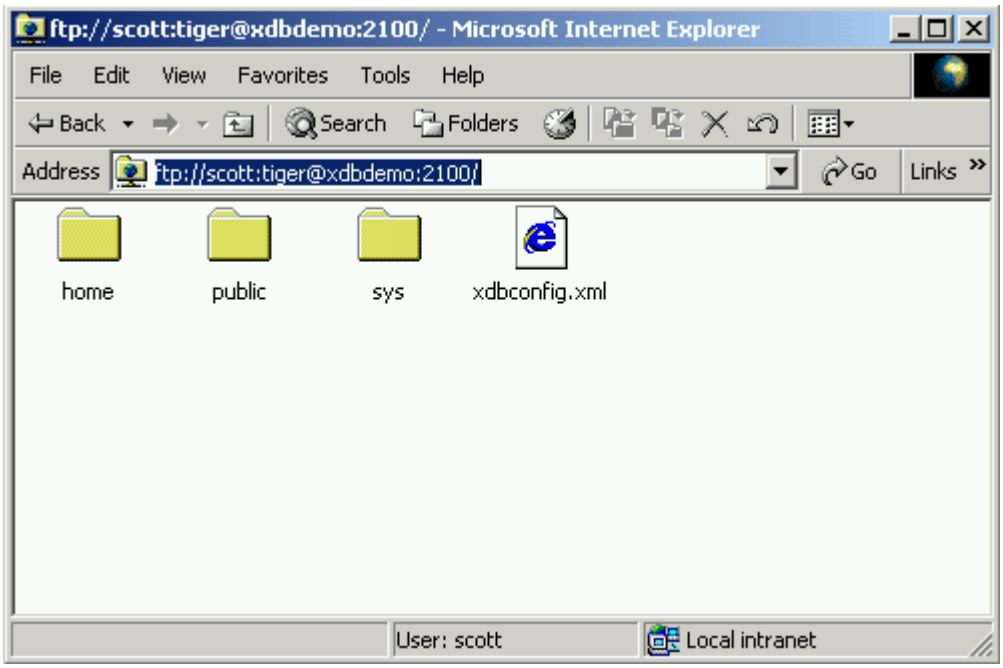
How Does Oracle XML DB Repository Work?

The relational model table-row-column metaphor, is accepted as an effective mechanism for managing structured data. The model is not as effective for managing semi-structured and unstructured data, such as document- or content-oriented XML. For example, a book is not easily represented as a set of rows in a table. It is more natural to represent a book as a hierarchy, `book:chapter:section:paragraph`, and to represent the hierarchy as a set of folders and subfolders.

- A hierarchical metaphor manages document-centric XML content. Relational databases are traditionally poor at managing hierarchical structures and traversing a path or URL. Oracle XML DB provides a hierarchically organized repository that can be queried and through which document-centric XML content can be managed.

- A hierarchical repository index speeds up folder and path traversals. Oracle XML DB includes a patented hierarchical index that speeds up folder and path traversals in Oracle XML DB Repository. The hierarchical repository index is transparent to end users, and lets Oracle XML DB perform folder and path traversals at speeds comparable to or faster than conventional file systems.
- You can access XML documents in Oracle XML DB Repository using standard connect-access protocols such as FTP, HTTP(S), and WebDAV, in addition to languages SQL, PL/SQL, Java, and C. The repository provides content authors and editors direct access to XML content stored in Oracle Database.
- A resource in this context is a file or folder, identified by a URL. WebDAV is an IETF standard that defines a set of extensions to the HTTP protocol. It lets an HTTP server act as a file server for a DAV-enabled client. For example, a WebDAV-enabled editor can interact with an HTTP/WebDAV server as if it were a file system. The WebDAV standard uses the term **resource** to describe a file or a folder. Each resource managed by a WebDAV server is identified by a URL. Oracle XML DB adds native support to Oracle Database for these protocols. The protocols were designed for document-centric operations. By providing support for these protocols, Oracle XML DB lets Windows Explorer, Microsoft Office, and products from vendors such as Altova, Macromedia, and Adobe work directly with XML content stored in Oracle XML DB Repository. Figure 1–4 shows the root-level directory of the repository as seen from Microsoft Web Folder.

Figure 1–4 Microsoft Web Folder View of Oracle XML DB Repository



See Also: Chapter 3, "Using Oracle XML DB"

Hence, WebDAV clients such as Microsoft Windows Explorer can connect directly to Oracle XML DB Repository. No additional Oracle Database or Microsoft-specific software or other complex middleware is needed. End users can work directly with Oracle XML DB Repository using familiar tools and interfaces.

Oracle XML DB Protocol Architecture

One key feature of the Oracle XML DB architecture is that HTTP(S), WebDAV, and FTP protocols are supported using the same architecture used to support Oracle Data Provider for .NET (ODP.NET) in a shared server configuration. The Listener listens for HTTP(S) and FTP requests in the same way that it listens for ODP.NET service requests. When the Listener receives an HTTP(S) or FTP request, it hands it off to an Oracle Database shared server process which services it and sends the appropriate response back to the client.

You can use the TNS Listener command, `lsnrctl status`, to verify that HTTP(S) and FTP support has been enabled – see Example 1–1.

Example 1–1 Listener Status with FTP and HTTP(S) Protocol Support Enabled

```
LSNRCTL for 32-bit Windows: Version 11.1.0.5.0 - Production on 20-AUG-2007 16:02:34

Copyright (c) 1991, 2007, Oracle.  All rights reserved.

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=IPC)(KEY=EXTPROC1521))) STATUS of the LISTENER
------------------------------------------------------------------------------------------
Alias                         LISTENER
Version                       TNSLSNR for 32-bit Windows: Version 11.1.0.5.0 - Beta
Start Date                    20-JUN-2007 15:35:40
Uptime                        0 days 16 hr. 47 min. 42 sec
Trace Level                   off
Security                      ON: Local OS Authentication
SNMP                          OFF
Listener Parameter File       C:\oracle\product\11.1.0\db_1\network\admin\listener.ora
Listener Log File             c:\oracle\diag\tnslsnr\quine-pc\listener\alert\log.xml

Listening Endpoints Summary...
(DESCRIPTION=(ADDRESS=(PROTOCOL=ipc)(PIPENAME=\\.\pipe\EXTPROC1521ipc)))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.us.mycompany.com)(PORT=1521)))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.us.mycompany.com)
             (PORT=21))(Presentation=FTP)(Session=RAW))
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=quine-pc.us.mycompany.com)
             (PORT=443))(Presentation=HTTP)(Session=RAW))
Services Summary...
Service "orcl.us.oracle.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
Service "orclXDB.us.oracle.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
Service "orcl_XPT.us.oracle.com" has 1 instance(s).
  Instance "orcl", status READY, has 1 handler(s) for this service...
The command completed successfully
```

See Also: Chapter 28, "Using Protocols to Access the Repository"

Programmatic Access to Oracle XML DB (Java, PL/SQL, and C)

All Oracle XML DB functionality is accessible from C, PL/SQL, and Java. These are the most popular ways to build Web-based applications:

- Using servlets and Java Server Pages (JSP). A typical API accesses data using Java Database Connectivity (JDBC).
- Using Extensible Stylesheet Language (XSL) plus XML Server Pages (XSP). A typical API accesses data in the form of XML documents that are processed using a Document Object Model (DOM) API implementation.

Oracle XML DB supports both of these styles of application development. It provides Java, PL/SQL, and C implementations of the DOM API.

Applications that use JDBC, such as those based on servlets, need prior knowledge of the data structure they are processing. Oracle JDBC drivers allow you to access and update `XMLType` tables and columns, and call PL/SQL procedures that access Oracle XML DB Repository.

Applications that use DOM, such as those based on XSLT transformations, typically require less knowledge of the data structure. DOM-based applications use string names to identify pieces of content, and must dynamically walk through the DOM tree to find the required information. For this, Oracle XML DB supports the use of the DOM API to access and update `XMLType` columns and tables. Programming to a DOM API is more flexible than programming through JDBC, but it may require more resources at run time.

Oracle XML DB Features

Any database used for managing XML must be able to persist XML documents. Oracle XML DB is capable of much more than this. It provides standard database features such as transaction control, data integrity, replication, reliability, availability, security, and scalability., while also allowing for efficient indexing, querying, updating, and searching of XML documents in an XML-centric manner.

The hierarchical nature of XML presents the traditional relational database with a number of challenges:

- In a relational database, the *table-row* metaphor locates content. Primary-Key Foreign-Key relationships help define the relationships between content. Content is accessed and updated using the table-row-column metaphor.
- XML, on the other hand, uses *hierarchical* techniques to achieve the same functionality. A URL is used to locate an XML document. URL-based standards such as XLink are used to define relationships between XML documents. W3C Recommendations such as XPath are used to access and update content contained within XML documents. Both URLs and XPath expressions are based on *hierarchical* metaphors. A URL uses a path through a *folder hierarchy* to identify a document, whereas XPath uses a path through the *node hierarchy* of an XML document to access part of an XML document.

Oracle XML DB addresses these challenges by introducing new SQL functions and methods that allow the use of XML-centric metaphors, such as XQuery and XPath expressions for querying and updating XML Documents.

These are the major features of Oracle XML DB:

- XMLType Data Type
- XML Schema Support
- XMLType Storage Models
- XML/SQL Duality
- SQL/XML INCITS Standard SQL Functions
- Rewriting of XQuery and XPath Expressions
- XMLType Storage. This was described on page 1-4.
- Overview of Oracle XML DB Repository. This was described on page 1-7.

XMLType Data Type

`XMLType` is a native data type for XML data. It provides methods that allow operations such as XML schema validation and XSL transformation on XML content. You can use `XMLType` as you would any other data type. For example, you can use `XMLType` when you do any of the following:

- Creating a column in a relational table
- Declaring PL/SQL variables
- Defining and calling PL/SQL procedures and functions

`XMLType` is an object type, so you can also create a table of `XMLType` instances. By default, an `XMLType` table or column can contain any well-formed XML document.

XMLType Tables and Columns Can Conform to an XML Schema

`XMLType` tables or columns can be constrained to conform to an XML schema. This has several advantages:

- The database ensures that only XML documents that validate against the XML schema are stored in the column or table.
- Since the contents of the table or column conform to a known XML structure, Oracle XML DB can use the information contained in the XML schema to provide optimized query and update processing of the XML.
- You have the option of storing the XML document content using structured storage. This decomposes the document and stores it as a set of object-relational objects. The object-relational model used to store the document is derived from the XML schema.

XMLType API

Data type `XMLType` provides the following:

- Constructors, which you can use to create an `XMLType` instance from a `VARCHAR`, `CLOB`, `BLOB`, or `BFILE` value.
- XML-specific methods that operate on `XMLType` instances. These include the following:
  - `extract()` – Extract a subset of nodes contained in the `XMLType` instance.
  - `existsNode()` – Check whether or not a particular node exists in the `XMLType` instance.
  - `schemaValidate()` – Validate the content of the `XMLType` instance against an XML schema.
  - `transform()` – Perform an XSL transformation on the content of an `XMLType` instance.

See Also: Chapter 4, "XMLType Operations" and Chapter 10, "Transforming and Validating XMLType Data"

XML Schema Support

Support for the Worldwide Web Consortium (W3C) XML Schema Recommendation is a key feature in Oracle XML DB. XML Schema specifies the structure, content, and certain semantics of a set of XML documents. It is described in detail at `http://www.w3.org/TR/xmlschema-0/`.

XML Schema Unifies Document Modeling and Data Modeling

In Oracle XML DB, you can use XML Schema to automatically create database tables and data types for storing XML data. You can thus use a standard data model for all of your data, whether the data is structured, unstructured, or semi-structured.

Create XMLType Tables and Columns, Ensure DOM Fidelity

You can create XML schema-based `XMLType` tables and columns and optionally specify that they conform to pre-registered XML schemas, maintaining DOM fidelity.

Use XMLType Views to Wrap Relational Data

You can also choose to wrap existing relational and object-relational data into XML format using `XMLType` views. You can store an `XMLType` object as an XML object that is based on an XML schema or not based on an XML schema:

- XML schema-based objects. These are stored in Oracle XML DB tables, columns, or views using binary XML storage, `CLOB` storage, or object-relational storage.
- Non-schema-based objects. These are stored in Oracle XML DB as LOBs only.

You can map from incoming XML documents to `XMLType` storage. The mapping is specified in an XML schema, which you register with Oracle XML DB. After it is registered, the XML schema can be referenced using its URL.

W3C Schema for Schemas

The W3C Schema Working Group publishes an XML schema, often referred to as the "schema for schemas". This XML schema provides the definition, or vocabulary, of the XML Schema language. An XML schema definition (XSD) is an XML document, that is compliant with the vocabulary defined by the schema for schemas. An XML schema uses vocabulary defined by W3C XML Schema Working Group to create a collection of type definitions and element declarations that declare a shared vocabulary for describing the contents and structure of a new class of XML documents.

XML Schema Base Set of Data Types Can be Extended

The XML Schema language provides strong typing of elements and attributes. It defines numerous scalar data types. This base set of data types can be extended to define more complex types, using object-oriented techniques such as inheritance and extension. The XML Schema vocabulary also includes constructs that you can use to define complex types, substitution groups, repeating sets, nesting, ordering, and so on. Oracle XML DB supports all of the constructs defined by the XML Schema Recommendation, except for `redefines`.

XML schemas are commonly used as a mechanism for checking (validating) whether XML instance documents conform with their specifications. Oracle XML DB includes `XMLType` methods and SQL functions that you can use to validate XML documents against an XML schema.

Note: This manual uses the term **XML schema** (lower-case "s") to reference any XML schema that conforms to the W3C XML Schema (upper-case "S") Recommendation. Since an XML schema is used to define a class of XML documents, the term **instance document** is often used to describe an XML document that conforms to a particular XML schema.

See Also: Chapter 6, "XML Schema Storage and Query: Basic" for more information about using XML schemas with Oracle XML DB

XMLType Storage Models

`XMLType` is an *abstract* data type that provides different *storage models* to best fit your data and your use of it. As an abstract data type, your applications and database queries gain in flexibility: the same interface is available for all `XMLType` operations. Because different storage (persistence) models are available, you can tailor performance and functionality to best fit the kind of XML data you have and the pattern of its use. One key decision to make when using Oracle XML DB for persisting XML data as `XMLType` is thus which storage model to use for which XML data.

You can change `XMLType` storage from one model to another, using database import/export (see Chapter 36, "Exporting and Importing XMLType Tables"); your application code does not need to change. You can change XML storage options when tuning your application.

`XMLType` tables and columns can be stored in these ways:

- **Structured** storage – `XMLType` data is stored as a set of objects. This is also referred to as **object-relational** storage and **object-based persistence**.
- **Unstructured** storage – `XMLType` data is stored in Character Large Object (`CLOB`) instances. This is also referred to as **CLOB** storage and **text-based persistence**.
- **Binary XML** storage – `XMLType` data is stored in a post-parse, binary format specifically designed for XML data. Binary XML is compact, post-parse, XML schema-aware XML. This is also referred to as **post-parse persistence**.

Unstructured and binary XML storage each provide two LOB storage options, SecureFile and BasicFile.

See Also:

- *Oracle Database SQL Language Reference*, section "CREATE TABLE", clause "LOB_storage_clause"
- *Oracle Database SecureFiles and Large Objects Developer's Guide* for information about LOB storage options SecureFile and BasicFile

You can mix storage models, using one model for one part of an XML document and a different model for another part. The mixture of structured and unstructured storage is sometimes called **hybrid** storage. What is true about structured storage is true about the structured part of hybrid storage. What is true about unstructured storage is true about the unstructured part of hybrid storage.

`XMLType` has multiple storage models, and some models can be configured in more than one way. Each model has its advantages, depending on the context. Each model has one or more types of index that are appropriate for it.

The first thing to consider, when choosing an `XMLType` storage model, is the nature of your XML data and the ways you use it. A spectrum exists, with data-centric use of highly structured data at one end, and document-centric use of highly unstructured data at the other. The first question to ask yourself is this: *Is your use case primarily data-centric or document-centric?*

- **Data-centric** – Your data is, in general, highly structured, with relatively static and predictable structure, and your applications take advantage of this structure. Your data conforms to an XML schema.

- **Document-centric** – Two cases:
  - If your data is relatively structured, your applications do not take advantage of that structure. That is, you treat the data as if it were without structure.
  - Your data is generally without structure or of variable structure. Document structure can vary over time (evolution). Content is **mixed** (**semi-structured**): many elements contain both text nodes and child elements. Many XML elements can be absent or can appear in different orders. Documents might or might not conform to an XML schema.

Note: Please be aware of the context, so as not to confuse discussion of storage options with discussion of the structure of the XML content to be stored. In this book, "structured" and "unstructured" generally refer to `XMLType` storage options; they refer less often to the nature of your data. "Hybrid" refers to object-relational storage with some embedded `CLOB` storage. "Semi-structured" refers to XML content, regardless of storage. Unstructured storage is `CLOB`-based storage, and structured storage is object-relational storage.

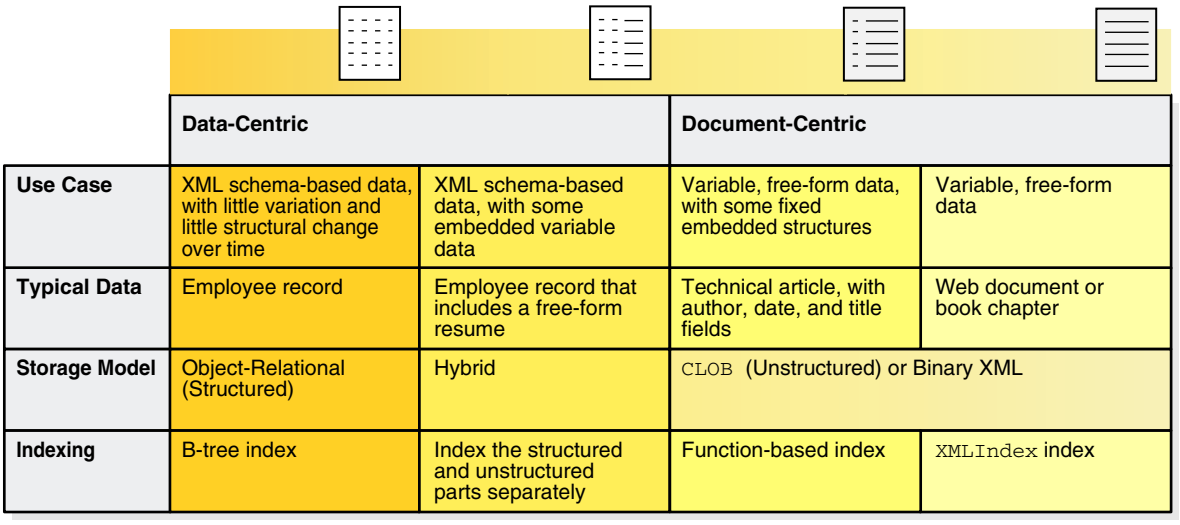
Once you've located the data-centric or document-centric half of the spectrum that is appropriate for your use case and data, consider whether your case is at an end of the spectrum or closer to the middle. That is, just how data-centric or document-centric is your case?

- Employ *object-relational* (structured) storage for purely data-centric uses. A typical example of this use case would be an employee record (fields employee number, name, address, and so on). Use B-tree indexing with object-relational storage.
- Employ *hybrid* storage if your data is composed primarily of invariable XML structures, but it does contain some variable data; that is, it contains a predictably few mixed-content elements. A typical example of this use case would be an employee record that includes a free-form resume. Index the structured and unstructured parts of your data separately, using appropriate indexes for each part.
- Employ *binary XML* storage or `CLOB`-*based* (unstructured) storage for all document-centric use cases. In terms of indexing, we can distinguish two use cases:
  - If your data contains some predictable, fixed structures that you query frequently, then you can employ function-based indexes on those parts. A typical example of this use case would be a free-form specification, with author, date, and title fields.
  - Otherwise, for general indexing of document-centric XML data, use `XMLIndex` indexing. A typical example of this use case would be an XML Web document or a book chapter.

  In all document-centric cases, you can additionally use Oracle Text indexing for full-text queries.

These considerations are summarized in Figure 1–5. The figure shows the spectrum of use cases, from most data-centric, at the left, to most document-centric, at the right. The table in the figure classifies use cases and shows the corresponding storage models and indexing methods.

Figure 1–5 XML Use Cases and XMLType Storage Models



	Data-Centric		Document-Centric	
Use Case	XML schema-based data, with little variation and little structural change over time	XML schema-based data, with some embedded variable data	Variable, free-form data, with some fixed embedded structures	Variable, free-form data
Typical Data	Employee record	Employee record that includes a free-form resume	Technical article, with author, date, and title fields	Web document or book chapter
Storage Model	Object-Relational (Structured)	Hybrid	`CLOB` (Unstructured) or Binary XML	
Indexing	B-tree index	Index the structured and unstructured parts separately	Function-based index	`XMLIndex` index

****

See Chapter 5, "Indexing XMLType Data" for more information about indexing XML data. In particular, note that some types of indexing are complementary or orthogonal, so you can use them together.

The following list and Table 1–3 outline some of the advantages of each storage model.

- *Structured* (object-relational) storage advantages over unstructured storage include optimized memory management, reduced storage requirements, B-tree indexing, and in-place updates. These advantages are at a cost of increased processing overhead during ingestion and retrieval of XML data, and reduced flexibility in the structure of the XML that can be managed by a given `XMLType` table or column. Structural flexibility is reduced, because data and metadata (such as column names) are separated in object-relational storage; instance structures cannot vary easily. Structured storage is particularly appropriate for highly structured data whose structure does not vary, if this maps to a manageable number of database tables and joins.
- *Unstructured* (`CLOB`) storage enables higher throughput than structured storage when inserting and retrieving entire XML documents. No data conversion is needed, so the same format can be used outside the database. Unstructured storage also provides greater flexibility than structured storage in the structure of the XML that can be stored. Unstructured storage is particularly appropriate for document-centric use cases. These advantages can come at the expense of certain aspects of intelligent processing: in the absence of indexing, there is little that the database can do to optimize queries or updates on XML data that is stored in a `CLOB` instance. In particular, the cost of XML parsing (often implicit) can significantly impact query performance. Indexing with `XMLIndex` can improve the performance of queries against unstructured storage.
- *Binary XML* storage provides more efficient database storage, updating, indexing, and fragment extraction than unstructured storage. It can provide better query performance than unstructured storage—it does not suffer from the XML parsing bottleneck (it is a post-parse persistence model). Like structured storage, binary XML storage is aware of XML Schema data types and can take advantage of native database data types. Like unstructured storage, no data conversion is needed

during database insertion or retrieval. Like structured storage, binary XML storage allows for piecewise updates. Because binary XML data can also be used outside the database, it can serve as an efficient XML exchange medium, and you can off load work from the database to increase overall performance in many cases. Like unstructured storage, binary XML data is kept in document order. Like structured storage, data and metadata can, using binary storage, be separated at the database level, for efficiency. Like unstructured storage, however, binary XML storage allows for intermixed data and metadata, which lets instance structures vary. Binary XML storage allows for very complex and variable data, which in the structured-storage model could necessitate using many database tables. Unlike the other `XMLType` storage models, you can use binary storage for XML schema-based data even if the XML schema is not known beforehand, and you can store multiple XML schemas in the same table and query across common elements.

Binary XML storage is the closest thing to a universal storage model for XML data—you can use it effectively for a very wide range of use cases, from document-centric to data-centric.

Table 1–3 XMLType Storage Models: Relative Advantages

Quality	Structured (Object-Relational) Storage	Unstructured (CLOB) Storage	Binary XML Storage
Throughput	– XML decomposition can result in reduced throughput when ingesting retrieving the entire content of an XML document.	+ High throughput when ingesting and retrieving the entire content of an XML document.	++ High throughput. Fast DOM loading.
Space efficiency (disk)	++ Extremely space-efficient.	– Consumes the most disk space, due to insignificant whitespace and repeated tags.	+ Space-efficient.
Data flexibility	– Limited flexibility. Only documents that conform to the XML schema can be stored in the `XMLType` table or column.	+ Flexibility in the structure of the XML documents that can be stored in an `XMLType` column or table.	+ Flexibility in the structure of the XML documents that can be stored in an `XMLType` column or table.
XML schema flexibility	– Relatively inflexible. Data and metadata are stored separately. Cannot use multiple XML schemas for the same `XMLType` table.	+ Flexible. Data and metadata are stored together. Cannot use multiple XML schemas for the same `XMLType` table.	++ Flexible. Can store data and metadata together or separately. Can use multiple XML schemas for the same `XMLType` table.
XML fidelity	– DOM fidelity: A DOM created from an XML document that has been stored in the database will be identical to a DOM created from the original document. However, insignificant whitespace may be discarded.	+ Document fidelity: Maintains the original XML data, byte for byte. In particular, all original whitespace is preserved.	– DOM fidelity (see structured storage description).
Update operations (DML)	++ In-place, piecewise update.	– When any part of the document is updated, the entire document must be written back to disk.	+ In-place, piecewise update for SecureFile LOB storage.
XPath-based queries	++ XPath operations can often be evaluated using XPath rewrite, leading to significantly improved performance, particularly with large collections of documents.	– XPath operations are evaluated by constructing a DOM from the `CLOB` data and using functional evaluation. Expensive when performing operations on large documents or large collections of documents. `XMLIndex` indexing can improve performance of XPath-based queries.	+ Streaming XPath evaluation avoids DOM construction and allows evaluation of multiple XPath expressions in a single pass. Navigational XPath evaluation is significantly faster than with unstructured storage. `XMLIndex` indexing can improve performance of XPath-based queries.
SQL constraint support	+ SQL constraints are supported.	– SQL constraints are not available.	+ SQL constraints are supported.
Support for SQL scalar data types	+ Yes	– No	+ Yes

Table 1–3 (Cont.) XMLType Storage Models: Relative Advantages

Quality	Structured (Object-Relational) Storage	Unstructured (CLOB) Storage	Binary XML Storage
Indexing support	B-tree, Oracle Text, and function-based indexes.	`XMLIndex`, function-based, and Oracle Text indexes.	`XMLIndex`, function-based, and Oracle Text indexes.
Optimized memory management	+ XML operations can be optimized to reduce memory requirements.	– XML operations on the document require creating a DOM from the document.	+ XML operations can be optimized to reduce memory requirements.
Validation upon insert	XML data is partially validated when it is inserted.	XML schema-based data is partially validated when it is inserted.	+ XML schema-based data is fully validated when it is inserted.

Note: When you insert XML schema-based data into binary `XMLType` columns or tables, the data is fully *validated* against the XML schema. Insertion fails if the data is invalid.

When `XMLType` is stored object-relationally, the `XMLType` instances contain hidden columns that store information about the XML data that does not fit into the SQL object model.

XML/SQL Duality

A key objective of Oracle XML DB is to provide XML/SQL duality. XML programmers can leverage the power of the relational model when working with XML content and SQL programmers can leverage the flexibility of XML when working with relational content. This lets you use the most appropriate tools for a particular business problem.

XML/SQL duality means that the same data can be exposed as rows in a table and manipulated using SQL or exposed as nodes in an XML document and manipulated using techniques such as DOM and XSL transformation. Access and processing techniques are independent of the underlying storage format.

These features provide simple solutions to common business problems. For example:

- You can use Oracle XML DB SQL functions to generate XML data directly from a SQL query. You can then transform the XML data into other formats, such as HTML, using the database-resident XSLT processor.
- You can access XML content without converting between different data formats, using SQL queries, on-line analytical processing (OLAP), and business-intelligence/data warehousing operations.
- You can perform text, spatial data, and multimedia operations on XML content.

SQL/XML INCITS Standard SQL Functions

Oracle XML DB provides the SQL functions defined in the SQL/XML standard. This standard is defined by specifications prepared by the International Committee for Information Technology Standards (INCITS) Technical Committee H2. INCITS is the main standards body for developing standards for the syntax and semantics of database languages, including SQL.

The SQL/XML standard is evolving, so the syntax and semantics of its functions are subject to change in the future. The Oracle XML DB implementation of SQL/XML functions will evolve accordingly.

SQL/XML functions fall into two categories:

- Functions that you can use to *query* and *access* XML content as part of normal SQL operations.
- Functions that you can use to *generate* XML data from the result of a SQL query.

With SQL/XML functions you can address XML content in any part of a SQL statement. These functions use XQuery or XPath expressions to traverse the XML structure and identify the nodes on which to operate. The ability to embed XQuery and XPath expressions in SQL statements greatly simplifies XML access.

See Also:

- `http://www.incits.org/tc_home/h2.htm` for information about INCITS Technical Committee H2
- `http://www.w3.org/TR/xpath` for the XPath recommendation
- Chapter 4, "XMLType Operations" for detailed descriptions of the SQL/XML standard functions for *querying* XML data
- Generating XML Using SQL Functions on page 17-2 for detailed descriptions of the SQL/XML standard functions for *generating* XML data
- Chapter 3, "Using Oracle XML DB" for *examples* that use the SQL/XML standard functions

Rewriting of XQuery and XPath Expressions

SQL/XML functions and their corresponding `XMLType` methods use XQuery or XPath expressions to search collections of XML documents and to access a subset of the nodes contained within an XML document. In many cases, Oracle XML DB is able to rewrite such expressions to code that executes directly against the underlying database objects.

See Also: "Generating XML Using SQL Functions" on page 17-2 for information about SQL/XML functions

How XPath Expressions Are Evaluated by Oracle XML DB

Oracle XML DB provides the following ways of evaluating XPath expressions that operate on `XMLType` columns and tables, depending on the XML storage method used:

- Structured storage – Oracle XML DB attempts to translate the XPath expression in a SQL/XML function into an equivalent SQL query. The SQL query references the object-relational data structures that underpin a schema-based `XMLType`. This process is referred to as **XPath rewrite**. It can occur when performing queries and `UPDATE` operations. In addition, function-based indexes, and B-tree indexes on the underlying object-relational tables, can be used to evaluate XPath expressions for structured storage.
- Unstructured storage – Function-based indexes can be used to evaluate XPath expressions for unstructured storage. In addition:
  - In the absence of an `XMLIndex` index, Oracle XML DB evaluates the XPath expression using functional evaluation. Functional evaluation builds a DOM tree for each XML document, and then resolves the XPath programmatically using the methods provided by the DOM API. If the operation involves

updating the DOM tree, the entire XML document must be written back to disk when the operation is completed.

  - If an `XMLIndex` can be used, then it is used instead of functional evaluation.

- Binary XML storage – Oracle XML DB can evaluate XPath expressions in different ways: using a function-based index, using `XMLIndex`, and using single-pass streaming. Single-pass streaming means evaluating a set of XPath expressions in a single scan of binary XML data. During query compilation, the cost-based optimizer picks the fastest combination of the methods.

  See Also: Table 1–3, " XMLType Storage Models: Relative Advantages"

Rewriting SQL Code That Contains XQuery and XPath Expressions

For XML data that is stored object-relationally, Oracle XML DB can rewrite SQL statements that contain XQuery and XPath expressions to purely relational SQL statements, which are then processed in an optimal manner. In this way, Oracle XML DB insulates the database optimizer from needing to understand the XQuery and XPath languages and the XML data model. The database optimizer processes a rewritten SQL statement the same way it processes other SQL statements. The general term applied to this rewriting process is **XPath rewrite**.

This means that the database optimizer can derive an execution plan based on conventional relational algebra. This in turn means that Oracle XML DB can leverage all of the features of the database, and ensure that SQL statements containing XQuery and XPath expressions are executed in a highly performant and efficient manner. There is little overhead with this rewriting, and Oracle XML DB executes XQuery-based and XPath-based queries at near-relational speed, while preserving the XML abstraction.

When Can XPath Rewrite Occur?

XPath rewrite is possible when all of the following conditions are met:

- An `XMLType` column or table uses structured storage techniques to provide the underlying storage model.
- An `XMLType` column or table is associated with a registered XML schema.
- A SQL statement contains SQL/XML functions or `XMLType` methods that use XPath expressions to refer to one or more nodes within a set of XML documents.
- The nodes referenced by an XPath expression can be mapped, using the XML schema, to attributes of the underlying SQL object model.

What is the XPath-Rewrite Process?

XPath rewrite performs the following tasks:

1. Identify the set of XPath expressions included in the SQL statement.
2. Translate each XPath expression into an object relational SQL expression that references the tables, types, and attributes of the underlying SQL: 1999 object model.
3. Rewrite the original SQL statement into an equivalent object relational SQL statement.
4. Pass the new SQL statement to the database optimizer for plan generation and query execution.

In certain cases, XPath rewrite is not possible. This normally occurs when there is no SQL equivalent of the XPath expression. In this situation, Oracle XML DB performs a functional evaluation of the XPath expressions.

In general, functional evaluation of a SQL statement is more expensive than XPath rewrite, particularly if the number of documents that needs to be processed is large. The advantage of functional evaluation is that it is always possible, regardless of whether the `XMLType` data is stored using structured storage and regardless of the complexity of the XPath expression.

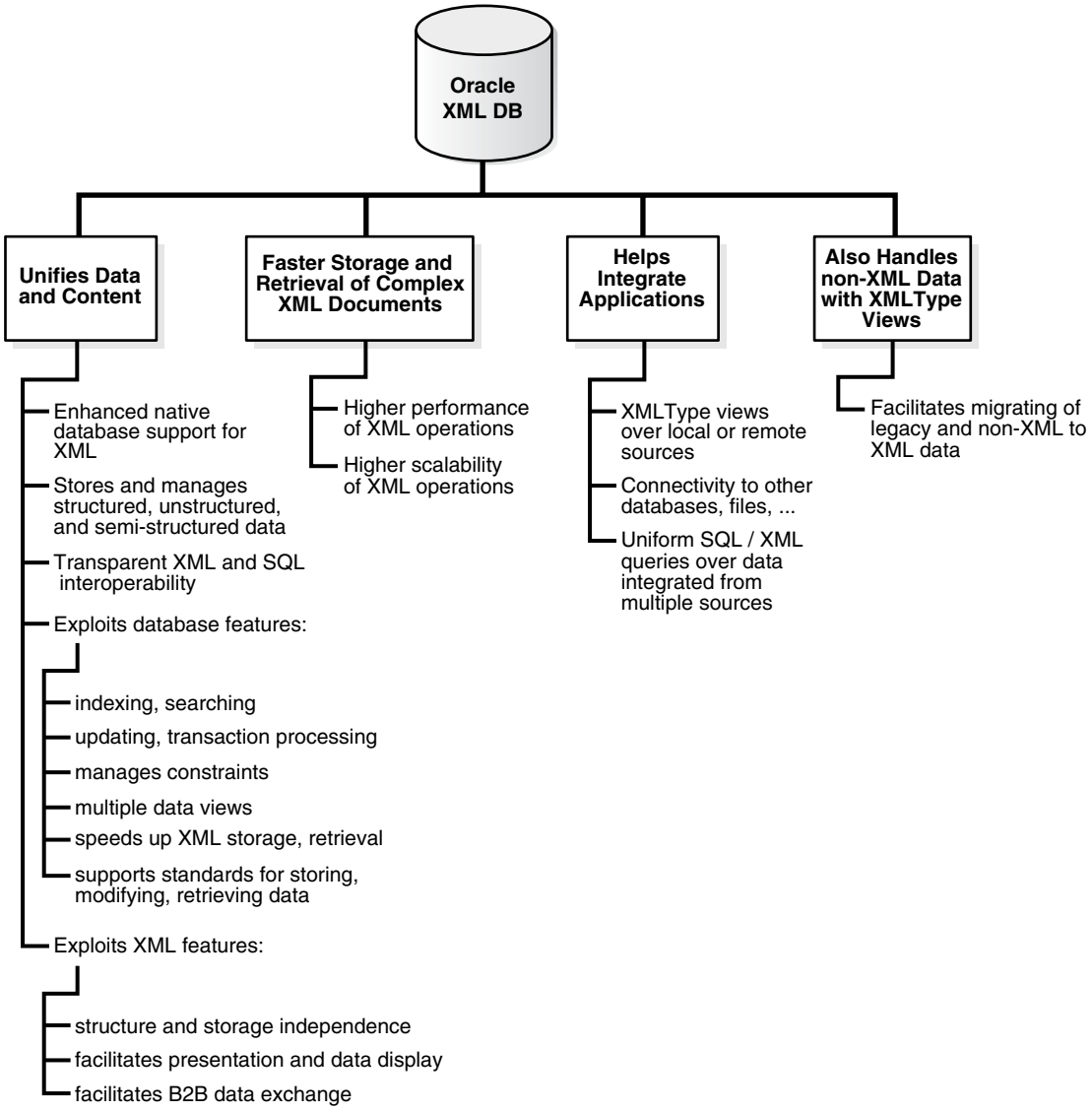
Understanding the concept of XPath rewrite, and the conditions under which it can take place, is a key step in developing Oracle XML DB applications that will deliver the required levels of scalability and performance.

See Also: Chapter 7, "XPath Rewrite"

Oracle XML DB Benefits

The following sections describe several benefits of using Oracle XML DB. Figure 1–6 outlines these benefits.

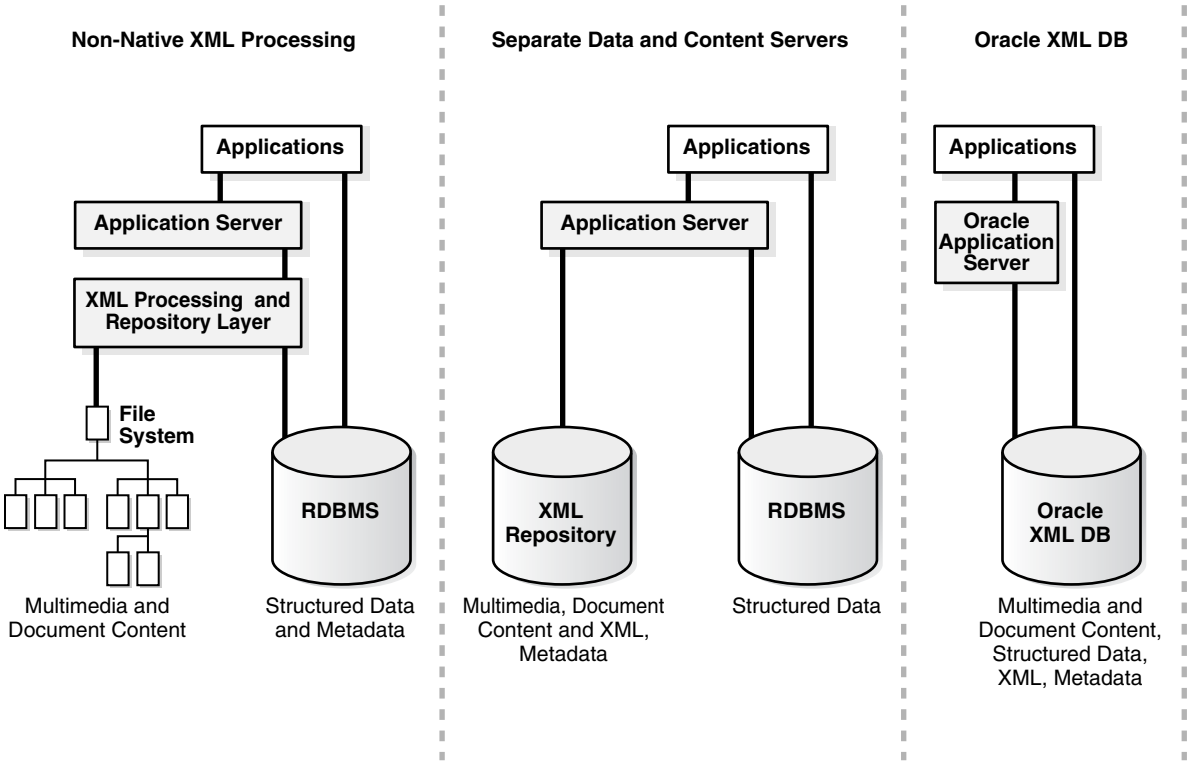
Figure 1–6 Oracle XML DB Benefits



Unifying Data and Content

Most application data and Web content is stored in a relational database, a file system, or both. XML data is often used for data exchange, and it can be generated from a relational database or a file system. As the volume of XML data exchanged grows, the cost of regenerating this data grows, and these storage methods become less effective at accommodating XML content.

Figure 1–7 Unifying Data and Content: Some Common XML Architectures



Organizations often manage their structured data and unstructured data differently:

- Unstructured data, in tables, makes document access transparent and table access complex.
- Structured data, often in binary large objects (such as in `BLOB` instances), makes access more complex and table access transparent.

With Oracle XML DB, you can store and manage data that is structured, unstructured, and semi-structured using a standard data model and standard SQL and XML. You can perform SQL operations on XML documents and XML operations on object-relational (such as table) data.

Exploiting Database Capabilities

Oracle Database has strong XML support with the following key capabilities:

- Indexing and search – Applications use queries such as "find all the product definitions created between March and April 2002", a query that is typically supported by a B-tree index on a date column. Oracle XML DB can enable efficient structured searches on XML data, saving content-management vendors the need to build proprietary query APIs to handle such queries. See Chapter 4, "XMLType Operations", Chapter 11, "Full-Text Search Over XML Data", and Chapter 17, "Generating XML Data from the Database".
- Updates and transaction processing – Commercial relational databases use fast updates of subparts of records, with minimal contention between users trying to update. As traditionally document-centric data participate in collaborative environments through XML, this requirement becomes more important. File or `CLOB` storage cannot provide the granular concurrency control that Oracle XML DB does. See Chapter 4, "XMLType Operations".

- Managing relationships – Data with any structure typically has foreign-key constraints. XML data stores generally lack this feature, so you must implement any constraints in application code. Oracle XML DB enables you to constrain XML data according to XML schema definitions, and hence achieve control over relationships that structured data has always enjoyed. See Chapter 6, "XML Schema Storage and Query: Basic" and the purchase-order examples in Chapter 4, "XMLType Operations".
- Multiple views of data – Most enterprise applications need to group data together in different ways for different modules. This is why relational views are necessary—to allow for these multiple ways to combine data. By allowing views on XML, Oracle XML DB creates different logical abstractions on XML for, say, consumption by different types of applications. See Chapter 19, "XMLType Views".
- Performance and scalability – Users expect data storage, retrieval, and query to be fast. Loading a file or `CLOB` value, and parsing, are typically slower than relational data access. Oracle XML DB dramatically speeds up XML storage and retrieval. See Chapter 2, "Getting Started with Oracle XML DB" and Chapter 3, "Using Oracle XML DB".
- Ease of development – Databases are foremost an application platform that provides standard, easy ways to manipulate, transform, and modify individual data elements. While typical XML parsers give standard read access to XML data they do not provide an easy way to modify and store individual XML elements. Oracle XML DB supports a number of standard ways to store, modify, and retrieve data: using XML Schema, XQuery, XPath, DOM, and Java.

  See Also:

  - Chapter 14, "Java DOM API for XMLType"
  - Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"
  - Chapter 26, "Using PL/SQL to Access the Repository"

Exploiting XML Capabilities

If the drawbacks of XML file storage force you to break down XML into database tables and columns, there are several XML advantages you have left:

- Structure independence: The open content model of XML cannot be captured easily in the pure tables-and-columns world. XML schemas allow global element declarations, not just scoped to a container. Hence you can find a particular data item regardless of where in the XML document it moves to as your application evolves. See Chapter 6, "XML Schema Storage and Query: Basic".
- Storage independence: When you use relational design, your client programs must know where your data is stored, in what format, what table, and what the relationships are among those tables. `XMLType` enables you to write applications without that knowledge and lets DBAs map structured data to physical table and column storage. See Chapter 6, "XML Schema Storage and Query: Basic" and Chapter 21, "Accessing Oracle XML DB Repository Data".
- Ease of presentation: XML is understood natively by Web browsers, many popular desktop applications, and most Internet applications. Relational data is not generally accessible directly from applications; programming is required to make relational data accessible to standard clients. Oracle XML DB stores data as XML and makes it available as XML outside the database; no extra programming is required to display database content. See:

  - Chapter 10, "Transforming and Validating XMLType Data".
  - Chapter 17, "Generating XML Data from the Database".
  - Chapter 19, "XMLType Views".
  - *Oracle XML Developer's Kit Programmer's Guide*, in the chapter, "XSQL Pages Publishing Framework". It includes `XMLType` examples.
- Ease of interchange – XML is the language of choice in business-to-business (B2B) data exchange. If you are forced to store XML in an arbitrary table structure, you are using some kind of proprietary translation. Whenever you translate a language, information is lost and interchange suffers. By natively understanding XML and providing DOM fidelity in the storage/retrieval process, Oracle XML DB enables a clean interchange. See:
  - Chapter 10, "Transforming and Validating XMLType Data"
  - Chapter 19, "XMLType Views"

Efficient Storage and Retrieval of Complex XML Documents

Users today face a performance barrier when storing and retrieving complex, large, or many XML documents. Oracle XML DB provides high performance and scalability for XML operations. The major performance features are:

- Native `XMLType`. See Chapter 4, "XMLType Operations".
- A lazily evaluated virtual DOM support. See Chapter 12, "PL/SQL APIs for XMLType".
- Database-integrated XQuery, XPath, and XSLT support. This support is described in several chapters, including Chapter 4, "XMLType Operations", Chapter 10, "Transforming and Validating XMLType Data", and Chapter 18, "Using XQuery with Oracle XML DB".
- XML schema-caching support. See Chapter 6, "XML Schema Storage and Query: Basic".
- Indexing – both full-text and XML. See Chapter 5, "Indexing XMLType Data" and Chapter 11, "Full-Text Search Over XML Data".
- A hierarchical index over Oracle XML DB Repository. See Chapter 21, "Accessing Oracle XML DB Repository Data".

Integrate Applications

Oracle XML DB enables data from disparate systems to be accessed through gateways and combined into one common data model. This reduces the complexity of developing applications that must deal with data from different stores.

Use XMLType Views If Your Data Is Not XML

`XMLType` views provide a way for you wrap existing relational and object-relational data in XML format. This is especially useful if, for example, your legacy data is not in XML format but you need to migrate to XML format. Using `XMLType` views, you do not need to alter your application code.

See Also: Chapter 19, "XMLType Views"

To use XMLType views, you must first register an XML schema with annotations that represent a bidirectional mapping between XML Schema data types and either SQL data types or binary XML encoding types. You can then create an XMLType view conforming to this mapping, by providing an underlying query that constructs instances of the appropriate types.

Searching XML Data Using Oracle Text

Oracle Database enables special indexing on XML data, including Oracle Text indexes for section searching, special SQL functions to process XML, aggregation of XML, and special optimization of queries involving XML. SQL functions hasPath and inPath are designed to optimize XML data searches where you can search within XML text for substring matches.

Oracle XML DB also provides:

- SQL function contains and XPath function ora:contains, which can be used with SQL function existsNode for XPath-based searches.
- The ability to create indexes on URIType and XDBURIType columns.

See Also:

- Chapter 11, "Full-Text Search Over XML Data"
- "Oracle Text Indexes on XML Data" on page 5-36
- *Oracle Text Application Developer's Guide*
- *Oracle Text Reference*

Building Messaging Applications using Oracle Streams Advanced Queuing

Oracle Streams Advanced Queuing supports the use of:

- XMLType as a message/payload type, including XML schema-based XMLType
- Queuing or dequeuing of XMLType messages

See Also:

- *Oracle Streams Advanced Queuing User's Guide* for information about using XMLType with Oracle Streams Advanced Queuing
- Chapter 37, "Exchanging XML Data with Oracle Streams AQ"

Requirements for Running Oracle XML DB

Oracle XML DB is available with Oracle9*i* release 2 (9.2) and higher.

See Also:

- http://www.oracle.com/technology/tech/xml/ for the latest news and white papers on Oracle XML DB
- Chapter 2, "Getting Started with Oracle XML DB"

Standards Supported by Oracle XML DB

Oracle XML DB supports all major XML, SQL, Java, and Internet standards:

- W3C XML Schema 1.0 Recommendation. You can register XML schemas, validate stored XML content against XML schemas, or constrain XML stored in the server to XML schemas.
- W3C XQuery 1.0 Recommendation and W3C XPath 2.0 Recommendation. You can search or traverse XML stored inside the database using XQuery and XPath, either from HTTP(S) requests or from SQL.
- ISO-ANSI Working Draft for XML-Related Specifications (SQL/XML) [ISO/IEC 9075 Part 14 and ANSI]. You can use the emerging ANSI SQL/XML functions to query XML from SQL. The task force defining these specifications falls under the auspices of the International Committee for Information Technology Standards (INCITS). The SQL/XML specification will be fully aligned with SQL:2003. SQL/XML functions are sometimes referred to as SQLX functions.
- Java Database Connectivity (JDBC) API. JDBC access to XML is available for Java programmers.
- W3C XSL 1.0 Recommendation. You can transform XML documents at the server using XSLT.
- W3C DOM Recommendation Levels 1.0 and 2.0 Core. You can retrieve XML stored in the server as an XML DOM, for dynamic access.
- Protocol support. You can store or retrieve XML data from Oracle XML DB using standard protocols such as HTTP(S), FTP, and IETF WebDAV, as well as Oracle Net.
- Java Servlet version 2.2, (except that the servlet WAR file, `web.xml` is not supported in its entirety, and only one `ServletContext` and one `web-app` are currently supported, and stateful servlets are not supported).
- Web services: SOAP 1.1. You can access XML stored in the server from SOAP requests. You can build, publish, or find Web Services using Oracle XML DB and Oracle9*i*AS, using WSDL and UDDI. You can use Oracle Streams Advanced Queuing IDAP, the SOAP specification for queuing operations, on XML stored in Oracle Database.

See Also:

- "SQL/XML INCITS Standard SQL Functions" for more information about the ANSI SQL/XML functions
- Chapter 28, "Using Protocols to Access the Repository" for more information about protocol support
- Chapter 32, "Writing Oracle XML DB Applications in Java" for information about using the Java servlet
- Chapter 37, "Exchanging XML Data with Oracle Streams AQ" and *Oracle Streams Advanced Queuing User's Guide* for information about using SOAP

Oracle XML DB Technical Support

Besides your regular channels of support through your customer representative or consultant, technical support for Oracle Database XML-enabled technologies is available free through the Discussions option on Oracle Technology Network (OTN):

`http://www.oracle.com/technology/tech/xml/`

Oracle XML DB Examples Used in This Manual

This manual contains examples that illustrate the use of Oracle XML DB and `XMLType`. The examples are based on a number of database schema, sample XML documents, and sample XML schema.

> **See Also:** Appendix A, "Oracle-Supplied XML Schemas and Examples"

Further Oracle XML DB Case Studies and Demonstrations

Visit OTN to view Oracle XML DB examples, white papers, case studies, and demonstrations.

Oracle XML DB Examples and Tutorials

You can peruse more Oracle XML DB examples on OTN:

`http://www.oracle.com/technology/tech/xml/`

Comprehensive XML classes on how to use Oracle XML DB are also available. See the Oracle University link on OTN.

Oracle XML DB Case Studies and Demonstrations

Several detailed Oracle XML DB case studies are available on OTN and include the following:

- Oracle XML DB Downloadable Demonstration. This detailed demonstration illustrates how to use many Oracle XML DB features. Parts of this demonstration are also included in Chapter 3, "Using Oracle XML DB".
- Content Management System (CMS) application. This illustrates how you can store files on the database using Oracle XML DB Repository in hierarchically organized folders, place the files under version control, provide security using ACLs, transform XML content to a desired format, search content using Oracle Text, and exchange XML messages using Oracle Streams Advanced Queueing (to request privileges on files or for sending externalization requests). See `http://www.oracle.com/technology/sample_code/tech/xml/xmldb/cmsxdb/content.html`.
- XML Dynamic News. This is a complete J2EE 1.3 based application that demonstrates Java and Oracle XML DB features for an online news portal. News feeds are stored and managed persistently in Oracle XML DB. Various other news portals can customize this application to provide static or dynamic news services to end users. End users can personalize their news pages by setting their preferences. The application also demonstrates the use of Model View Controller (MVC) architecture and various J2EE design patterns. See `http://www.oracle.com/technology/sample_code/tech/xml/xmlnews/content.html`
- SAX Loader Application. This demonstrates an efficient way to break up large files containing multiple XML documents outside the database and insert them into the database as a set of separate documents. This is provided as a standalone and a Web-based application.
- Oracle XML DB Utilities package. This highlights the subprograms provided with the `XDB_Utilities` package. These subprograms operate on `BFILE` values, `CLOB` values, DOM, and Oracle XML DB Resource APIs. With this package, you

can perform basic Oracle XML DB foldering operations, read and load XML files into a database, and perform basic DOM operations through PL/SQL.

- Card Payment Gateway Application. This application uses Oracle XML DB to store all your data in XML format and enables access to the resulting XML data using SQL. It illustrates how a credit card company can store its account and transaction data in the database and also maintain XML fidelity.
- Survey Application. This application determines what members want from Oracle products. OTN posts the online surveys and studies the responses. This Oracle XML DB application demonstrates how a company can create dynamic, interactive HTML forms, deploy them to the Internet, store the responses as XML, and analyze them using the XML enabled Oracle Database.

2

Getting Started with Oracle XML DB

This chapter provides some preliminary design criteria for consideration when planning your Oracle XML DB solution.

This chapter contains these topics:

Oracle XML DB Installation

Oracle XML DB is installed automatically in the following situations:

- If Database Configuration Assistant (DBCA) is used to build Oracle Database using the general-purpose template
- If you use SQL script `catqm` to install Oracle Database

You can determine whether or not Oracle XML DB is already installed. If it is installed, then the following are true:

- Database schema (user account) `XDB` exists. To check that, run this query:

  ```
  SELECT * FROM ALL_USERS;
  ```

- View `RESOURCE_VIEW` exists. To check that, use this command:

  ```
  DESCRIBE RESOURCE_VIEW
  ```

See Also:

- Chapter 34, "Administering Oracle XML DB" for information about installing and de-installing Oracle XML DB *manually*
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

When to Use Oracle XML DB

Oracle XML DB is suited for any application where some or all of the data processed by the application is represented using XML. Oracle XML DB provides for high performance ingestion, storage, processing and retrieval of XML data. Additionally, it also provides the ability to quickly and easily generate XML from existing relational data.

The type of applications that Oracle XML DB is particularly suited to include:

- Business-to-Business (B2B) and Application-to-Application (A2A) integration
- Internet applications
- Content-management applications
- Messaging
- Web Services

A typical Oracle XML DB application has one or more of the following requirements and characteristics:

- Large numbers of XML documents must be ingested or generated
- Large XML documents need to be processed or generated
- High performance searching, both within a document and across a large collections of documents
- High levels of security. Fine grained control of security
- Data processing must be contained in XML documents and data contained in traditional relational tables
- Uses languages such as Java that support open standards such as SQL, XML, XQuery, XPath, and XSLT
- Accesses information using standard Internet protocols such as FTP, HTTP(S)/WebDAV, or Java Database Connectivity (JDBC)
- Ability to query from SQL and integration with analytic capabilities
- Validation of XML documents is critical

Designing Your XML Application

Oracle XML DB provides you with the ability to fine tune how XML documents will be stored and processed in Oracle Database. Depending on the nature of the application being developed, XML storage must have at least one of the following features

- High performance ingestion and retrieval of XML documents
- High performance indexing and searching of XML documents
- Be able to update sections of an XML document

- Manage highly either or both structured and unstructured XML documents

Application Design with Oracle XML DB

This section discusses the preliminary design criteria you can consider when planning your Oracle XML DB application. Figure 2–1 provides an overview of your main design options for building Oracle XML DB applications.

Data

Will your data be highly structured (mostly XML), semi-structured, or mostly unstructured? If highly structured, will your tables be XML schema-based or non-schema-based? See "How Structured Is Your Data?" on page 2-4 and Chapter 3, "Using Oracle XML DB".

Access

How will other applications and users access your XML and other data? How secure must the access be? Do you need versioning? See "Access Models" on page 2-4.

Application Language

In which language(s) will you be programming your application? See "Application Language" on page 2-5.

Processing

Will you need to generate XML? See Chapter 17, "Generating XML Data from the Database".

How often will XML documents be accessed, updated, and manipulated? Will you need to update fragments or the whole document?

Will you need to transform the XML to HTML, WML, or other languages, and how will your application transform the XML? See Chapter 10, "Transforming and Validating XMLType Data".

Does your application need to be primarily database resident or work in both database and middle tier?

Is your application data-centric, document- and content-centric, or *integrated* (is both data- and document-centric). "Processing Models" on page 2-5.

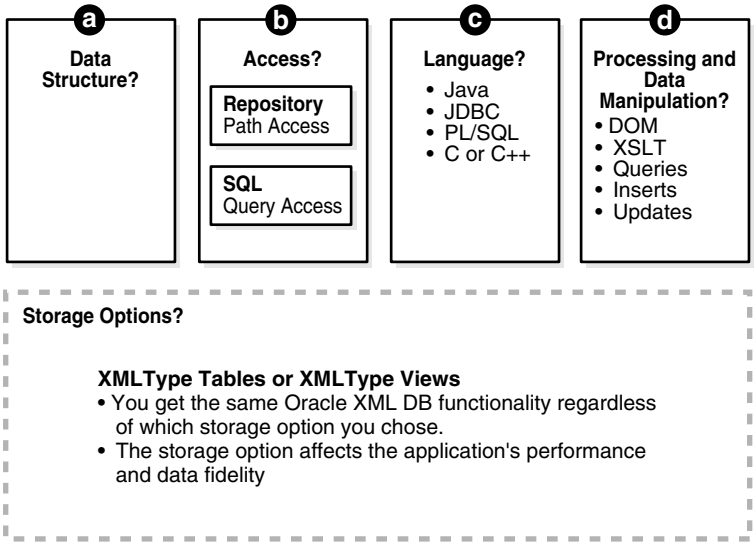
Will you be exchanging XML data with other applications, across gateways? Will you need Advanced Queuing (AQ) or SOAP compliance? See Chapter 37, "Exchanging XML Data with Oracle Streams AQ".

Storage

How and where will you store the data, XML data, XML schema, and so on? See "Storage Models" on page 2-6.

Note: The choices you make for data structure, access, language, and processing are typically interdependent, but they are not dependent on the storage model you choose.

Figure 2–1 Oracle XML DB Design Options



How Structured Is Your Data?

If your XML data is *not* XML schema-based, then, regardless of how structured it is, you can store it in an `XMLType` table or view as binary XML or as a `CLOB` instance, or you can store it as a file in an Oracle XML DB Repository folder.

If your XML data is XML schema-based then you can use unstructured, structured (object-relational), or binary XML storage for its structured parts. For the unstructured parts, you have the same options as for data that is not XML schema-based. See also "Storage Models" on page 2-6.

Access Models

There are two main data access modes to consider when designing your Oracle XML DB applications:

- Navigation-based access or path-based access. This is suitable for both content/document and data oriented applications. Oracle XML DB provides the following languages and access APIs:
  - SQL access through resource and path views. See Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW".
  - PL/SQL access through `DBMS_XDB`. See Chapter 26, "Using PL/SQL to Access the Repository".
  - Protocol-based access using HTTP(S)/WebDAV or FTP, most suited to content-oriented applications. See Chapter 28, "Using Protocols to Access the Repository".
- Query-based access. This can be most suited to data oriented applications. Oracle XML DB provides access using SQL queries through the following APIs:
  - Java access (through JDBC). See Java DOM API for XMLType.
  - PL/SQL access. See Chapter 12, "PL/SQL APIs for XMLType".

These options for accessing Oracle XML DB Repository data are also discussed in Chapter 21, "Accessing Oracle XML DB Repository Data".

You can also consider the following access model criteria:

- What level of security do you need? See Chapter 27, "Repository Resource Security".
- What kind of indexing will best suit your application? Will you need to use Oracle Text indexing and querying? See Chapter 4, "XMLType Operations", Chapter 5, "Indexing XMLType Data", and Chapter 11, "Full-Text Search Over XML Data".
- Do you need to version the data? If yes, see Chapter 24, "Managing Resource Versions".

Application Language

You can program your Oracle XML DB applications in the following languages:

- Java (JDBC, Java Servlets)

  See Also:

  - Chapter 14, "Java DOM API for XMLType"
  - Chapter 32, "Writing Oracle XML DB Applications in Java"

- PL/SQL

  See Also:

  - Chapter 12, "PL/SQL APIs for XMLType"
  - Chapter 26, "Using PL/SQL to Access the Repository"
  - "APIs for XML" on page 1-5

Processing Models

The following processing options are available and should be considered when designing your Oracle XML DB application:

- XSLT. Will you need to transform the XML to HTML, WML, or other languages, and how will your application transform the XML? While storing XML documents in Oracle XML DB you can optionally ensure that their structure complies with (validates against) specific XML schemas. See Chapter 10, "Transforming and Validating XMLType Data".
- DOM fidelity, document fidelity. Use unstructured storage to preserve document fidelity. Use binary XML or structured storage for XML schema-based data to preserve DOM fidelity. See Chapter 12, "PL/SQL APIs for XMLType" and "DOM Fidelity" on page 6-15.
- XPath searching. You can use XPath syntax embedded in a SQL statement or as part of an HTTP(S) request to query XML content in the database. See Chapter 4, "XMLType Operations", Chapter 11, "Full-Text Search Over XML Data", Chapter 21, "Accessing Oracle XML DB Repository Data", and Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW".
- XML Generation and `XMLType` views. Will you need to generate or regenerate XML? If yes, see Chapter 17, "Generating XML Data from the Database".

How often will XML documents be accessed, updated, and manipulated? See Chapter 4, "XMLType Operations" and Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW".

Will you need to update fragments or the whole document? You can use XPath expressions to specify individual elements and attributes of your document during updates, without rewriting the entire document. This is more efficient, especially for large XML documents. Chapter 6, "XML Schema Storage and Query: Basic".

Is your application data-centric, document- and content-centric, or *integrated* (is both data- and document-centric)? See Chapter 3, "Using Oracle XML DB".

Messaging Options

Advanced Queuing (AQ) supports XML and `XMLType` applications. You can create queues with payloads that contain `XMLType` attributes. These can be used for transmitting and storing messages that contain XML documents. By defining Oracle Database objects with `XMLType` attributes, you can do the following:

- Store more than one type of XML document in the same queue. The documents are stored internally as `CLOB` values.
- Selectively dequeue messages with `XMLType` attributes using SQL functions such as `existsNode` and `extract`.
- Define rule-based subscribers that query message content using SQL functions such as `existsNode` and `extract`.
- Define transformations to convert Oracle Database objects to `XMLType`.

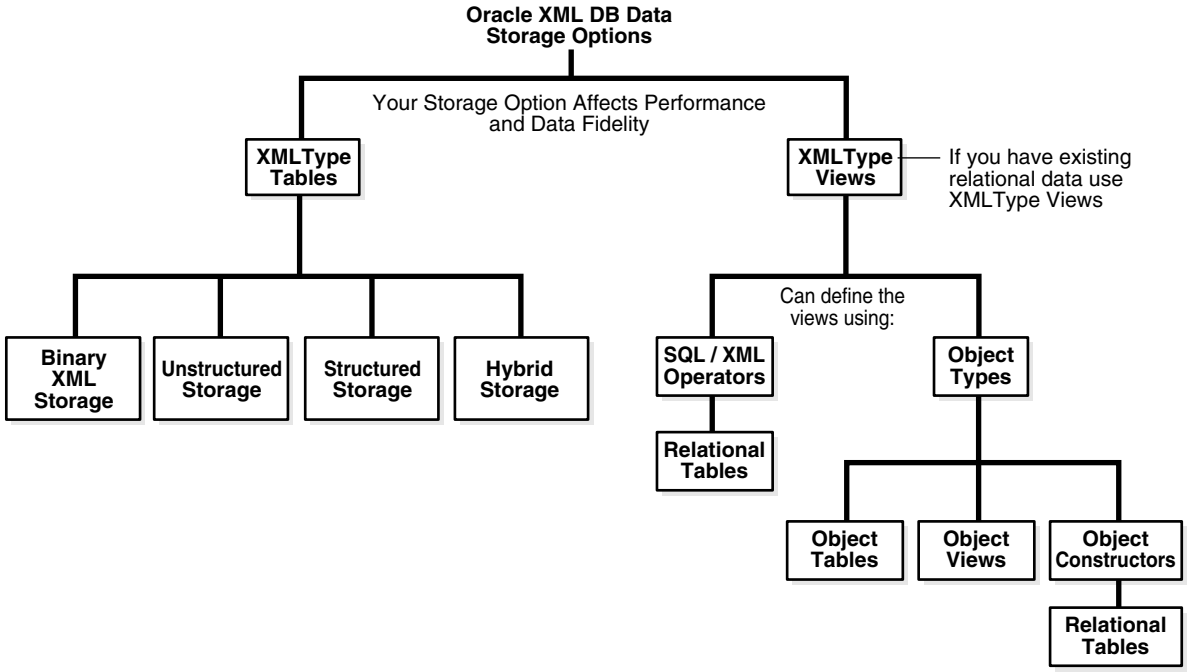
See Also:

- Chapter 37, "Exchanging XML Data with Oracle Streams AQ"
- *Oracle Streams Advanced Queuing User's Guide*

Storage Models

Figure 2–2 shows the Oracle XML DB storage options for `XMLType` tables and views.

Figure 2–2 Oracle XML DB Storage Options for XML Data



If you have existing relational data, you can access it as XML data by creating `XMLType` views over it. You can use the following to define the `XMLType` views:

- SQL/XML functions. See Chapter 17, "Generating XML Data from the Database".
- Object types: object tables, object constructors, and object views.

Regardless of which storage options you choose for your application, Oracle XML DB provides the same functionality. Though the storage model you use can affect your application performance and XML data fidelity, it is totally independent of all of the following:

- How, and how often, you query or update your data.
- How you access your data. This is determined only by your application processing requirements.
- What language(s) your application uses. This is determined only by your application processing requirements.

See Also:

- "XMLType Storage Models" on page 1-15
- "DOM Fidelity" on page 6-15

Oracle XML DB Performance

One objection to using XML to represent data is that it generates higher overhead than other representations. Oracle XML DB incorporates a number of features specifically designed to address this issue by significantly improving the performance of XML processing. These are described in the following sections:

- XML Storage Requirements
- XML Memory Management

XML Storage Requirements

Data represented in XML and stored in a text file averages three times the size of the same data in a Java object or in relational tables. There are two main reasons for this:

- Tag names (metadata describing the data) and white space (formatting characters) take up a significant amount of space in the document, particularly for highly structured, data-centric XML.
- All data in an XML file is represented in human readable (string) format.

Storing Structured Documents in Oracle XML DB Saves Space

The string representation of a numeric value needs about twice as many bytes as the native (binary) representation. When XML documents are stored in Oracle XML DB using structured or binary XML storage, the storage process discards all tags and white space in the document.

The amount of space saved by this optimization depends on the ratio of tag names to data, and the number of collections in the document. For highly-structured, data-centric XML data, the savings can be significant. When a document is printed, or when node-based operations such as XPath evaluation take place, Oracle XML DB uses the information contained in the associated XML schema to dynamically reconstruct any necessary tag information.

XML Memory Management

Document Object Model (DOM) is the dominant programming model for XML documents. DOM APIs are easy to use but the DOM Tree that underpins them is expensive to generate, in terms of memory. A typical DOM implementation maintains approximately 80 to 120 bytes of system overhead for each node in the DOM tree. This means that for highly structured data, the DOM tree can require 10 to 20 times more memory than the document on which it is based.

A conventional DOM implementation requires the entire contents of an XML document to be loaded into the DOM tree before any operations can take place. If an application only needs to process a small percentage of the nodes in the document, this is extremely inefficient in terms of memory and processing overhead. The alternative SAX approach reduces the amount of memory required to process an XML document, but its disadvantage is that it only allows linear processing of nodes in the XML Document.

Oracle XML DB Reduces Memory Overhead for XML Schema-Based Documents by Using XML Objects (XOBs)

Oracle XML DB reduces memory overhead associated with DOM programming by managing XML schema-based XML documents using an internal in-memory structure called an XML Object (XOB). A XOB is much smaller than the equivalent DOM since it does not duplicate information like tag names and node types, that can easily be

obtained from the associated XML schema. Oracle XML DB automatically uses a XOB whenever an application works with the contents of a schema-based `XMLType`. The use of the XOB is transparent to you. It is hidden behind the `XMLType` data type and the C, PL/SQL, and Java APIs.

XOB Uses Lazily-Loaded Virtual DOM

The XOB can also reduce the amount of memory required to work with an XML document using the Lazily-Loaded Virtual DOM feature. This lets Oracle XML DB defer loading in-memory representation of nodes that are part of sub-elements or collection until methods attempt to operate on a node in that object. Consequently, if an application only operates on a few nodes in a document, only those nodes and their immediate siblings are loaded into memory.

The XOB can only used when an XML document is based on an XML schema. If the contents of the XML document are not based on an XML schema, a traditional DOM is used instead of the XOB.

XML Parsing Optimizations

To populate a DOM tree the application must parse the XML document. The process of creating a DOM tree from an XML file is very CPU- intensive. In a typical DOM-based application, where the XML documents are stored as text, every document has to be parsed and loaded into the DOM tree before the application can work with it. If the contents of the DOM tree are updated the entire tree must be serialized back into a text format and written out to disk.

With Oracle XML DB No Re-Parsing is Needed

Oracle XML DB eliminates the need to keep re-parsing documents. No parsing is necessary when an XML document is loaded from disk into memory, if the document is stored as structured or binary XML storage. Oracle XML DB maps directly between the on-disk format and the in-memory format using information derived from the associated XML schema. When changes are made to XML schema-based data, Oracle XML DB is able to write just the updated data back to disk. When XML data is not based on an XML schema, a traditional DOM is used instead.

Node-Searching Optimizations

Most DOM implementations use string comparisons when searching for a particular node in the DOM tree. Even a simple search of a DOM tree can require hundreds or thousands of instruction cycles. Searching for a node in a XOB is much more efficient than searching for a node in a DOM. A XOB is based on a computed offset model, similar to a C/C++ object, and uses dynamic hashtables rather than string comparisons to perform node searches.

XML Schema Optimizations

Making use of the powerful features associated with XML schema in a conventional XML application can generate significant amounts of additional overhead. For example, before an XML document can be validated against an XML schema, the schema itself must be located, parsed, and validated.

Minimizing XML Schema Overhead After a Schema Is Registered

Oracle XML DB minimizes the overhead associated with using XML schema. When an XML schema is registered with the database, it is loaded in the Oracle XML DB schema cache, along with all of the metadata required to map between the XML, XOB and on-

disk representations of the data. This means that once the XML schema has been registered with the database, no additional parsing or validation of the XML schema is required before it can be used. The schema cache is shared by all users of the database. Whenever an Oracle XML DB operation requires information contained in the XML schema, it can access the required information directly from the cache.

Load Balancing Through Cached XML Schema

Some operations, such as performing a full schema validation, or serializing an XML document back into text form, can still require significant memory and CPU resources. Oracle XML DB let these operations be off-loaded to the client or middle tier processor. Oracle Call Interface (OCI) interface and thick Java Database Connectivity (JDBC) driver both allow the XOB to be managed by the client.

The cached representation of the XML schema can also be downloaded to the client. This lets operations such as XML printing, and XML schema validation be performed using client or middle tier resources, rather than server resources.

Reduced Bottlenecks From Code That Is Not Native

Another bottleneck for XML-based Java applications happens when parsing an XML file. Even natively compiled or JIT compiled Java performs XML parsing operations twice as slowly compared to using native C language. One of the major performance bottlenecks in implementing XML applications is the cost of transforming data in an XML document between text, Java, and native server representations. The cost of performing these transformations is proportional to the size and complexity of the XML file and becomes severe even in moderately sized files.

Oracle XML DB Implements Java and PL/SQL APIs Over Native C

Oracle XML DB addresses these issues by implementing all of the Java and PL/SQL interfaces as very thin facades over a native C-language implementation. This provides for language-neutral XML support (Java, C, PL/SQL, and SQL all use the same underlying implementation), as well as the higher performance XML parsing and DOM processing.

Reduced Java Type Conversion Bottlenecks

One of the biggest bottlenecks when using Java and XML is with type conversions. Internally, Java uses UCS-2 to represent character data. Most XML files and databases do not contain UCS-2 encoded data. This means that all data contained in an XML file has to be converted from 8-Bit or UTF-8 encoding to UCS-2 encoding before it can be manipulated in a Java program.

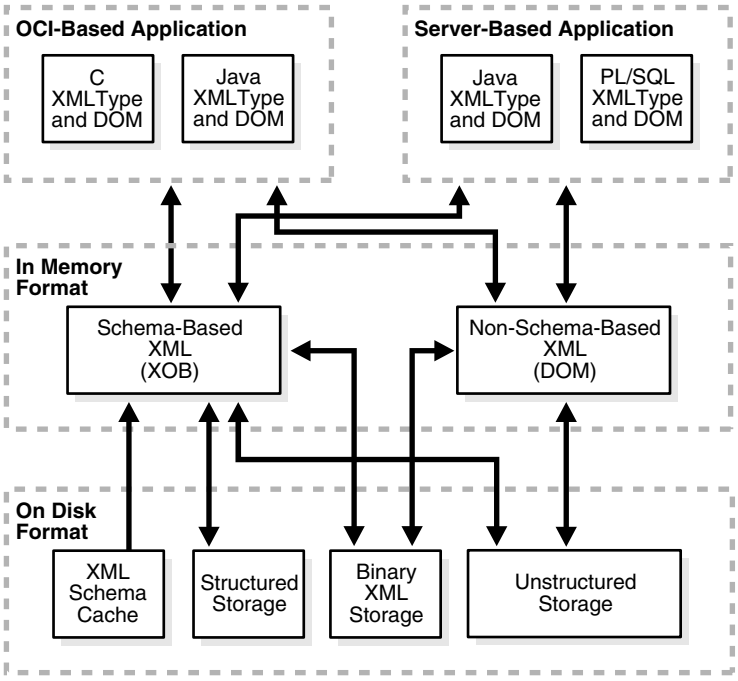
Oracle XML DB Uses Lazy Type Conversion to Avoid Unneeded Type Conversions

Oracle XML DB addresses these problems with lazy type conversions. With lazy type conversions, the content of a node is not converted into the format required by Java until the application attempts to access the contents of the node. Data remains in the internal representation till the last moment. Avoiding unnecessary type conversions can result in significant performance improvements when an application only needs to access a few nodes in an XML document.

Consider a JSP that loads a name from the Oracle Database and prints it out in the generated HTML output. Typical JSP implementations read the name from the database (that probably contains data in the ASCII or ISO8859 character sets), convert the data to UCS-2, and return it to Java as a string. The JSP would not look at the string

content, but only print it out after printing the enclosing HTML, probably converting back to the same ASCII or ISO8859 for the client browser. Oracle XML DB provides a write interface on `XMLType` so that any element can write itself directly to a stream (such as a `ServletOutputStream`) without conversion through Java character sets. Figure 2–3 shows the Oracle XML DB Application Program Interface (API) stack.

Figure 2–3 Oracle XML DB Application Program Interface (API) Stack



3

Using Oracle XML DB

This chapter provides an overview of how to use Oracle XML DB. The examples here illustrate techniques for accessing and managing XML content in purchase orders. The format and data of XML purchase orders are well suited for Oracle XML DB storage and processing techniques because purchase orders are highly structured XML documents. However, the majority of techniques introduced here can also be used to manage other types of XML documents, such as those containing unstructured or semi-structured data. This chapter also further explains Oracle XML DB concepts introduced in Chapter 1, "Introduction to Oracle XML DB".

This chapter contains these topics:

Storing XML as XMLType

Before the introduction of Oracle XML DB, there were two ways to store XML content in Oracle Database:

- Use Oracle XML Developer's Kit (XDK) to parse the XML document outside Oracle Database, and store the extracted XML data as rows in one or more tables in the database.
- Store the XML document in Oracle Database using a Character Large Object (`CLOB`), Binary Large Object (`BLOB`), Binary File (`BFILE`), or `VARCHAR` column.

In both cases, Oracle Database is unaware that it is managing XML content.

The introduction of Oracle XML DB and the `XMLType` data type provides new techniques that facilitate the persistence of XML content in the database. These techniques include the ability to store XML documents in an `XMLType` column or table, or in Oracle XML DB Repository. Storing XML as an `XMLType` column or table makes Oracle Database aware that the content is XML. This lets the database:

- Perform XML-specific validations, operations, and optimizations on the XML content
- Facilitate highly efficient processing of XML content by Oracle XML DB

What is XMLType?

Oracle9*i* release 1 (9.0.1) introduced a new data type, `XMLType`, to facilitate native handling of XML data in the database:

- `XMLType` can represent an XML document in the database, so it is accessible in SQL.
- `XMLType` has built-in methods that operate on XML content. For example, you can use `XMLType` methods to create, extract, and index XML data stored in Oracle Database.
- `XMLType` functionality is also available through a set of Application Program Interfaces (APIs) provided in PL/SQL and Java.
- `XMLType` can be used in PL/SQL stored procedures for parameters, return values, and variables.

With `XMLType`, SQL developers can leverage the power of the relational database while working in the context of XML. XML developers can leverage the power of XML standards while working in the context of a relational database.

`XMLType` can be used as the data type of columns in tables and views. `XMLType` variables can be used in PL/SQL stored procedures as parameters and return values. You can also use `XMLType` in SQL, PL/SQL, C, Java (through JDBC), and Oracle Data Provider for .NET (ODP.NET).

The `XMLType` API provides a number of useful methods that operate on XML content. For example, method `extract()` extracts one or more nodes from an `XMLType` instance. Many of these `XMLType` methods are also provided as SQL functions. For example, SQL function `extract` corresponds to `XMLType` method `extract()`.

Oracle XML DB functionality is based on the Oracle XML Developer's Kit C implementations of the relevant XML standards such as XML Parser, XML DOM, and XML Schema Validator.

See Also:

- "XMLType Data Type" on page 1-13
- "XMLType Storage Models" on page 1-15 for the available `XMLType` storage options and their relative advantages

Benefits of XMLType Data Type and API

The `XMLType` data type and application programming interface (API) enable SQL operations on XML content and XML operations on SQL content:

- Versatile API – `XMLType` has a versatile API for application development that includes built-in functions, indexing, and navigation support.
- `XMLType` and SQL – You can use `XMLType` in SQL statements, combined with other data types. For example, you can query `XMLType` columns and join the result of the extraction with a relational column. Oracle Database determines an optimal way to run such queries.
- Indexing – You can created several kinds of indexes to improve the performance of queries on XML data.
  - For structured storage of `XMLType` data, you can create B-tree indexes on the object-relational tables that underlie `XMLType` tables and columns.
  - For unstructured and binary XML storage of `XMLType` data, you can create an `XMLIndex` index, which specifically targets the XML structure of a document.
  - You can create function-based indexes on explicit XPath expressions. This applies to all `XMLType` storage models.
  - You can index the textual content of XML data with an Oracle Text `CONTEXT` index, for use in full-text search. This applies to all `XMLType` storage models.

When to Use XMLType

Use `XMLType` whenever you want to use the database as a persistent storage of XML data. `XMLType` features include the following:

- *SQL queries on part of or the whole XML document* – SQL functions `existsNode` and `extract` provide the necessary SQL query functions over XML documents.
- *XPath access using SQL functions* `existsNode` *and* `extract` – `XMLType` uses the built-in C XML parser and processor and hence provides better performance and scalability when used inside the server.
- *Strong typing inside SQL statements and PL/SQL functions* – The strong typing offered by `XMLType` ensures that the values passed in are XML values and not any arbitrary text string.
- *Indexing on XPath document queries* – `XMLType` has methods that you can use to create function-based indexes that optimize searches.
- *Separation of applications from storage models* – Using `XMLType` instead of directly using `CLOB`, object-relational, or binary XML storage lets applications gracefully move to various storage alternatives later without affecting any of the query or DML statements in the application.
- *Support for future optimizations* – New XML functionality will support `XMLType`. Because Oracle Database is natively aware that `XMLType` can store XML data, better optimizations and indexing techniques can be done. By writing applications

to use XMLType, these optimizations and enhancements can be easily achieved and preserved in future releases without your needing to rewrite applications.

Creating XMLType Tables and Columns

The following examples create XMLType columns and tables for managing XML content in Oracle Database.

Example 3–1 Creating a Table with an XMLType Column

```
CREATE TABLE mytable1 (key_column VARCHAR2(10) PRIMARY KEY, xml_column XMLType);

Table created.
```

Example 3–2 Creating a Table of XMLType

```
CREATE TABLE mytable2 OF XMLType;

Table created.
```

Using Virtual Columns to Constrain Data Stored as Binary XML

XML data has its own structure, which, except for object-relational storage of XMLType, is not reflected directly in database structure. That is, individual XML elements and attributes are not mapped to individual database columns or tables.

This means that, to constrain XML data according to the values of individual elements or attributes, the standard approach for relational data does not apply. Instead, you must create *virtual columns* that represent the XML data of interest, and then use those virtual columns to define the constraints that you need.

This approach applies only to XML data that is stored as binary XML. For XML data that uses unstructured storage, the database has no knowledge of the XML structure—the data is treated as flat text, but for binary XML storage that structure is known. You exploit this structural knowledge to create virtual columns, which the database can then use with constraints.

The technique is as follows:

1. Define virtual columns that correspond to the XML data that you are interested in.
2. Use those columns to constrain the XMLType data as a whole.

You create virtual columns on XMLType data as you would create virtual columns using any other type of data, but using a slightly different syntax. In particular, you cannot specify any constraints in association with the column definition.

Because XMLType is an abstract data type, if you create virtual columns on an XMLType table, those columns are *hidden*; they do not show up in DESCRIBE statements and so on. This enables tools that use operations such as DESCRIBE to function normally and not be misled by the virtual columns. If you create virtual columns on a table that has an XMLType *column*, the virtual columns will be listed by a DESCRIBE operation, along with all of the non-virtual columns.

You create a virtual column based on an XML element or attribute by defining it in terms of a SQL expression that involves that element or attribute; that is, you create a function-based column. You can use SQL function extractValue as the function.

See Also:

- "Using SQL Constraints to Enforce Referential Integrity" on page 3-33
- *Oracle Database SQL Language Reference* for information about creating tables with virtual columns

Loading XML Content into Oracle XML DB

You can load XML content into Oracle XML DB using these techniques:

- Table-based loading:
  - Loading XML Content Using SQL or PL/SQL
  - Loading XML Content Using Java
  - Loading XML Content Using C
  - Loading Large XML Files That Contain Small XML Documents
  - Loading Large XML Files Using SQL*Loader
- Path-based repository loading techniques:
  - Loading XML Documents into the Repository Using DBMS_XDB
  - Loading Documents into the Repository Using Protocols

Loading XML Content Using SQL or PL/SQL

You can use a simple `INSERT` operation in SQL or PL/SQL to load an XML document into the database. Before the document can be stored as an `XMLType` column or table, it must be converted into an `XMLType` instance using one of the `XMLType` constructors.

See Also:

- Chapter 4, "XMLType Operations"
- "APIs for XML" on page 1-5
- *Oracle Database PL/SQL Packages and Types Reference* for a description of the `XMLType` constructors

`XMLType` **constructors** allow an `XMLType` instance to be created from different sources, including `VARCHAR`, `CLOB`, and `BFILE` values. The constructors accept additional arguments that reduce the amount of processing associated with `XMLType` creation. For example, if you are sure that a given source XML document is valid, you can provide an argument to the constructor that disables the type-checking that is otherwise performed.

In addition, if the source data is not encoded in the database character set, an `XMLType` instance can be constructed using a `BFILE` or `BLOB` value. The encoding of the source data is specified through the character set id (`csid`) argument of the constructor.

Create a SQL Directory That Points to the Needed Directory

Example 3–3 shows how to insert XML content into an `XMLType` table. Before making this insertion, you must create a SQL directory object that points to the directory

containing the file to be processed. To do this, you must have the `CREATE ANY DIRECTORY` privilege.

> **See Also:** *Oracle Database SQL Language Reference*, Chapter 18, under `GRANT`

```
CREATE DIRECTORY xmldir AS path_to_folder_containing_XML_file;
```

Example 3–3 Inserting XML Content into an XMLType Table

```
INSERT INTO mytable2 VALUES (XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
                                     nls_charset_id('AL32UTF8')));

1 row created.
```

The value passed to `nls_charset_id()` indicates that the encoding for the file to be read is UTF-8.

Loading XML Content Using Java

Example 3–4 Inserting XML Content into an XML Type Table Using Java

This example shows how to load XML content into Oracle XML DB by first creating an `XMLType` instance in Java, given a Document Object Model (DOM).

```
public void doInsert(Connection conn, Document doc)
throws Exception
{
   String SQLTEXT = "INSERT INTO purchaseorder VALUES (?)";
   XMLType xml = null;
   xml = XMLType.createXML(conn,doc);
   OraclePreparedStatement sqlStatement = null;
   sqlStatement = (OraclePreparedStatement) conn.prepareStatement(SQLTEXT);
   sqlStatement.setObject(1,xml);
   sqlStatement.execute();
}

1 row selected.
```

The "Simple Bulk Loader Application" available on the Oracle Technology Network (OTN) site at `http://www.oracle.com/technology/sample_code/tech/xml/xmldb/content.html` demonstrates how to load a directory of XML files into Oracle XML DB using Java Database Connectivity (JDBC). JDBC is a set of Java interfaces to Oracle Database.

Loading XML Content Using C

Example 3–5 shows, in C, how to insert XML content into an `XMLType` table by creating an `XMLType` instance given a DOM.

Example 3–5 Inserting XML Content into an XMLType Table Using C

```
#include "stdio.h"
#include <xml.h>
#include <stdlib.h>
#include <string.h>
#include <ocixmldb.h>
OCIEnv *envhp;
```

```
OCIError *errhp;
OCISvcCtx *svchp;
OCIStmt *stmthp;
OCIServer *srvhp;
OCIDuration dur;
OCISession *sesshp;
oratext *username = "QUINE";
oratext *password = "CURRY";
oratext *filename = "AMCEWEN-20021009123336171PDT.xml";
oratext *schemaloc = "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd";

/*---------------------------------------------------------*/
/* Execute a SQL statement that binds XML data             */
/*---------------------------------------------------------*/

sword exec_bind_xml(OCISvcCtx *svchp, OCIError *errhp, OCIStmt *stmthp,
                    void *xml,        OCIType *xmltdo, OraText *sqlstmt)
{
  OCIBind *bndhp1 = (OCIBind *) 0;
  sword  status = 0;
  OCIInd ind = OCI_IND_NOTNULL;
  OCIInd *indp = &ind;
  if(status = OCIStmtPrepare(stmthp, errhp, (OraText *)sqlstmt,
                             (ub4)strlen((const char *)sqlstmt),
                             (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindByPos(stmthp, &bndhp1, errhp, (ub4) 1, (dvoid *) 0,
                           (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                           (ub2 *)0, (ub4) 0, (ub4 *) 0, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindObject(bndhp1, errhp, (CONST OCIType *) xmltdo,
                            (dvoid **) &xml, (ub4 *) 0,
                            (dvoid **) &indp, (ub4 *) 0))
    return OCI_ERROR;
  if(status = OCIStmtExecute(svchp, stmthp, errhp, (ub4) 1, (ub4) 0,
                             (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                             (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  return OCI_SUCCESS;
}

/*---------------------------------------------------------*/
/* Initialize OCI handles, and connect                     */
/*---------------------------------------------------------*/

sword init_oci_connect()
{
. . .
}

/*---------------------------------------------------------*/
/* Free OCI handles, and disconnect                        */
/*---------------------------------------------------------*/

void free_oci()
{
. . .
}

void main()
{
  OCIType *xmltdo;
  xmldocnode  *doc;
  ocixmldbparam params[1];
  xmlerr       err;
  xmlctx  *xctx;
```

```
  oratext *ins_stmt;
  sword    status;
  xmlnode *root;
  oratext buf[10000];

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_connect();

  /* Get an XML context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, 1);
  if (!(doc = XmlLoadDom(xctx, &err, "file", filename,
                         "schema_location", schemaloc, NULL)))
    {
      printf("Parse failed.\n");
      return;
    }
  else
    printf("Parse succeeded.\n");
  root = XmlDomGetDocElem(xctx, doc);
  printf("The xml document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "buffer", buf, "buffer_length", 10000, NULL);
  printf("%s\n", buf);

  /* Insert the document into my_table */
  ins_stmt = (oratext *)"insert into purchaseorder values (:1)";
  status = OCITypeByName(envhp, errhp, svchp, (const text *) "SYS",
                         (ub4) strlen((const char *)"SYS"), (const text *) "XMLTYPE",
                         (ub4) strlen((const char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  if (status == OCI_SUCCESS)
    {
      status = exec_bind_xml(svchp, errhp, stmthp, (void *)doc,
                             xmltdo, ins_stmt);
    }
  if (status == OCI_SUCCESS)
    printf ("Insert successful\n");
  else
    printf ("Insert failed\n");

  /* Free XML instances */
  if (doc)
    XmlFreeDocument((xmlctx *)xctx, (xmldocnode *)doc);
  /* Free XML CTX */
  OCIXmlDbFreeXmlCtx(xctx);
  free_oci();
}
```

See Also: Appendix A, "Oracle-Supplied XML Schemas and Examples" for a complete listing of this example

Loading Large XML Files That Contain Small XML Documents

When loading large XML files consisting of a collection of smaller XML documents, it is often more efficient to use Simple API for XML (SAX) parsing to break the file into a set of smaller documents, and then insert those documents. SAX is an XML standard interface provided by XML parsers for event-based applications.

You can use SAX to load a database table from very large XML files in the order of 30 MB or larger, by creating individual documents from a collection of nodes. You can also bulk load XML files.

See Also: http://www.oracle.com/technology/sample_code/tech/xml/xmldb/content.html, "SAX Loader Application" for an example of how to do this

Loading Large XML Files Using SQL*Loader

Use SQL*Loader to load large amounts of XML data into Oracle Database. SQL*Loader loads in one of two modes, conventional or direct path. Table 3–1 compares these modes.

Table 3–1 SQL*Loader – Conventional and Direct-Path Load Modes

Conventional Load Mode	Direct-Path Load Mode
Uses SQL to load data into Oracle Database. This is the *default* mode.	Bypasses SQL and streams the data directly into Oracle Database.
Advantage: Follows SQL semantics. For example triggers are fired and constraints are checked.	*Advantage:* This loads data much faster than the conventional load mode.
Disadvantage: This loads data slower than with the direct load mode.	*Disadvantage:* SQL semantics are not obeyed. For example triggers are not fired and constraints are not checked.

When loading LOBs with SQL*Loader direct-path load, much memory can be used. If the message `SQL*Loader 700 (out of memory)` appears, then it is likely that more rows are being batched in each load call than can be handled by your operating system and process memory. *Workaround:* use the `ROWS` option to read a smaller number of rows in each data save.

See Also:

- Chapter 35, "Loading XML Data Using SQL*Loader"
- Example 35–1, "Loading Very Large XML Documents Into Oracle Database Using SQL*Loader" on page 35-4 for an example of direct loading of XML data.

Loading XML Documents into the Repository Using DBMS_XDB

You can also store XML documents in Oracle XML DB Repository, and access these documents using path-based rather than table-based techniques. To load an XML document into the repository under a given path, use PL/SQL package `DBMS_XDB`. This is illustrated by the following example.

Example 3–6 Inserting XML Content into the Repository Using PL/SQL DBMS_XDB

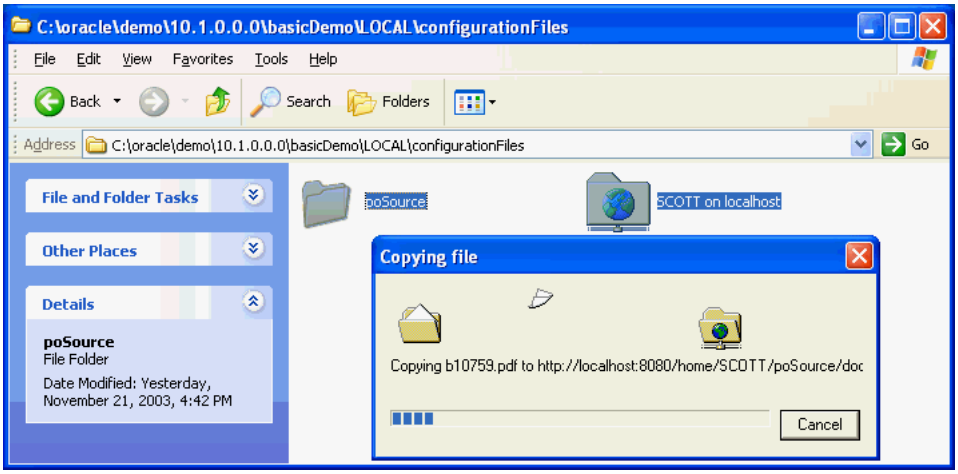
```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB.createResource('/home/QUINE/purchaseOrder.xml',
                                 bfilename('XMLDIR', 'purchaseOrder.xml'),
                                 nls_charset_id('AL32UTF8'));
END;
/
```

Many operations for configuring and using Oracle XML DB are based on processing one or more XML documents. Examples include registering an XML schema and performing an XSL transformation. The easiest way to make these XML documents available to Oracle Database is to load them into Oracle XML DB Repository.

Loading Documents into the Repository Using Protocols

You can load XML documents from a local file system into Oracle XML DB Repository using protocols such as WebDAV, from Windows Explorer or other tools that support WebDAV. Figure 3–1 shows a simple drag and drop operation for copying the contents of the `SCOTT` folder from the local hard drive to the `poSource` folder in the Oracle XML DB Repository.

Figure 3–1 Using Windows Explorer to Load Content into the Repository



The copied folder might contain, for example, an XML schema document, an HTML page, and some XSLT style sheets.

Note: Oracle XML DB Repository can also store content that is not XML data, such as HTML files, JPEG images, word documents, as well as XML documents (schema-based and non-schema-based).

Character Sets of XML Documents

This section describes how character sets of XML documents are determined.

Caution: *AL32UTF8* is the Oracle Database character set that is appropriate for `XMLType` data. It is equivalent to the IANA registered standard UTF-8 encoding, which supports all valid XML characters.

Do not confuse Oracle Database database character set UTF8 (no hyphen) with database character set AL32UTF8 or with character *encoding* UTF-8. Database character set UTF8 has been *superseded* by AL32UTF8. Do *not* use UTF8 for XML data. UTF8 supports only Unicode version 3.1 and earlier; it does not support all valid XML characters. AL32UTF8 has no such limitation.

Using database character set UTF8 for XML data could potentially *stop a system or affect security negatively*. If a character that is not supported by the database character set appears in an input-document element name, a replacement character (usually "`?`") will be substituted for it. This will terminate parsing and raise an exception. It could cause a fatal error.

XML Encoding Declaration

Each XML document is composed of units called entities. Each entity in an XML document may use a different encoding for its characters. Entities that are stored in an encoding other than UTF-8 or UTF-16 must begin with a declaration containing an encoding specification indicating the character encoding in use. For example:

```
<?xml version='1.0' encoding='EUC-JP' ?>
```

Entities encoded in UTF-16 must begin with the Byte Order Mark (BOM), as described in Appendix F of the XML 1.0 Reference. For example, on big-endian platforms, the BOM required of a UTF-16 data stream is `#xFEFF`.

In the absence of both the encoding declaration and the BOM, the XML entity is assumed to be encoded in UTF-8. Because ASCII is a subset of UTF-8, ASCII entities do not require an encoding declaration.

In many cases, external sources of information are available, besides the XML data, to provide the character encoding in use. For example, the encoding of the data can be obtained from the `charset` parameter of the `Content-Type` field in an HTTP(S) request as follows:

```
Content-Type: text/xml; charset=ISO-8859-4
```

Character-Set Determination When Loading XML Documents into the Database

In releases prior to Oracle Database 10*g* release 1, all XML documents were assumed to be in the *database* character set, regardless of the document encoding declaration. With Oracle Database 10*g* release 1, the document encoding is detected from the encoding declaration when the document is loaded into the database.

However, if the XML data is obtained from a `CLOB` or `VARCHAR` value, then the encoding declaration is *ignored*, because these two data types are always encoded in the database character set.

In addition, when loading data into Oracle XML DB, either through programmatic APIs or transfer protocols, you can provide external encoding to override the document encoding declaration. An error is raised if you try to load a schema-based XML document that contains characters that are not legal in the determined encoding.

The following examples show different ways to specify external encoding:

- Using PL/SQL function `DBMS_XDB.createResource` to create a file resource from a `BFILE`, you can specify the file encoding with the *`CSID`* argument. If a zero *`CSID`* is specified then the file encoding is auto-detected from the document encoding declaration.

  ```
  CREATE DIRECTORY xmldir AS '/private/xmldir';
  CREATE OR REPLACE PROCEDURE loadXML(filename VARCHAR2, file_csid NUMBER) IS
     xbfile  BFILE;
     RET     BOOLEAN;
  BEGIN
     xbfile := bfilename('XMLDIR', filename);
     ret := DBMS_XDB.createResource('/public/mypurchaseorder.xml',
                                    xbfile,
                                    file_csid);
  END;
  /
  ```

- Use the FTP protocol to load documents into Oracle XML DB. Use the `quote set_charset` FTP command to indicate the encoding of the files to be loaded.

```
FTP> quote set_charset Shift_JIS
FTP> put mypurchaseorder.xml
```

- Use the HTTP(S) protocol to load documents into Oracle XML DB. Specify the encoding of the data to be transmitted to Oracle XML DB in the request header.

  ```
  Content-Type: text/xml; charset= EUC-JP
  ```

Character-Set Determination When Retrieving XML Documents from the Database

XML documents stored in Oracle XML DB can be retrieved using a SQL client, programmatic APIs, or transfer protocols. You can specify the encoding of the retrieved data (except in Oracle Database releases prior to 10*g*, where XML data is retrieved only in the database character set).

When XML data is stored as a `CLOB` or `VARCHAR2` value, the encoding declaration, if present, is always ignored for retrieval, just as for storage. This means that the encoding of a retrieved document can be different from the encoding explicitly declared in that document.

The character set for an XML document retrieved from the database is determined in the following ways:

- SQL client – If a SQL client (such as SQL*Plus) is used to retrieve XML data, then the character set is determined by the client-side environment variable `NLS_LANG`. In particular, this setting overrides any explicit character-set declarations in the XML data itself.

  For example, if you set the client side `NLS_LANG` variable to `AMERICAN_AMERICA.AL32UTF8` and then retrieve an XML document with encoding `EUC_JP` provided by declaration `<?xml version="1.0" encoding="EUC-JP"?>`, the character set of the retrieved document is `AL32UTF8`, *not* `EUC_JP`.

  > **See Also:** *Oracle Database Globalization Support Guide* for information about `NLS_LANG`

- PL/SQL and APIs – Using PL/SQL or programmatic APIs, you can retrieve XML data into `VARCHAR`, `CLOB`, or `XMLType` data types. As for SQL clients, you can control the encoding of the retrieved data by setting `NLS_LANG`.

  You can also retrieve XML data into a `BLOB` value using `XMLType` and `URIType` methods. These methods let you specify the character set of the returned `BLOB` value. Here is an example:

  ```
  CREATE OR REPLACE FUNCTION getXML(pathname VARCHAR2, charset VARCHAR2)
                      RETURN BLOB IS
      xblob  BLOB;
  BEGIN
      SELECT e.RES.getBLOBVal(nls_charset_id(charset)) INTO xblob
        FROM RESOURCE_VIEW e WHERE equals_path(e.RES, pathname) = 1;
     RETURN xblob;
  END;
  /
  ```

- FTP – You can use the FTP `quote set_nls_locale` command to set the character set:

  ```
  FTP> quote set_nls_locale EUC-JP
  FTP> get mypurchaseorder.xml
  ```

See Also: FTP Quote Methods on page 28-10

- HTTP(S) – You can use the `Accept-Charset` parameter in an HTTP(S) request:

```
/httptest/mypurchaseorder.xml  1.1 HTTP/Host: localhost:2345
Accept: text/*
Accept-Charset:  iso-8859-1, utf-8
```

See Also: Controlling Character Sets for HTTP(S) on page 28-18

Overview of the W3C XML Schema Recommendation

The W3C XML Schema Recommendation defines a standardized language for specifying the structure, content, and certain semantics of a set of XML documents. An XML schema can be considered the metadata that describes a class of XML documents. The XML Schema Recommendation is described at:
http://www.w3.org/TR/xmlschema-0/

XML Instance Documents

Documents conforming to a given XML schema can be considered as members or instances of the class defined by that XML schema. Consequently the term *instance document* is often used to describe an XML document that conforms to a given XML schema. The most common use of an XML schema is to validate that a given instance document conforms to the rules defined by the XML schema.

XML Schema for Schemas

The W3C Schema working group publishes an XML schema, often referred to as the "Schema for Schemas". This XML schema provides the definition, or vocabulary, of the XML Schema language. All valid XML schemas can be considered as members of the class defined by this XML schema. This means that an XML schema is an XML document that conforms to the class defined by the XML schema published at http://www.w3.org/2001/XMLSchema.

Editing XML Schemas

XML schemas can be authored and edited using any of the following:

- A simple text editor, such as emacs or vi
- An XML schema-aware editor, such as the XML editor included with Oracle JDeveloper
- An explicit XML schema-authoring tool, such as XMLSpy from Altova Corporation

XML Schema Features

The XML Schema language defines 47 scalar data types. This provides for strong typing of elements and attributes. The W3C XML Schema Recommendation also supports object-oriented techniques such as inheritance and extension, hence you can design XML schema with complex objects from base data types defined by the XML Schema language. The vocabulary includes constructs for defining and ordering, default values, mandatory content, nesting, repeated sets, and redefines. Oracle XML DB supports all the constructs, except for redefines.

Text Representation of the PurchaseOrder XML Schema

The following example `purchaseOrder.xsd`, is an XML schema example fragment, in its native form, as an XML Document:

Example 3–7 Purchase-Order XML Schema, purchaseOrder.xsd

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" version="1.0">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType"/>
  <xs:complexType name="PurchaseOrderType">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType"/>
      <xs:element name="Actions" type="ActionsType"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0"/>
      <xs:element name="Requestor" type="RequestorType"/>
      <xs:element name="User" type="UserType"/>
      <xs:element name="CostCenter" type="CostCenterType"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"/>
      <xs:element name="LineItems" type="LineItemsType"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"/>
      <xs:element name="Part" type="PartType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer"/>
  </xs:complexType>
  <xs:complexType name="PartType">
    <xs:attribute name="Id">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
    <xs:attribute name="Quantity" type="moneyType"/>
    <xs:attribute name="UnitPrice" type="quantityType"/>
  </xs:complexType>
  <xs:simpleType name="ReferenceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="18"/>
      <xs:maxLength value="30"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="ActionsType">
    <xs:sequence>
      <xs:element name="Action" maxOccurs="4">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="User" type="UserType"/>
            <xs:element name="Date" type="DateType" minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
```

```
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0"/>
    <xs:element name="Date" type="DateType" minOccurs="0"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0"/>
    <xs:element name="address" type="AddressType" minOccurs="0"/>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="4"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="VendorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PurchaseOrderNumberType">
  <xs:restriction base="xs:integer"/>
</xs:simpleType>
<xs:simpleType name="SpecialInstructionsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="2048"/>
```

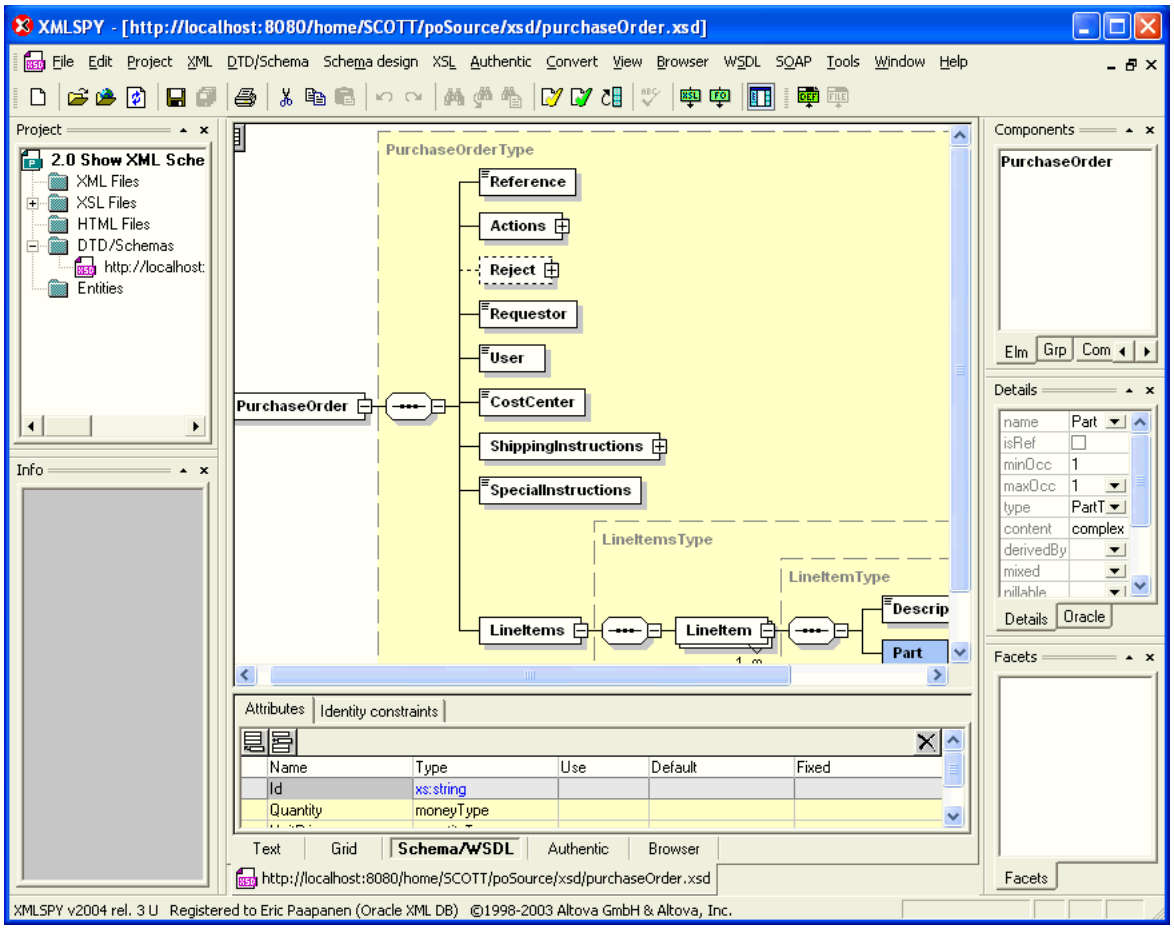
```
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NameType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="AddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="TelephoneType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="24"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DateType">
    <xs:restriction base="xs:date"/>
  </xs:simpleType>
  <xs:simpleType name="CommentsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

See Also: Example 3–8, "Annotated Purchase-Order XML Schema, purchaseOrder.xsd" on page 3-20

Graphical Representation of the Purchase-Order XML Schema

Figure 3–2 shows the purchase-order XML schema displayed using XMLSpy. XMLSpy is a graphical and user-friendly tool from Altova Corporation for creating and editing XML schema and XML documents. See `http://www.altova.com` for details. XMLSpy also supports WebDAV and FTP protocols hence can directly access and edit content stored in Oracle XML DB Repository.

Figure 3–2 XMLSpy Graphical Representation of the PurchaseOrder XML Schema



The PurchaseOrder XML schema is a simple XML schema that demonstrates key features of a typical XML document:

- Global element `PurchaseOrder` is an instance of the `complexType` `PurchaseOrderType`
- `PurchaseOrderType` defines the set of nodes that make up a `PurchaseOrder` element
- `LineItems` element consists of a collection of `LineItem` elements
- Each `LineItem` element consists of two elements: `Description` and `Part`
- `Part` element has attributes `Id`, `Quantity`, and `UnitPrice`

Using XML Schema with Oracle XML DB

This section describes the use of XML Schema with Oracle XML DB.

Why Use XML Schema With Oracle XML DB?

The following paragraphs describe the main reasons for using XML schema with Oracle XML DB.

Validating Instance Documents with XML Schema

The most common usage of XML Schema is as a mechanism for validating that instance documents conform to a given XML schema. The `XMLType` data type methods `isSchemaValid()` and `schemaValidate()` allow Oracle XML DB to validate the contents of an instance document stored in an `XMLType`, against an XML schema.

Constraining Instance Documents for Business Rules or Format Compliance

An XML schema can also be used as a constraint when creating tables or columns of `XMLType`. For example, the `XMLType` is constrained to storing XML documents compliant with one of the global elements defined by the XML schema.

Defining How XMLType Contents Must be Stored in the Database

Oracle XML DB also uses XML Schema as a mechanism for defining how the contents of an `XMLType` instance should be stored inside the database. All storage models support the use of XML Schema: binary XML, structured, unstructured, and hybrid (a combination of structured and unstructured). See "XMLType Storage Models" on page 1-15 for information on the available storage models for `XMLType`.

Structured Storage of XML Documents

Structured storage of XML documents is based on decomposing the content of the document into a set of SQL objects. These SQL objects are based on the SQL 1999 Type framework. When an XML schema is registered with Oracle XML DB, the required SQL type definitions are automatically generated from the XML schema.

A SQL type definition is generated from each `complexType` defined by the XML schema. Each element or attribute defined by the `complexType` becomes a SQL attribute in the corresponding SQL type. Oracle XML DB automatically maps the 47 scalar data types defined by the XML Schema Recommendation to the 19 scalar data types supported by SQL. A varray type is generated for each element and this can occur multiple times.

The generated SQL types allow XML content, compliant with the XML schema, to be decomposed and stored in the database as a set of objects without any loss of information. When the document is ingested the constructs defined by the XML schema are mapped directly to the equivalent SQL types.

This lets Oracle XML DB leverage the full power of Oracle Database when managing XML and can lead to significant reductions in the amount of space required to store the document. It can also reduce the amount of memory required to query and update XML content.

Annotating an XML Schema to Control Naming, Mapping, and Storage

The W3C XML Schema Recommendation defines an annotation mechanism that lets vendor-specific information be added to an XML schema. Oracle XML DB uses this mechanism to control the mapping between the XML schema and database features.

You can use XML schema annotations to do the following:

- Specify which database tables are used to store the XML data.
- Override the default mapping between XML Schema data types and either binary XML encoding types or, for structured storage, SQL data types.

- Name the database objects and attributes that are created to store XML data (for structured storage).

Controlling How Collections are Stored for Object-Relational XMLType Storage

When you register an XML schema for data that is stored object-relationally and you set registration parameter `GENTABLES` to `TRUE`, default tables are created automatically to store the associated XML instance documents.

Order is preserved among XML collection elements when they are stored. The result is an **ordered collection**.[1] You can store data in an ordered collection in these ways:

- **Varray in a table**. Each element in the collection is mapped to a SQL object. The collection of SQL objects is stored as a set of rows in a table, called an **ordered collection table** (**OCT**). By default, all collections are stored in OCTs; this corresponds to the XML schema annotation `xdb:storeVarrayAsTable = "true"` (default value).
- **Varray in a LOB**. Each element in the collection is mapped to a SQL object. The entire collection of SQL objects is serialized as a varray and stored in a LOB column. To store a given collection as a varray in a LOB, use XML schema annotation `xdb:storeVarrayAsTable = "false"`.

You can also use out-of-line storage for an ordered collection. This corresponds to XML schema annotation `SQLInline = "false"`, and it means that a varray of `REF`s in the collection table or LOB tracks the collection content, which is stored out of line.

There is no requirement to annotate an XML schema before using it. Oracle XML DB uses a set of default assumptions when processing an XML schema that contains no annotations.

If you do not supply any of the annotations mentioned in this section, then Oracle XML DB stores a collection as a heap-based OCT. You can force OCTs to be stored as **index-organized tables** (**IOTs**) instead, by passing **`REGISTER_NT_AS_IOT`** in the `OPTIONS` parameter of `DBMS_XMLSCHEMA.registerschema`.

Note: Oracle recommends that you use heap-based OCTs, not IOTs. Oracle Text does not support IOTs.

See also: Chapter 11, "Full-Text Search Over XML Data" for information about using Oracle Text with XML data.

Note: In releases prior to Oracle Database 11g Release 1:

- The default value for `xdb:storeVarrayAsTable` was `false`.
- OCTs were stored as IOTs by default.

---

[1] If you use XML schema annotation `maintainOrder = "false"`, then an unordered collection is used, instead of an ordered collection. Oracle recommends that you use ordered collections (`maintainOrder="true"`) for XML data.

See Also:

- Chapter 6, "XML Schema Storage and Query: Basic"
- "Setting Attribute SQLInline to false for Out-Of-Line Storage" on page 8-4

Declaring the Oracle XML DB Namespace

Before annotating an XML schema you must first declare the Oracle XML DB namespace. The Oracle XML DB namespace is defined as:

```
http://xmlns.oracle.com/xdb
```

The namespace is declared in the XML schema by adding a namespace declaration such as the following to the root element of the XML schema:

```
xmlns:xdb="http://xmlns.oracle.com/xdb"
```

Note the use of a namespace prefix (`xdb`). This makes it possible to abbreviate the namespace to `xdb` when adding annotations.

Example 3–8 shows the beginning of the `PurchaseOrder` XML schema with annotations. See Example A–1 on page A-27 for the complete schema listing.

Example 3–8 Annotated Purchase-Order XML Schema, purchaseOrder.xsd

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0"
           xdb:storeVarrayAsTable="true">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType" xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType" minOccurs="1" xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" minOccurs="1" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                  xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"
                  xdb:SQLName="DESCRIPTION"/>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                  xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
      <xs:simpleType>
        <xs:restriction base="xs:string">
```

```
        <xs:minLength value="10"/>
        <xs:maxLength value="14"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
  <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
</xs:complexType>
<xs:simpleType name="ReferenceType">
  <xs:restriction base="xs:string">
    <xs:minLength value="18"/>
    <xs:maxLength value="30"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
  <xs:sequence>
    <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
      <xs:complexType xdb:SQLType="ACTION_T">
        <xs:sequence>
          <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
          <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
    <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
    <xs:element name="address" type="AddressType" minOccurs="0" xdb:SQLName="SHIP_TO_ADDRESS"/>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
```

```
      <xs:minLength value="1"/>
      <xs:maxLength value="4"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="VendorType">
    <xs:restriction base="xs:string">
      <xs:minLength value="0"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PurchaseOrderNumberType">
    <xs:restriction base="xs:integer"/>
  </xs:simpleType>
  <xs:simpleType name="SpecialInstructionsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="0"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NameType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="AddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="TelephoneType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="24"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DateType">
    <xs:restriction base="xs:date"/>
  </xs:simpleType>
  <xs:simpleType name="CommentsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

The `PurchaseOrder` XML schema defines the following two *namespaces*:

- `http://www.w3c.org/2001/XMLSchema`. This is reserved by W3C for the Schema for Schemas.
- `http://xmlns.oracle.com/xdb`. This is reserved by Oracle for the Oracle XML DB schema annotations.

The `PurchaseOrder` schema uses several *annotations*, including the following:

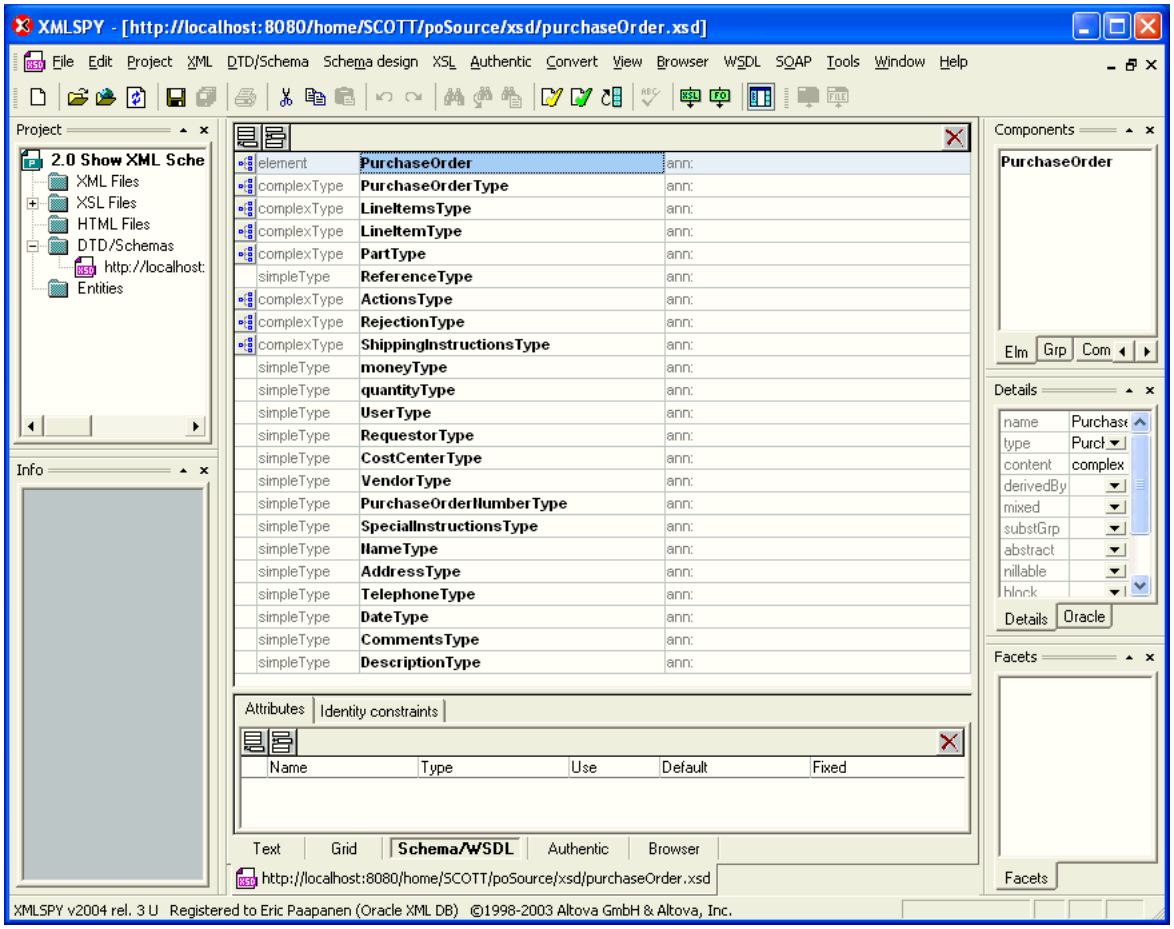
- `defaultTable` annotation in the `PurchaseOrder` element. This specifies that XML documents, compliant with this XML schema are stored in a database table called `purchaseorder`.
- `SQLType` annotation.

  The first occurrence of `SQLType` specifies that the name of the SQL type generated from `complexType` element `PurchaseOrderType` is `purchaseorder_t`.

  The second occurrence of `SQLType` specifies that the name of the SQL type generated from the `complexType` element `LineItemType` is `lineitem_t` and the SQL type that manages the collection of `LineItem` elements is `lineitem_v`.
- `SQLName` annotation. This provides an explicit name for each SQL attribute of `purchaseorder_t`.

Figure 3–3 shows the XMLSpy Oracle tab, which facilitates adding Oracle XML DB schema annotations to an XML schema while working in the graphical editor.

Figure 3–3 XMLSpy Showing Support for Oracle XML DB Schema Annotations



Registering an XML Schema with Oracle XML DB

For an XML schema to be useful to Oracle XML DB you must first register it with Oracle XML DB. After it has been registered, it can be used for validating XML documents and for creating `XMLType` tables and columns bound to the XML schema.

Two items are required to register an XML schema with Oracle XML DB:

- The XML schema document
- A string that can be used as a unique identifier for the XML schema, after it is registered with Oracle Database. Instance documents use this unique identifier to identify themselves as members of the class defined by the XML schema. The identifier is typically in the form of a URL, and is often referred to as the **schema location hint** or **document location hint**.

You register an XML schema with PL/SQL procedure `DBMS_XMLSCHEMA.registerschema`. See Example 3–9. By default, when an XML schema is registered, Oracle XML DB automatically generates all of the SQL object types and `XMLType` tables required to manage the instance documents.

XML schemas can be registered as global or local.

See Also:

- "Delete and Reload Documents, Before Registering an XML Schema They Reference" on page 6-7 for considerations to keep in mind when you register an XML schema
- Chapter 6, "XML Schema Storage and Query: Basic" for a discussion of the differences between global and local schemas
- *Oracle Database PL/SQL Packages and Types Reference* for information about `DBMS_XMLSCHEMA.registerschema`

Example 3–9 Registering an XML Schema with DBMS_XMLSCHEMA.registerSchema

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd',
    XDBURIType('/source/schemas/poSource/xsd/purchaseOrder.xsd').getCLOB(),
    TRUE,
    TRUE,
    FALSE,
    TRUE);
END;
/
```

In this example, the unique identifier for the XML schema is:

```
http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
```

The XML schema document was previously loaded into Oracle XML DB Repository at this path: `/source/schemas/poSource/xsd/purchaseOrder.xsd`.

During XML schema registration, an `XDBURIType` accesses the content of the XML schema document, based on its location in the repository. Flags passed to procedure `registerSchema` specify that the XML schema must be registered as a local schema, and that SQL objects and tables must be generated by the registration process.

Procedure `DBMS_XMLSCHEMA.registerSchema` performs the following operations:

- Parses and validates the XML schema.
- Creates a set of entries in Oracle Data Dictionary that describe the XML schema.
- Creates a set of SQL object definitions, based on `complexType` elements defined in the XML schema.
- Creates an `XMLType` table for each global element defined by the XML schema.

SQL Types and Tables Created During XML Schema Registration

Example 3–10 illustrates the creation of object types during XML schema registration with Oracle XML DB.

Example 3–10 Objects Created During XML Schema Registration

```
DESCRIBE purchaseorder_t
 purchaseorder_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 REFERENCE                                          VARCHAR2(30 CHAR)
 ACTIONS                                            ACTIONS_T
 REJECTION                                          REJECTION_T
 REQUESTOR                                          VARCHAR2(128 CHAR)
 USERID                                             VARCHAR2(10 CHAR)
 COST_CENTER                                        VARCHAR2(4 CHAR)
 SHIPPING_INSTRUCTIONS                              SHIPPING_INSTRUCTIONS_T
 SPECIAL_INSTRUCTIONS                               VARCHAR2(2048 CHAR)
 LINEITEMS                                          LINEITEMS_T

DESCRIBE lineitems_t
 lineitems_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 LINEITEM                                           LINEITEM_V

DESCRIBE lineitem_v
 lineitem_v VARRAY(2147483647) OF LINEITEM_T
 LINEITEM_T is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 ITEMNUMBER                                         NUMBER(38)
 DESCRIPTION                                        VARCHAR2(256 CHAR)
 PART                                               PART_T
```

This example shows that SQL type definitions were created when the XML schema was registered with Oracle XML DB. These SQL type definitions include:

- `purchaseorder_t`. This type is used to persist the SQL objects generated from a `PurchaseOrder` element. When an XML document containing a `PurchaseOrder` element is stored in Oracle XML DB the document is broken up, and the contents of the document are stored as an instance of `purchaseorder_t`.
- `lineitems_t`, `lineitem_v`, and `lineitem_t`. These types manage the collection of `LineItem` elements that may be present in a `PurchaseOrder` document. Type `lineitems_t` consists of a single attribute `lineitem`, defined as an instance of type `lineitem_v`. Type `lineitem_v` is defined as a varray of `linteitem_t` objects. There is one instance of the `lineitem_t` object for each `LineItem` element in the document.

Working with Large XML Schemas

A number of issues can arise when working with large, complex XML schemas.

Sometimes, you will encounter one of these errors when you register an XML schema or you create a table that is based on a global element defined by an XML schema:

- `ORA-01792: maximum number of columns in a table or view is 1000`

- `ORA-04031: unable to allocate string bytes of shared memory ("string","string","string","string")`

These errors are raised when an attempt is made to create an `XMLType` table or column based on a global element and the global element is defined as a `complexType` that contains a very large number of element and attribute definitions.

The errors are raised only when creating an `XMLType` table or column that uses object-relational storage. In this case, the table or column is persisted using a SQL type, and each object attribute defined by the SQL type counts as one column in the underlying table. If the SQL type contains object attributes that are based on other SQL types, then the attributes defined by those types also count as columns in the underlying table.

If the total number of object attributes in all of the SQL types exceeds the Oracle Database limit of 1000 columns in a table, then the storage table cannot be created. When the total number of elements and attributes defined by a `complexType` reaches 1000, it is not possible to create a single table that can manage the SQL objects that are generated when an instance of that type is stored in the database.

Error `ORA-01792` reports that the 1000-column limit has been exceeded. Error `ORA-04031` reports that memory is insufficient during the processing of a large number of element and attribute definitions.

To resolve this problem of having too many element and attribute definitions, you must reduce the total number of object attributes in the SQL types that are used to create the storage tables.

As a quick resolution of the problem, you can register the XML schema using **`REGISTER_AUTO_OOL`** in the `OPTIONS` parameter of procedure `DBMS_XMLSCHEMA.registerSchema`. When you do that, Oracle XML DB automatically moves large types out of line, reducing the likelihood of raising these errors. If you use this option, then you must also set registration parameter `GENTABLES` to `TRUE`.

Keep in mind that this option is only a stopgap; it is not a panacea. It will usually enable you to register the XML schema. You can then examine the automatically generated tables and try to achieve a result suitable to your application, reducing the number of object attributes used to create storage tables.

There are two ways to achieve this reduction:

- Use a top-down technique, with *multiple* `XMLType` *tables* that manage the XML documents. This reduces the number of SQL attributes in the SQL type hierarchy for a given storage table. As long as none of the tables need to manage more than 1000 object attributes, the problem is resolved.
- Use a bottom-up technique, which reduces the number of SQL attributes in the SQL type hierarchy, *collapsing some elements and attributes* defined by the XML schema so that they are stored as a single `CLOB` value.

Both techniques rely on annotating the XML schema to define how a particular `complexType` will be stored in the database.

For the top-down technique, annotations `SQLInline = "false"` and `defaultTable` force some subelements in the XML document to be stored as rows in a separate `XMLType` table. Oracle XML DB maintains the relationship between the two tables using a `REF` of `XMLType`. Good candidates for this approach are XML schemas that do either of the following:

- Define a *choice*, where each element within the choice is defined as a `complexType`

- Define an element based on a `complexType` that contains a *large number of element and attribute definitions*

The bottom-up technique involves reducing the total number of attributes in the SQL object types by choosing to store some of the lower-level `complexType` elements as `CLOB` values, rather than as objects. This is achieved by annotating the `complexType` or the usage of the `complexType` with `SQLType = "CLOB"`.

Which technique you use depends on the application and the type of queries and updates to be performed against the data.

Working with Global Elements

By default, when an XML schema is registered with the database, Oracle XML DB generates a *default table for each global element* defined by the XML schema.

You can use attribute `xdb:defaultTable` to specify the name of the default table for a given global element. Each `xdb:defaultTable` attribute value you provide must be *unique* among *all schemas* registered by a given database user. If you do *not* supply a nonempty default table name for some element, then a unique name is provided automatically.

In practice, however, you do *not* want to create a default table for most global elements. Elements that never serve as the root element for an XML instance document do not need default tables—such tables are never used. Creating default tables for all global elements can lead to significant overhead in processor time and space used, especially if an XML schema contains a large number of global element definitions.

As a general rule, then, you want to prevent the creation of a default table for any global element (or any local element stored out of line) that you are sure will *not* be used as a root element in any document. You can do this in one of the following ways:

- Add the annotation `xdb:defaultTable = ""` (empty string) to the definition of *each* global element that will *not* appear as the root element of an XML instance document. Using this approach, you allow automatic default-table creation, in general, and you prohibit it explicitly where needed, using `xdb:defaultTable = ""`.
- Set parameter `GENTABLES` to `false` when registering the XML schema, and then *manually create the default table* for each global element that can legally appear as the root element of an instance document. Using this approach, you inhibit automatic default-table creation, and you create only the tables that are needed, by hand.

Creating XML Schema-Based XMLType Columns and Tables

After an XML schema has been registered with Oracle XML DB, it can be referenced when defining tables that contain `XMLType` columns or creating `XMLType` tables.

Example 3–11 shows how to manually create table `purchaseorder`, the default table for `PurchaseOrder` elements.

Example 3–11 Creating an XMLType Table that Conforms to an XML Schema

```
CREATE TABLE purchaseorder OF XMLType
  XMLSCHEMA "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY "XMLDATA"."ACTIONS"."ACTION"
    STORE AS TABLE action_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  VARRAY "XMLDATA"."LINEITEMS"."LINEITEM"
```

```
    STORE AS TABLE lineitem_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)));
```

Each member of the varray that manages the collection of `Action` elements is stored in the ordered collection table `action_table`. Each member of the varray that manages the collection of `LineItem` elements is stored as a row in ordered collection table `lineitem_table`. The ordered collection tables are heap-based. Because of the `PRIMARY KEY` specification, they automatically contain pseudocolumn `NESTED_TABLE_ID` and column `SYS_NC_ARRAY_INDEX$`, which are required to link them back to the parent column.

This `CREATE TABLE` statement is equivalent to the `CREATE TABLE` statement that is generated automatically by Oracle XML DB when you set parameter `GENTABLES` to `TRUE` during XML schema registration. By default, the value of XML schema annotation `storeVarrayAsTable` is `true`, which automatically generates ordered collection tables (OCTs) for collections during XML schema registration. These OCTs are given system-generated names, which can be difficult to work with. You can give them more meaningful names using the SQL statement `RENAME TABLE`.

The `CREATE TABLE` statement in Example 3–11 corresponds to a purchase-order document with a single level of nesting: The varray that manages the collection of `LineItem` elements is ordered collection table `lineitem_table`. What if you had a different XML schema that had, say a collection of `Shipment` elements inside a `Shipments` element that was, in turn, inside a `LineItem` element? In that case, you could create the table manually as shown in Example 3–12.

Example 3–12 Creating an XMLType Table for Nested Collections

```
CREATE TABLE purchaseorder OF XMLType
  XMLSCHEMA "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY "XMLDATA"."ACTIONS"."ACTION"
    STORE AS TABLE action_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  VARRAY "XMLDATA"."LINEITEMS"."LINEITEM"
    STORE AS TABLE lineitem_table
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$))
                   VARRAY "SHIPMENTS"."SHIPMENT"
                     STORE AS TABLE shipments_table
                                   ((PRIMARY KEY (NESTED_TABLE_ID,
                                                  SYS_NC_ARRAY_INDEX$))));
```

Example 3–13 Using DESCRIBE for an XML Schema-Based XMLType Table

A SQL*Plus `DESCRIBE` statement (it can be abbreviated to `DESC`), can be used to view information about an `XMLType` table.

```
DESCRIBE purchaseorder
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
TABLE of SYS.XMLTYPE(XMLSchema
"http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd"
Element "PurchaseOrder") STORAGE Object-relational TYPE "PURCHASEORDER_T"
```

The output of the `DESCRIBE` statement shows the following information about the `purchaseorder` table:

- The table is an `XMLType` table

- The table is constrained to storing `PurchaseOrder` documents as defined by the `PurchaseOrder` XML schema
- Rows in this table are stored as a set of objects in the database
- SQL type `purchaseorder_t` is the base object for this table

Default Tables

The XML schema in Example 3–11 specifies that the `PurchaseOrder` table is the default table for `PurchaseOrder` elements. When an XML document compliant with the XML schema is inserted into Oracle XML DB Repository using protocols or PL/SQL, the content of the XML document is stored as a row in the `purchaseorder` table.

When an XML schema is registered as a global schema, you must grant the appropriate access rights on the default table to all other users of the database, before they can work with instance documents that conform to the globally registered XML schema.

Identifying XML Schema Instance Documents

Before an XML document can be inserted into an XML schema-based `XMLType` table or column the document must identify the associated XML schema. There are two ways to do this:

- Explicitly identify the XML schema when creating the `XMLType`. This can be done by passing the name of the XML schema to the `XMLType` constructor, or by invoking `XMLType` method `createSchemaBasedXML()`.
- Use the `XMLSchema-instance` mechanism to explicitly provide the required information in the XML document. This option can be used when working with Oracle XML DB.

The advantage of the `XMLSchema-instance` mechanism is that it lets the Oracle XML DB protocol servers recognize that an XML document inserted into Oracle XML DB Repository is an instance of a registered XML schema. The content of the instance document is automatically stored in the default table specified by that XML schema.

The `XMLSchema-instance` mechanism is defined by the W3C XML Schema working group. It is based on adding attributes that identify the target XML schema to the root element of the instance document. These attributes are defined by the `XMLSchema-instance` namespace.

To identify an instance document as a member of the class defined by a particular XML schema you must declare the `XMLSchema-instance` namespace by adding a namespace declaration to the root element of the instance document. For example:

```
xmlns:xsi = http://www.w3.org/2001/XMLSchema-instance
```

Once the `XMLSchema-instance` namespace has been declared and given a `namespace` prefix, attributes that identify the XML schema can be added to the root element of the instance document. In the preceding example, the namespace prefix for the `XMLSchema-instance` namespace was defined as `xsi`. This prefix can then be used when adding the `XMLSchema-instance` attributes to the root element of the instance document.

Which attributes must be added depends on a number of factors. There are two possibilities, `noNamespaceSchemaLocation` and `schemaLocation`. Depending on

the XML schema, one or both of these attributes is required to identify the XML schemas that the instance document is associated with.

Attributes noNamespaceSchemaLocation and schemaLocation

If the target XML schema does not declare a target namespace, the `noNamespaceSchemaLocation` attribute is used to identify the XML schema. The value of the attribute is the *schema location hint*. This is the unique identifier passed to PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema` when the schema is registered with the database.

For the `purchaseOrder.xsd` XML schema, the correct definition of the root element of the instance document would read as follows:

```
<PurchaseOrder
  xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
  xsi:noNamespaceSchemaLocation=
    "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
```

If the target XML schema declares a target namespace, then the `schemaLocation` attribute is used to identify the XML schema. The value of this attribute is a pair of values separated by a space:

- the value of the *target namespace* declared in the XML schema
- the *schema location hint*, the unique identifier passed to procedure `DBMS_XMLSCHEMA.registerSchema` when the schema is registered with the database

For example, assume that the `PurchaseOrder` XML schema includes a target namespace declaration. The root element of the schema would look like this:

```
<xs:schema targetNamespace="http://demo.oracle.com/xdb/purchaseOrder"
           xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0" xdb:storeVarrayAsTable="true">
   <xs:element name="PurchaseOrder" type="PurchaseOrderType"
               xdb:defaultTable="PURCHASEORDER"/>
```

In this case, the correct form of the root element of the instance document would read as follows:

```
<PurchaseOrder
    xnlns="http://demo.oracle.com/xdb/purchaseOrder"
    xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
    xsi:schemaLocation=
      "http://demo.oracle.com/xdb/purchaseOrder
       http://mdrake-lap:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
```

Dealing with Multiple Namespaces

When the XML schema includes elements defined in multiple namespaces, an entry must occur in the `schemaLocation` attribute for each of the XML schemas. Each entry consists of the namespace declaration and the *schema location hint*. The entries are separated from each other by one or more whitespace characters. If the primary XML schema does not declare a target namespace, then the instance document also needs to include a `noNamespaceSchemaLocation` attribute that provides the *schema location hint* for the primary XML schema.

Using the Database to Enforce XML Data Integrity

One advantage of using Oracle XML DB to manage XML content is that SQL can be used to supplement the functionality provided by XML schema. Combining the power of SQL and XML with the ability of the database to enforce rules makes the database a powerful framework for managing XML content.

Only well-formed XML documents can be stored in `XMLType` tables or columns. A **well-formed** XML document is one that conforms to the syntax of the XML version declared in its XML declaration. This includes having a single root element, properly nested tags, and so forth. Additionally, if the `XMLType` table or column is constrained to an XML schema, only documents that conform to that XML schema can be stored in that table or column. Any attempt to store or insert any other kind of XML document in an XML schema-based `XMLType` raises an error. Example 3–14 illustrates this.

Example 3–14 Error From Attempting to Insert an Incorrect XML Document

```
INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'Invoice.xml'), nls_charset_id('AL32UTF8')))
  VALUES (XMLType(bfilename('XMLDIR', 'Invoice.xml'), nls_charset_id('AL32UTF8')))
          *
ERROR at line 2:
ORA-19007: Schema - does not match expected
http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd.
```

Such an error only occurs when content is inserted directly into an `XMLType` table. It indicates that Oracle XML DB did not recognize the document as a member of the class defined by the XML schema. For a document to be recognized as a member of the class defined by the schema, the following conditions must be true:

- The name of the XML document root element must match the name of global element used to define the `XMLType` table or column.
- The XML document must include the appropriate attributes from the `XMLSchema-instance` namespace, or the XML document must be explicitly associated with the XML schema using the `XMLType` constructor or the `createSchemaBasedXML()` method.

If the constraining XML schema declares a `targetNamespace`, then the instance documents must contain the appropriate namespace declarations to place the root element of the document in the `targetNamespace` defined by the XML schema.

> **Note:** XML constraints are enforced only within individual XML documents. Database (SQL) constraints are enforced across sets of XML documents.

Comparing Partial to Full XML Schema Validation

This section describes the differences between partial and full XML schema validation used when inserting XML documents into the database.

Partial Validation

For binary XML storage, Oracle XML DB performs a full validation whenever an XML document is inserted into an XML schema-based `XMLType` table or column. For all other models of XML storage, Oracle XML DB performs only a partial validation of the document. This is because, except for binary XML storage, complete XML schema validation is quite costly, in terms of performance.

Partial validation ensures only that all of the mandatory elements and attributes are present, and that there are no unexpected elements or attributes in the document. That is, it ensures only that the structure of the XML document conforms to the SQL data type definitions that were derived from the XML schema. Partial validation does not ensure that the instance document is fully compliant with the XML schema. Example 3–15 provides an example of failing partial validation while inserting an XML document into table `PurchaseOrder`, which is stored object-relationally.

Example 3–15 Error When Inserting Incorrect XML Document (Partial Validation)

```
INSERT INTO purchaseorder
  VALUES(XMLType(bfilename('XMLDIR', 'InvalidElement.xml'),
                 nls_charset_id('AL32UTF8')));
  VALUES(XMLType(bfilename('XMLDIR', 'InvalidElement.xml'),
         *
ERROR at line 2:
ORA-30937: No schema definition for 'UserName' (namespace '##local') in parent
'/PurchaseOrder'
```

Full Validation

Loading XML data into XML schema-based binary XML storage causes full validation against the target XML schemas. Otherwise, regardless of storage model, you can force full validation of XML instance documents against an XML schema at any time, using either of the following:

- Table level `CHECK` constraint
- PL/SQL `BEFORE INSERT` trigger

Both approaches ensure that only valid XML documents can be stored in the `XMLType` table.

The advantage of a `TABLE CHECK` constraint is that it is easy to code. The disadvantage is that it is based on SQL function `XMLisValid`, so it can only indicate whether or not the XML document is valid. When the XML document is invalid it cannot provide any information as to *why* it is invalid.

A `BEFORE INSERT` trigger requires slightly more code. The trigger validates the XML document by invoking the `XMLType schemaValidate()` method. The advantage of using `schemaValidate()` is that the exception raised provides additional information about what was wrong with the instance document. Using a `BEFORE INSERT` trigger also makes it possible to attempt corrective action when an invalid document is encountered.

Full XML Schema Validation Costs Processing Time and Memory Usage Unless you are using binary XML storage, full XML schema validation costs processing time and memory. You should thus perform full XML schema validation only when necessary. If you can rely on your application to validate an XML document, you can obtain higher overall throughput with non-binary XML storage, by avoiding the overhead associated with full validation. If you cannot be sure about the validity of incoming XML documents, you can rely on the database to ensure that an `XMLType` table or column contains only schema-valid XML documents.

Example 3–16 shows how to force a full XML schema validation by adding a `CHECK` constraint to an `XMLType` table. In Example 3–16, the XML document `InvalidReference` is a not valid with respect to the XML schema. The XML schema defines a minimum length of 18 characters for the text node associated with the `Reference` element. In this document, the node contains the value `SBELL-20021009`, which is only 14 characters long. Partial validation would not

catch this error. Unless the constraint or trigger is present, attempts to insert this document into the database would succeed.

Example 3–16 Using CHECK Constraint to Force Full XML Schema Validation

Here, a CHECK constraint is added to PurchaseOrder table. Any attempt to insert an invalid document into the table fails:

```
ALTER TABLE purchaseorder p
  ADD CONSTRAINT validate_purchaseorder
  CHECK (XMLIsValid(p.OBJECT_VALUE) = 1);

Table altered.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidReference.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
*

ERROR at line 1:
ORA-02290: check constraint (QUINE.VALIDATE_PURCHASEORDER) violated
```

The pseudocolumn name OBJECT_VALUE can be used to access the content of an XMLType table from within a trigger.

Example 3–17 Using BEFORE INSERT Trigger to Enforce Full XML Schema Validation

This example shows how to use a BEFORE INSERT trigger to validate that the data being inserted into the XMLType table conforms to the specified XML schema.

```
CREATE OR REPLACE TRIGGER validate_purchaseorder
   BEFORE INSERT ON purchaseorder
   FOR EACH ROW
BEGIN
  IF (:new.OBJECT_VALUE IS NOT NULL) THEN :new.OBJECT_VALUE.schemavalidate();
  END IF;
END;
/

Trigger created.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidReference.xml'),
                  nls_charset_id('AL32UTF8')));
  VALUES (XMLType( bfilename('XMLDIR', 'InvalidReference.xml'),
          *
ERROR at line 2:
ORA-31154: invalid XML document
ORA-19202: Error occurred in XML processing
LSX-00221: "SBELL-20021009" is too short (minimum length is 18)
ORA-06512: at "SYS.XMLTYPE", line 354
ORA-06512: at "QUINE.VALIDATE_PURCHASEORDER", line 3
ORA-04088: error during execution of trigger 'QUINE.VALIDATE_PURCHASEORDER'
```

Using SQL Constraints to Enforce Referential Integrity

The W3C XML Schema Recommendation defines a powerful language for defining the contents of an XML document. However, there are a number of simple data

management concepts that are not currently addressed by the W3C XML Schema Recommendation. These include the ability to ensure that the value of an element or attribute has either of these properties:

- It is unique across a set of XML documents (a `UNIQUE` constraint).
- It exists in a particular data source that is outside of the current document (`FOREIGN KEY` constraint).

With Oracle XML DB, however, you can enforce such constraints. The mechanisms that you use to enforce integrity on XML data are the same mechanisms that you use to enforce integrity on relational data. Simple rules, such as uniqueness and foreign-key relationships, can be enforced by specifying constraints. More complex rules can be enforced by specifying database triggers.

Oracle XML DB lets you use the database to enforce business rules on XML content, in addition to enforcing rules that can be specified using XML Schema constructs. The database enforces these business rules regardless of whether XML is inserted directly into a table or uploaded using one of the protocols supported by Oracle XML DB Repository.

Example 3–18, Example 3–19, and Example 3–20 illustrate how you can use SQL constraints to enforce referential integrity. Example 3–18 defines a uniqueness constraint on an `XMLType` table that is stored as binary XML. It defines a virtual column, using the `Reference` element in a purchase-order document. The uniqueness constraint `reference_is_unique` ensures that the value of node `/PurchaseOrder/Reference/text()` is unique across all documents that are stored in the table.

> **See Also:** "Using Virtual Columns to Constrain Data Stored as Binary XML" on page 3-4

Example 3–18 Using a Virtual Column to Constrain an XMLType Table Stored as Binary XML

```
CREATE TABLE po_binaryxml OF XMLType
  XMLTYPE STORE AS BINARY XML
  VIRTUAL COLUMNS
    (c_reference AS (extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference')));

INSERT INTO po_binaryxml SELECT OBJECT_VALUE FROM OE.purchaseorder;

132 rows created.

ALTER TABLE po_binaryxml ADD CONSTRAINT reference_is_unique UNIQUE (c_reference);

INSERT INTO po_binaryxml
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));
INSERT INTO po_binaryxml
*
ERROR at line 1:
ORA-00001: unique constraint (OE.REFERENCE_IS_UNIQUE) violated
```

Example 3–19 defines a similar uniqueness constraint on `XMLType` table `purchaseorder` in standard database schema `OE`. In addition, it defines a foreign-key constraint that requires the `User` element of each purchase-order document to be the email address of an employee that is in standard database table `HR.employees`. For XML data that is stored object-relationally, such as that in table `OE.purchaseorder`,

constraints must be specified in terms of object attributes of the SQL data types that are used to manage the XML content.

Example 3–19 Database Integrity Constraints and Triggers for an XMLType Table Stored Object-Relationally

```
ALTER TABLE purchaseorder
  ADD CONSTRAINT reference_is_unique
  UNIQUE (XMLDATA."REFERENCE");

Table altered.

ALTER TABLE purchaseorder
  ADD CONSTRAINT user_is_valid
  FOREIGN KEY (XMLDATA."USERID") REFERENCES hr.employees(email);

Table altered.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
                  nls_charset_id('AL32UTF8')));

1 row created.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'DuplicateReference.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
*
ERROR at line 1:
ORA-00001: unique constraint (QUINE.REFERENCE_IS_UNIQUE) violated

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'InvalidUser.xml'),
                  nls_charset_id('AL32UTF8')));

INSERT INTO purchaseorder
*
ERROR at line 1:
ORA-02291: integrity constraint (QUINE.USER_IS_VALID) violated - parent key not
 found
```

Just as for Example 3–18, the uniqueness constraint `reference_is_unique` here ensures the uniqueness of the purchase-order `Reference` element across all documents stored in the table. The foreign key constraint `user_is_valid` here ensures that the value of element `User` corresponds to a value in the `email` column in the `employees` table.

The text node associated with the `Reference` element in the XML document `DuplicateRefernce.xml` contains the same value as the corresponding node in XML document `PurchaseOrder.xml`. This means that attempting to store both documents in Oracle XML DB violates the constraint `reference_is_unique`.

The text node associated with the `User` element in XML document `InvalidUser.xml` contains the value `HACKER`. There is no entry in the `employees` table where the value of the `email` column is `HACKER`. Attempting to store this document in Oracle XML DB violates the constraint `user_is_valid`.

Integrity rules defined using constraints and triggers are also enforced when XML schema-based XML content is loaded into Oracle XML DB Repository.

Example 3–20 Enforcing Database Integrity When Loading XML Using FTP

This example shows that database integrity is also enforced when a protocol, such as FTP, is used to upload XML schema-based XML content into Oracle XML DB Repository.

```
$ ftp localhost 2100
Connected to localhost.
220 mdrake-sun FTP Server (Oracle XML DB/Oracle Database 10g Enterprise Edition
Release 10.1.0.0.0 - Beta) ready.
Name (localhost:oracle10): QUINE
331 pass required for QUINE
Password:
230 QUINE logged in
ftp> cd /source/schemas
250 CWD Command successful
ftp> put InvalidReference.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-31154: invalid XML document
ORA-19202: Error occurred in XML processing
LSX-00221: "SBELL-20021009" is too short (minimum length is 18)
ORA-06512: at "SYS.XMLTYPE", line 333
ORA-06512: at "QUINE.VALIDATE_PURCHASEORDER", line 3
ORA-04088: error during execution of trigger 'QUINE.VALIDATE_PURCHASEORDER'
550 End Error Response
ftp> put InvalidElement.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-30937: No schema definition for 'UserName' (namespace '##local') in parent
'PurchaseOrder'
550 End Error Response
ftp> put DuplicateReference.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-00001: unique constraint (QUINE.REFERENCE_IS_UNIQUE) violated
550 End Error Response
ftp> put InvalidUser.xml
200 PORT Command successful
150 ASCII Data Connection
550- Error Response
ORA-00604: error occurred at recursive SQL level 1
ORA-02291: integrity constraint (QUINE.USER_IS_VALID) violated - parent key not
 found
550 End Error Response
```

Full SQL Error Trace

When an error occurs while a document is being uploaded with a protocol, Oracle XML DB provides the client with the full SQL error trace. How the error is interpreted and reported to you is determined by the error-handling built into the client application. Some clients, such as the command line FTP tool, reports the error

returned by Oracle XML DB, while others, such as Microsoft Windows Explorer, report a generic error message.

See also:

- "Specifying Relational Constraints on XMLType Tables and Columns" on page 6-32
- *Oracle Database Error Messages*

DML Operations on XML Content Using Oracle XML DB

Another major advantage of using Oracle XML DB to manage XML content is that it leverages the power of Oracle Database to deliver powerful, flexible capabilities for querying and updating XML content, including the following:

- Retrieving nodes and fragments within an XML document
- Updating nodes and fragments within an XML document
- Creating indexes on specific nodes within an XML document
- Indexing the entire content of an XML document
- Determining whether an XML document contains a particular node

XPath and Oracle XML

Oracle XML DB includes `XMLType` methods and XML-specific SQL functions. With these, you can query and update XML content stored in Oracle Database. They use the W3C XPath Recommendation to identify the required node or nodes. Each node in an XML document can be uniquely identified by an XPath expression.

An XPath expression consists of a slash-separated list of element names, attributes names, and XPath functions. XPath expressions can contain positions and conditions that determine which branch of the tree is traversed in determining the target nodes.

By supporting XPath-based methods and functions, Oracle XML DB makes it possible for XML programmers to query and update XML documents in a familiar, standards-compliant manner.

Note: Oracle SQL functions and `XMLType` methods respect the W3C XPath recommendation, which states that if an XPath expression targets *no nodes* when applied to XML data, then an empty sequence must be returned; an error must *not* be raised.

The specific semantics of an Oracle SQL function or `XMLType` method that applies an XPath-expression to XML data determines what is returned. For example, SQL function `extract` returns `NULL` if its XPath-expression argument targets no nodes, and the updating SQL functions, such as `deleteXML`, return the input XML data unchanged. An error is never raised if no nodes are targeted, but updating SQL functions may raise an error if an XPath-expression argument targets inappropriate nodes, such as attribute nodes or text nodes.

Querying XML Content Stored in Oracle XML DB

This section describes techniques for querying Oracle XML DB and retrieving XML content. This section contains these topics:

PurchaseOrder XML Document

Examples in this section are based on the following `PurchaseOrder` XML document:

Example 3–21 PurchaseOrder XML Instance Document

```
<PurchaseOrder
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation=
    "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
      Redwood Shores
      CA
      94065
      USA</address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
</PurchaseOrder>
```

Retrieving the Content of an XML Document Using Pseudocolumn OBJECT_VALUE

The OBJECT_VALUE pseudocolumn can be used as an alias for the value of an object table. For an XMLType table that consists of a single column of XMLType, the entire XML document is retrieved. (OBJECT_VALUE replaces the value(x) and SYS_NC_ROWINFO$ aliases used in releases prior to Oracle Database10g Release 1.)

Example 3–22 Using OBJECT_VALUE to Retrieve an Entire XML Document

In this example, the SQL*Plus settings PAGESIZE and LONG are used to ensure that the entire document is printed correctly, without line breaks. (The output has been formatted for readability.)

```
SET LONG 10000
SET PAGESIZE 100

SELECT OBJECT_VALUE FROM purchaseorder;

OBJECT_VALUE
--------------------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:noNamespaceSchemaLocation="http://localhost:8080/source/schemas
/poSource/xsd/purchaseOrder.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
Redwood Shores
CA
94065
USA</address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
</PurchaseOrder>

1 row selected.
```

Accessing Fragments or Nodes of an XML Document Using EXTRACT

SQL function `extract` returns the nodes that match an XPath expression. Nodes are returned as an instance of `XMLType`. The result of `extract` can be either a complete document or an XML fragment. The functionality of SQL function `extract` is also available through `XMLType` method `extract()`.

Example 3–23 Accessing XML Fragments Using EXTRACT

This query returns an `XMLType` value containing the `Reference` element that matches the XPath expression.

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Reference')
  FROM purchaseorder;

EXTRACT(OBJECT_VALUE, '/PURCHASEORDER/REFERENCE')
--------------------------------------------------
<Reference>SBELL-20021009123336O1PDT</Reference>

1 row selected.
```

This query returns an `XMLType` value containing the first `LineItem` element in the `LineItems` collection:

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[1]')
  FROM purchaseorder;

EXTRACT(OBJECT_VALUE, '/PURCHASEORDER/LINEITEMS/LINEITEM[1]')
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.
```

The following query returns an `XMLType` instance that contains the three `Description` elements that match the XPath expression. These elements are returned as nodes in a single `XMLType`, so the `XMLType` value does not have a single root node. It is treated as an XML *fragment*.

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem/Description')
  FROM purchaseorder;

EXTRACT(OBJECT_VALUE, '/PURCHASEORDER/LINEITEMS/LINEITEM/DESCRIPTION')
----------------------------------------------------------------------
<Description>A Night to Remember</Description>
<Description>The Unbearable Lightness Of Being</Description>
<Description>Sisters</Description>

1 row selected.
```

> **See Also:** "Performing SQL Operations on XMLType Fragments with XMLTABLE" on page 3-41

Accessing Text Nodes and Attribute Values Using XMLCAST and XMLQUERY

You can access text node and attribute values using SQL/XML standard functions `XMLQuery` and `XMLCast`. To do this, the XPath expression passed to `XMLQuery` must uniquely identify a *single* text node or attribute value within the document – that is, a *leaf* node.

Example 3–24 Accessing a Text Node Value Using XMLCAST

This query returns the value of the text node associated with the `Reference` element that matches the XPath expression. The value is returned as a `VARCHAR2` value.

```
SELECT  XMLCast(XMLQuery('$p/PurchaseOrder/Reference/text()'
                         PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                 AS VARCHAR2(30))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
SBELL-2002100912333601PDT

1 row selected.
```

The following query returns the value of the text node associated with a `Description` element contained in a `LineItem` element. The particular `LineItem` element is specified by its `Id` attribute value. The predicate that identifies the `LineItem` element is `[Part/@Id="715515011020"]`. The at-sign character (`@`) specifies that `Id` is an attribute rather than an element. The value is returned as a `VARCHAR2` value.

```
SELECT XMLCast(
         XMLQuery('$p/PurchaseOrder/LineItems/LineItem[Part/@Id="715515011020"]/Description/text()'
                  PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEO
------------------------------
Sisters

1 row selected.
```

The following query returns the value of the text node associated with the `Description` element contained in the first `LineItem` element. The first `LineItem` element is indicated by the position predicate `[1]`.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/LineItems/LineItem[1]/Description'
                        PASSING OBJECT_VALUE AS "p" RETURNING CONTENT)
                AS VARCHAR2(4000))
  FROM purchaseorder;

XMLCAST(XMLQUERY('$P/PURCHASEORDER/LINEITEMS/LINEITEM[1]/DESCRIPTION'PASSINGOBJECT_VALUEAS"P"
--------------------------------------------------------------------------------------------
A Night to Remember

1 row selected.
```

See Also:

- "Querying XMLType Data with SQL Functions" on page 4-4 for information on SQL/XML function `XMLCast`
- Chapter 18, "Using XQuery with Oracle XML DB" for information on SQL/XML function `XMLQuery`

Performing SQL Operations on XMLType Fragments with XMLTABLE

Example 3–23 demonstrates how SQL function `extract` returns an `XMLType` instance containing the node or nodes that match an XPath expression. When the document

contains *multiple* nodes that match the supplied XPath expression, `extract` returns an XML *fragment* that contains all of the matching nodes. Unlike an XML document, an XML **fragment** has no single element that is the *root* element.

This kind of result is common in these cases:

- when `extract` is used to retrieve the set of elements contained in a *collection*, in which case all nodes in the fragment are of the same type – see Example 3–25
- when the XPath expression ends in a *wildcard*, in which case the nodes in the fragment can be of different types – see Example 3–27

You can use SQL/XML standard function `XMLTable` to break up an XML fragment contained in an `XMLType` instance, inserting the collection-element data into a new, virtual table, which you can then query using SQL—in a join expression, for example. In particular, converting an XML fragment into a virtual table makes it easier to process the result of an `extract` expression that returns multiple nodes.

Example 3–25 Using XMLTABLE to Access Description Nodes

This example demonstrates how to access the text nodes for each `Description` element in the `PurchaseOrder` document.

An initial attempt uses SQL function `extractValue`. It *fails*, because there is more than one `Description` element in the document.

```
SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Description')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;
SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Description')
 *
ERROR at line 1:
ORA-01427: single-row subquery returns more than one row
```

A second attempt uses SQL function `extract` to access the required values. This returns the set of `Description` nodes as a *single* `XMLType` object that contains a single fragment consisting of the three `Description` nodes. This is better, but still not very useful, because the objective is to be able to process the text-node values further, using SQL.

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem/Description')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM/DESCRIPTION')
--------------------------------------------------------------------
<Description>A Night to Remember</Description>
<Description>The Unbearable Lightness Of Being</Description>
<Description>Sisters</Description>

1 row selected.
```

To use SQL to process the contents of the text nodes, we convert the collection of `Description` nodes into a *virtual table*, using SQL/XML function `XMLTable`. The

virtual table has three rows, each of which contains a single XMLType instance with a single Description element.

```
SELECT des.COLUMN_VALUE
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

COLUMN_VALUE
------------------------------------------------------------
<Description>A Night to Remember</Description>
<Description>The Unbearable Lightness Of Being</Description>
<Description>Sisters</Description>

3 rows selected.
```

Function XMLTable is passed the XPath expression that targets the Description elements we want. The PASSING clause tells XMLTable to use the contents (OBJECT_VALUE) of XMLType table purchaseorder as the context for evaluating the XPath expression.

This means that the XMLTable expression *depends* on the purchaseorder table. This is a *left lateral join*. This correlated join ensures a one-to-many (1:N) relationship between the purchaseorder row accessed and the rows generated from it by XMLTable. Because of this correlated join, the purchaseorder table *must appear before* the XMLTable expression in the FROM list. This is a general requirement in any situation where the PASSING clause refers to a column of the table.

Since each XMLType instance in the virtual table contains a single Description element, SQL function extractValue can be used to access the value of the text node associated with the each Description element:

```
SELECT extractValue(des.COLUMN_VALUE, '/Description')
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACTVALUE(DES.COLUMN_VALUE,'/DESCRIPTION')
---------------------------------------------
A Night to Remember
The Unbearable Lightness Of Being
Sisters

3 rows selected.
```

An equivalent but more readable query does away with the need to use extractValue, by using the COLUMNS clause of XMLTable to break up the Description elements into a column named description:

```
SELECT des.description
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
                COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
```

```
       = 1;

DESCRIPTION
--------------------------------
A Night to Remember
The Unbearable Lightness Of Being
Sisters

3 rows selected.
```

The `COLUMNS` clause here tells `XMLTable` to break up the data targeted by the XPath expression `'Description'` into a column named `description` of SQL data type `VARCHAR2(256)`. The `'Description'` expression defining this column is *relative* to the *context* XPath expression, `'/PurchaseOrder/LineItems/LineItem'`.

In this example, which uses only a single column (`description`), the gain in readability is perhaps negligible. However, when multiple XPath expressions are used to access different parts of the `XMLType` instance, it is much more readable to use the `COLUMNS` clause than `extractValue`. See, for instance, Example 3–32.

In addition to making queries more readable, use of the `COLUMNS` clause has the advantage that you can specify more precise SQL data types, which can make static type-checking more helpful.

When you need to expose data contained at multiple levels in an `XMLType` table as individual rows in a relational view, you apply `XMLTable` to each document level that needs to be broken up and stored in relational columns. See Example 3–32 for an example.

Example 3–26 Counting the Number of Elements in a Collection Using XMLTABLE

This example counts the number of elements in a collection. It also shows how SQL keywords such as `ORDER BY` and `GROUP BY` can be applied to the virtual table data created by SQL function `XMLTable`.

In this case, the query first locates the set of XML documents that match the XPath argument to SQL function `existsNode`. It then generates a virtual table containing the set of `LineItem` nodes for each document selected. Finally, it counts the number of `LineItem` nodes for each `PurchaseOrder` document. A correlated join ensures that the `GROUP BY` correctly determines which `LineItem` elements belong to which `PurchaseOrder` element.

```
SELECT extractValue(p.OBJECT_VALUE, '/PurchaseOrder/Reference'), count(*)
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE)
  WHERE existsNode(p.OBJECT_VALUE, '/PurchaseOrder[User="SBELL"]') = 1
  GROUP BY extractValue(p.OBJECT_VALUE, '/PurchaseOrder/Reference')
  ORDER BY extractValue(p.OBJECT_VALUE, '/PurchaseOrder/Reference');

EXTRACTVALUE(P.OBJECT_VALUE,'/   COUNT(*)
-----------------------------   --------
SBELL-20021009123335280PDT            20
SBELL-20021009123335771PDT            21
SBELL-2002100912333601PDT              3
SBELL-20021009123336231PDT            25
SBELL-20021009123336331PDT            10
SBELL-20021009123336362PDT            15
SBELL-20021009123336532PDT            14
SBELL-20021009123337353PDT            10
SBELL-2002100912333763PDT             21
SBELL-20021009123337673PDT            10
```

```
SBELL-20021009123338204PDT            14
SBELL-20021009123338304PDT            24
SBELL-20021009123338505PDT            20

13 rows selected.
```

Example 3–27 Counting the Number of Child Elements in an Element Using XMLTABLE

This example demonstrates how to use SQL function `XMLTable` to count the number of *child* elements of a given element. The XPath expression passed to `XMLTable` contains a wildcard (`*`) that matches all elements that are direct descendants of a `PurchaseOrder` element. Each row of the virtual table created by `XMLTable` contains a node that matches the XPath expression. Counting the number of rows in the virtual table provides the number of element children of element `PurchaseOrder`.

```
SELECT count(*)
  FROM purchaseorder p, XMLTable('/PurchaseOrder/*' PASSING p.OBJECT_VALUE)
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

  COUNT(*)
----------
         9

1 row selected.
```

Searching the Content of an XML Document Using XMLEXISTS

SQL/XML standard function `XMLExists` evaluates whether or not a given document contains a node that matches a W3C XPath expression. Function `XMLExists` returns a Boolean value of `true` if the document contains the node specified by the XPath expression supplied to the function and a value of `false` if it does not. Since XPath expressions can contain predicates, `XMLExists` can determine whether or not a given node exists in the document, and whether or not a node with the specified value exists in the document. Functionality similar to that provided by SQL/XML function `XMLExists` is also available through Oracle SQL function `existsNode` and `XMLType` method `existsNode()`.

Example 3–28 Searching XML Content Using XMLExists

This query uses SQL/XML function `XMLExists` to check if the XML document contains an element named `Reference` that is a child of the root element `PurchaseOrder`:

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
       132

1 row selected.
```

This query checks if the value of the text node associated with the `Reference` element is `SBELL-2002100912333601PDT`:

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]'
                  PASSING OBJECT_VALUE AS "p");
```

```
  COUNT(*)
----------
         1
1 row selected.
```

This query checks if the value of the text node associated with the `Reference` element is `SBELL-XXXXXXXXXXXXXXXXXX`:

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[Reference="SBELL-XXXXXXXXXXXXXXXXXX"]'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
         0

1 row selected.
```

This query checks if the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element that contains a `LineItem` element that contains a `Part` element with an `Id` attribute.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part/@Id'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
       132

1 row selected.
```

This query checks if the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element that contains a `LineItem` element that contains a `Part` element with `Id` attribute value `715515009058`.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]'
                  PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
        21
```

This query checks if the XML document contains a root element `PurchaseOrder` that contains a `LineItems` element whose third `LineItem` element contains a `Part` element with `Id` attribute value `715515009058`.

```
SELECT count(*) FROM purchaseorder
  WHERE XMLExists(
          '$p/PurchaseOrder/LineItems/LineItem[3]/Part[@Id="715515009058"]'
          PASSING OBJECT_VALUE AS "p");

  COUNT(*)
----------
         1
1 row selected.
```

This query limits the results of the `SELECT` statement to rows where the text node associated with the `User` element starts with the letter `S`. XPath 1.0 does not include support for `LIKE`-based queries.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                         RETURNING CONTENT)
                 AS VARCHAR2(30))
        LIKE 'S%';

XMLCAST(XMLQUERY('$P/PURCHASEORDER
---------------------------------
SBELL-20021009123336231PDT
SBELL-20021009123336331PDT
SKING-20021009123336321PDT
...
36 rows selected.
```

This query performs a join based on the values of a node in an XML document and data in another table:

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
                AS VARCHAR2(30))
  FROM purchaseorder p, hr.employees e
  WHERE XMLCast(XMLQuery('$p/PurchaseOrder/User' PASSING OBJECT_VALUE AS "p"
                         RETURNING CONTENT)
                 AS VARCHAR2(30)) = e.email
    AND e.employee_id = 100;

XMLCAST(XMLQUERY('$P/PURCHASEOREDER
---------------------------------
SKING-20021009123336321PDT
SKING-20021009123337153PDT
SKING-20021009123335560PDT
SKING-20021009123336952PDT
SKING-20021009123336622PDT
SKING-20021009123336822PDT
SKING-20021009123336131PDT
SKING-20021009123336392PDT
SKING-20021009123337974PDT
SKING-20021009123338294PDT
SKING-20021009123337703PDT
SKING-20021009123337383PDT
SKING-20021009123337503PDT

13 rows selected.
```

See Also:

- "Querying XMLType Data with SQL Functions" on page 4-4 for information on SQL/XML functions `XMLCast` and `XMLExists`
- Chapter 18, "Using XQuery with Oracle XML DB" for information on SQL/XML function `XMLQuery`

Using XMLEXISTS in a SQL WHERE Clause

The examples in the preceding section demonstrate how you can use SQL/XML function `XMLExists` in a `SELECT` list to return information that is contained in an XML document. You can also use `XMLExists` in a `WHERE` clause, to determine whether or not a document must be included in the result set of a `SELECT`, `UPDATE`, or `DELETE` statement.

Example 3–29 shows how to use `XMLExists` to restrict the result set to documents containing nodes that match an XPath expression.

Example 3–29 Limiting the Results of a SELECT Using XMLExists in a WHERE Clause

This query limits the results of the `SELECT` statement to rows where the text node associated of the `User` element contains the value `SBELL`.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30)) "Reference"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder[User="SBELL"]' PASSING OBJECT_VALUE AS "p");

Reference
------------------------------
SBELL-20021009123336231PDT
SBELL-20021009123336331PDT
SBELL-20021009123337353PDT
SBELL-20021009123338304PDT
SBELL-20021009123338505PDT
SBELL-20021009123335771PDT
SBELL-20021009123335280PDT
SBELL-20021009123333763PDT
SBELL-20021009123333601PDT
SBELL-20021009123336362PDT
SBELL-20021009123336532PDT
SBELL-20021009123338204PDT
SBELL-20021009123337673PDT

13 rows selected.
```

Example 3–30 Finding the Reference for any PurchaseOrder Using XMLQuery and XMLExists

This example uses SQL/XML functions `XMLQuery` and `XMLExists` to find the `Reference` element for any `PurchaseOrder` element whose first `LineItem` element contains an order for the item with `Id` `715515009058`. Function `XMLExists` is used in the `WHERE` clause to determine which rows are selected, and `XMLQuery` is used in the `SELECT` list to control which part of the selected documents appears in the result.

```
SELECT XMLCast(XMLQuery('$p/PurchaseOrder/Reference' PASSING OBJECT_VALUE AS "p"
                        RETURNING CONTENT)
               AS VARCHAR2(30)) "Reference"
  FROM purchaseorder
  WHERE XMLExists('$p/PurchaseOrder/LineItems/LineItem[1]/Part[@Id="715515009058"]'
                  PASSING OBJECT_VALUE AS "p");

Reference
-------------------------
SBELL-20021009123333601PDT

1 row selected.
```

See Also:

- "Querying XMLType Data with SQL Functions" on page 4-4 for information on SQL/XML functions `XMLCast` and `XMLExists`
- Chapter 18, "Using XQuery with Oracle XML DB" for information on SQL/XML function `XMLQuery`

Relational Access to XML Content Stored in Oracle XML DB Using Views

The XML-specific functions and methods provided by Oracle XML DB can be used to create conventional *relational views* that provide relational access to XML content. This lets programmers, tools, and applications that understand Oracle Database, but not XML, to work with XML content stored in the database.

The relational views can use XPath expressions and SQL functions such as `extractValue` and `XMLTable` to define a mapping between columns in the view and nodes in the XML document. For performance reasons, this approach is recommended only when XML documents are stored using structured (object-relational) or binary XML storage, not when stored as `CLOB` instances.

See Also:

- Chapter 4, "XMLType Operations" for a description of `XMLType` data type and functions
- `http://www.w3.org/TR/xpath` for information about XPath 1.0
- `http://www.w3.org/TR/xpath20/` for information about XPath 2.0
- `http://www.w3.org/TR/2002/NOTE-unicode-xml-20020218/` for information about using Unicode in XML

Breaking Up a Single Level of XML Data

When you need to expose each document in an `XMLType` table as a row in a relational view, you can use this technique:

1. Define the set of columns that make up the view, using `CREATE OR REPLACE VIEW`.
2. Map the nodes in the XML document to the columns defined by the view. You do this by extracting the nodes, using SQL function `extractValue` with appropriate XPath expressions.

This technique can be used whenever there is a one-to-*one* (1:1) relationship between documents in the `XMLType` table and the rows in the view.

Example 3–31 Creating a Relational View On XML Content

This example shows how to create a simple relational view that exposes XML content:

```
CREATE OR REPLACE VIEW
  purchaseorder_master_view(reference, requestor, userid, costcenter,
                            ship_to_name, ship_to_address, ship_to_phone,
                            instructions)
AS SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference'),
          extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor'),
          extractValue(OBJECT_VALUE, '/PurchaseOrder/User'),
          extractValue(OBJECT_VALUE, '/PurchaseOrder/CostCenter'),
```

```
          extractValue(OBJECT_VALUE,
                       '/PurchaseOrder/ShippingInstructions/name'),
          extractValue(OBJECT_VALUE,
                       '/PurchaseOrder/ShippingInstructions/address'),
          extractValue(OBJECT_VALUE,
                       '/PurchaseOrder/ShippingInstructions/telephone'),
          extractValue(OBJECT_VALUE, '/PurchaseOrder/SpecialInstructions')
     FROM purchaseorder;

View created.

DESCRIBE purchaseorder_master_view

Name            Null?    Type
----------------------------------------
REFERENCE                VARCHAR2(30 CHAR)
REQUESTOR                VARCHAR2(128 CHAR)
USERID                   VARCHAR2(10 CHAR)
COSTCENTER               VARCHAR2(4 CHAR)
SHIP_TO_NAME             VARCHAR2(20 CHAR)
SHIP_TO_ADDRESS          VARCHAR2(256 CHAR)
SHIP_TO_PHONE            VARCHAR2(24 CHAR)
INSTRUCTIONS             VARCHAR2(2048 CHAR)
```

This example creates relational view `purchaseorder_master_view`. There is one row in the view for each row in table `purchaseorder`.

Breaking Up Multiple Levels of XML Data

When you need to expose data contained at multiple levels in an `XMLType` table as individual rows in a relational view, you use the same general approach as for breaking up a single level: 1) define the columns making up the view, and 2) map the XML nodes to the columns. However, in this case it is best to use SQL/XML standard function `XMLTable`, applying it to each document level that needs to be broken up and stored in relational columns.

This technique can be used whenever there is a one-to-*many* (1:N) relationship between documents in the `XMLType` table and the rows in the view.

For example, each `PurchaseOrder` element contains a `LineItems` element, which in turn contains one or more `LineItem` elements. Each `LineItem` element has child elements, such as `Description`, and an `ItemNumber` attribute. To make such lower-level data accessible as a relational value, you must break up both the `PurchaseOrder` element and the `LineItem` collection. Each such decomposition is done with `XMLTable`. When element `PurchaseOrder` is broken up, the `LineItem` element is mapped to a relational column of type `XMLType`, which contains an XML fragment. That column is then passed to the second call to `XMLType`, to be broken into its various parts as multiple rows of relational values. See Example 3–32.

Example 3–32 Using a View to Access Individual Members of a Collection

This example shows how to use SQL function `XMLTable` for a one-to-*many* (1:N) relationship between the documents in `XMLType` table `purchaseorder` and the view rows. The view provides access to the individual members of a *collection*, and exposes the collection members as a set of rows.

```
CREATE OR REPLACE VIEW purchaseorder_detail_view AS
  SELECT po.reference, li.*
    FROM purchaseorder p,
```

```
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS
                    reference VARCHAR2(30) PATH 'Reference',
                    lineitem  XMLType      PATH 'LineItems/LineItem') po,
         XMLTable('LineItem' PASSING po.lineitem
                  COLUMNS
                    itemno      NUMBER(38)    PATH '@ItemNumber',
                    description VARCHAR2(256) PATH 'Description',
                    partno      VARCHAR2(14)  PATH 'Part/@Id',
                    quantity    NUMBER(12, 2) PATH 'Part/@Quantity',
                    unitprice   NUMBER(8, 4)  PATH 'Part/@UnitPrice') li;

View created.

DESCRIBE purchaseorder_detail_view
Name           Null?    Type
----------------------------
REFERENCE               VARCHAR2(30 CHAR)
ITEMNO                  NUMBER(38)
DESCRIPTION             VARCHAR2(256 CHAR)
PARTNO                  VARCHAR2(14 CHAR)
QUANTITY                NUMBER(12,2)
UNITPRICE               NUMBER(8,4)
```

There is one row in view `purchaseorder_detail_view` for each `LineItem` element in the XML documents stored in `XMLType` table `purchaseorder`.

The `CREATE OR REPLACE VIEW` statement defines the set of columns that make up the view. The `SELECT` statement passes the `purchaseorder` table as context to function `XMLTable`, to create the virtual table `p`, which has columns `reference` and `lineitem`. These columns contain the `Reference` and `LineItem` elements of the purchase-order documents, respectively.

Column `lineitem` contains a collection of `LineItem` elements, as an `XMLType` instance—one row for each `LineItem` element. These rows are, in turn, passed to a second `XMLTable` expression, to serve as its context. This second `XMLTable` expression creates a virtual table of line-item rows, with columns corresponding to various descendant nodes of element `LineItem`. Most of these descendants are attributes (`ItemNumber`, `Part/@Id`, and so on); one of them is the `Description` child element.

The `Reference` element is included in view `purchaseorder_detail_view` as column `reference`. It provides a foreign key that can be used to joins rows in view `purchaseorder_detail_view` to the corresponding row in view `purchaseorder_master_view`. The correlated join in the `CREATE VIEW` statement ensures that the one-to-many (1:N) relationship between the `Reference` element and the associated `LineItem` elements is maintained whenever the view is accessed.

Querying XML Content As Relational Data

The examples in this section show relational queries of XML data. They point out some of the benefits provided by creating relational views over `XMLType` tables and columns.

Example 3–33 SQL queries on XML Content Using Views

This example uses a simple query against the master view. A conventional `SELECT` statement selects rows where the `userid` column starts with `S`.

```
SELECT reference, costcenter, ship_to_name
```

```
  FROM purchaseorder_master_view
  WHERE userid LIKE 'S%';

REFERENCE                      COST SHIP_TO_NAME
------------------------------ ---- --------------
SBELL-20021009123336231PDT     S30  Sarah J. Bell
SBELL-20021009123336331PDT     S30  Sarah J. Bell
SKING-20021009123336321PDT     A10  Steven A. King
...
36 rows selected.
```

The following query is based on a join between the master view and the detail view. A conventional `SELECT` statement finds the `purchaseorder_detail_view` rows where the value of the `itemno` column is `1` and the corresponding `purchaseorder_master_view` row contains a `userid` column with the value `SBELL`.

```
SELECT d.reference, d.itemno, d.partno, d.description
  FROM purchaseorder_detail_view d, purchaseorder_master_view m
  WHERE m.reference = d.reference
    AND m.userid = 'SBELL'
    AND d.itemno = 1;

REFERENCE                        ITEMNO PARTNO         DESCRIPTION
------------------------------ ---------------------------------------------
SBELL-20021009123336231PDT              1 37429165829    Juliet of the Spirits
SBELL-20021009123336331PDT              1 715515009225   Salo
SBELL-20021009123337353PDT              1 37429141625    The Third Man
SBELL-20021009123338304PDT              1 715515009829   Nanook of the North
SBELL-20021009123338505PDT              1 37429122228    The 400 Blows
SBELL-20021009123335771PDT              1 37429139028    And the Ship Sails on
SBELL-20021009123335280PDT              1 715515011426   All That Heaven Allows
SBELL-20021009123333763PDT              1 715515010320   Life of Brian - Python
SBELL-20021009123333601PDT              1 715515009058   A Night to Remember
SBELL-20021009123336362PDT              1 715515012928   In the Mood for Love
SBELL-20021009123336532PDT              1 37429162422    Wild Strawberries
SBELL-20021009123338204PDT              1 37429168820    Red Beard
SBELL-20021009123337673PDT              1 37429156322    Cries and Whispers

13 rows selected.
```

Because the views look and act like standard relational views they can be queried using standard relational syntax. No XML-specific syntax is required in either the query or the generated result set.

By exposing XML content as relational data, Oracle XML DB lets advanced database features, such as business intelligence and analytic capabilities, be applied to XML content. Even though the business intelligence features themselves are not XML-aware, the XML-SQL duality provided by Oracle XML DB lets these features be applied to XML content.

Example 3–34 Querying XML Using Views of XML Content

This example demonstrates how to use relational views over XML content to perform business-intelligence queries on XML documents. The query selects `PurchaseOrder` documents that contain orders for titles identified by UPC codes `715515009058` and `715515009126`.

```
SELECT partno, count(*) "No of Orders", quantity "No of Copies"
  FROM purchaseorder_detail_view
  WHERE partno IN (715515009126, 715515009058)
```

```
  GROUP BY rollup(partno, quantity);

PARTNO         No of Orders No of Copies
-------------- ------------ ------------
715515009058              7            1
715515009058              9            2
715515009058              5            3
715515009058              2            4
715515009058             23
715515009126              4            1
715515009126              7            3
715515009126             11
                          34
9 rows selected.
```

The query determines the number of copies of each title that are ordered in each `PurchaseOrder` document. For part number `715515009126`, there are four `PurchaseOrder` documents where one copy of the item is ordered and seven `PurchaseOrder` documents where three copies of the item are ordered.

Updating XML Content Stored in Oracle XML DB

Oracle XML DB lets update operations take place on XML content. Update operations can either replace the entire contents of a document or parts of a document. The ability to perform partial updates on XML documents is very powerful, particularly when you make small changes to large documents, as it can significantly reduce the amount of network traffic and disk input-output required to perform the update.

SQL function `updateXML` enables partial update of an XML document stored as an `XMLType` instance. It lets multiple changes be made to the document in a single operation. Each change consists of an XPath expression that identifies a node to be updated, and the new value for the node.

Example 3–35 Updating XML Content Using UPDATEXML

This example uses SQL function `updateXML` to update the text node associated with the `User` element.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACTVAL
----------
SBELL

1 row selected.

UPDATE purchaseorder
SET OBJECT_VALUE =
    updateXML(OBJECT_VALUE, '/PurchaseOrder/User/text()','SKING')
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
      = 1;

1 row updated.
```

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACTVAL
----------
SKING

1 row selected.
```

Example 3–36 Replacing an Entire Element Using UPDATEXML

This example uses SQL function `updateXML` to replace an entire element within an XML document. The XPath expression references the element, and the replacement value is passed as an `XMLType` object.

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[1]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[1]')
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
        updateXML(
          OBJECT_VALUE,
          '/PurchaseOrder/LineItems/LineItem[1]',
          XMLType('<LineItem ItemNumber="1">
                     <Description>The Lady Vanishes</Description>
                     <Part Id="37429122129" UnitPrice="39.95" Quantity="1"/>
                   </LineItem>'))
    WHERE existsNode(OBJECT_VALUE,
                     '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
          = 1;

1 row updated.

SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[1]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE, '/PURCHASEORDER/LINEITEMS/LINEITEM[1]')
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>The Lady Vanishes</Description>
  <Part Id="37429122129" UnitPrice="39.95" Quantity="1"/>
</LineItem>
```

```
1 row selected.
```

Example 3–37 Incorrectly Updating a Node That Occurs Multiple Times In a Collection

This example show a common error that occurs when using SQL function `updateXML` to update a *node that occurs multiple times* in a collection. The `UPDATE` statement sets the value of the text node of a `Description` element to "`The Wizard of Oz`", where the current value of the text node is "`Sisters`". The statement includes an `existsNode` expression in the `WHERE` clause that identifies the set of nodes to be updated.

```
SELECT extractValue(des.COLUMN_VALUE, '/Description')
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
         = 1;

EXTRACTVALUE(DES.COLUMN_VALUE,'/DESCRIPTION')
--------------------------------------------
The Lady Vanishes
The Unbearable Lightness Of Being
Sisters

3 rows selected.

UPDATE purchaseorder p
  SET p.OBJECT_VALUE =
        updateXML(p.OBJECT_VALUE,
                  '/PurchaseOrder/LineItems/LineItem/Description/text()',
                  'The Wizard of Oz')
    WHERE existsNode(p.OBJECT_VALUE,
                     '/PurchaseOrder/LineItems/LineItem[Description="Sisters"]')
          = 1
      AND existsNode(p.OBJECT_VALUE,
                     '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
          = 1;

1 row updated.

SELECT extractValue(des.COLUMN_VALUE, '/Description')
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
         = 1;

EXTRACTVALUE(DES.COLUMN_VALUE,'/DESCRIPTION')
--------------------------------------------
The Wizard of Oz
The Wizard of Oz
The Wizard of Oz

3 rows selected.
```

Instead of updating the required node, SQL function `updateXML` updates the values of *all* text nodes that belong to the `Description` element. This is the correct behavior,

but it is not what was intended. *A `WHERE` clause can be used only to identify which **documents** must be updated, not which nodes within a document must be updated.*

After the document has been selected, the *XPath expression* passed to `updateXML` determines which *nodes* within the document must be updated. In this case, the XPath expression identifies all three `Description` nodes, so all three of the associated text nodes were updated. See Example 3–38 for the correct way to update the nodes.

Example 3–38 Correctly Updating a Node That Occurs Multiple Times In a Collection

To correctly use SQL function `updateXML` to update a node that occurs multiple times within a collection, use the XPath expression passed to `updateXML` to identify which nodes in the XML document to update. By introducing the appropriate predicate into the XPath expression, you can limit which nodes in the document are updated. This example shows the correct way of updating one node within a collection:

```
SELECT extractValue(des.COLUMN_VALUE, '/Description')
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
        = 1;

EXTRACTVALUE(P.OBJECT_VALUE,'/DESCRIPTION')
-------------------------------------------
A Night to Remember
The Unbearable Lightness Of Being
Sisters
3 rows selected.

UPDATE purchaseorder p
 SET p.OBJECT_VALUE =
       updateXML(
         p.OBJECT_VALUE,
         '/PurchaseOrder/LineItems/LineItem/Description[text()="Sisters"]/text()',
         'The Wizard of Oz')
 WHERE existsNode(p.OBJECT_VALUE,
                  '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')
       = 1;

1 row updated.

SELECT extractValue(des.COLUMN_VALUE, '/Description')
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder/LineItems/LineItem/Description'
                PASSING p.OBJECT_VALUE) des
  WHERE existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

EXTRACTVALUE(DES.COLUMN_VALUE,'/DESCRIPTION')
---------------------------------------------
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz

3 rows selected.
```

Example 3–39 Changing Text Node Values Using UPDATEXML

SQL function `updateXML` lets multiple changes be made to the document in one statement. This example shows how to change the values of text nodes belonging to the `User` and `SpecialInstructions` elements in one statement.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/CostCenter') "Cost Center",
       extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/SpecialInstructions') "Instructions"
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

Cost Center  Instructions
------------ ------------
S30          Air Mail

1 row selected.
```

This single `UPDATE` SQL statement changes the `User` and `SpecialInstructions` element text node values:

```
UPDATE purchaseorder
  SET OBJECT_VALUE =
        updateXML(OBJECT_VALUE,
                  '/PurchaseOrder/CostCenter/text()',
                  'B40',
                  '/PurchaseOrder/SpecialInstructions/text()',
                  'Priority Overnight Service')
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/CostCenter') "Cost Center",
       extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/SpecialInstructions') "Instructions"
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

Cost Center  Instructions
------------ -------------------------
B40          Priority Overnight Service

1 row selected.
```

Updating XML Schema-Based and Non-Schema-Based XML Documents

The way SQL functions such as `updateXML` modify an XML document depends on how the XML document is stored and whether it is based on an XML schema:

- XML documents stored in `CLOB` values – When a SQL function such as `updateXML` modifies an XML document stored as a `CLOB` (whether or not it is XML schema-based), Oracle XML DB performs the update by creating a Document Object Model (DOM) from the document and using DOM API methods to modify the appropriate XML data. After modification, the updated DOM is returned back to the underlying `CLOB` value.
- XML documents stored object-relationally – When a SQL function such as `updateXML` modifies an XML schema-based document that is stored

object-relationally, Oracle XML DB can use XPath rewrite to modify the underlying objects in place. This is a partial update, which translates the XPath argument to the SQL function into an equivalent SQL operation. The SQL operation then directly modifies the attributes of underlying objects. Such a partial update can be much quicker than a DOM-based update. This can improve performance significantly when executing SQL code that applies a SQL function such as `updateXML` to a large number of documents.

- XML documents stored as binary XML – When SQL function `updateXML` is used on a binary XML column, Oracle XML DB often need not build a DOM. The exact portion of the document that needs to be updated is calculated using query evaluation techniques such as streaming and `XMLIndex`. The updated data is written to disk starting only where the first change occurs—anything before that is unchanged. In addition, if SecureFile LOBs are used for storing the data, then the change is applied in a sliding manner, without causing the rest of the LOB to be rewritten. That is, with SecureFile LOB storage of binary XML data, only the data that is actually changed is updated. This can significantly improve performance relative to unstructured storage. These optimizations apply to both non-schema-based and XML schema-based data.

See Also: Chapter 7, "XPath Rewrite"

Namespace Support in Oracle XML DB

Namespace support is a key feature of the W3C XML Recommendations. Oracle XML DB fully supports the W3C Namespace Recommendation. All `XMLType` methods and XML-specific SQL functions work with XPath expressions that include namespace prefixes. All methods and functions accept an optional `namespace` argument that provides the namespace declarations for correctly resolving namespace prefixes used in XPath expressions.

The `namespace` parameter is required whenever the provided XPath expression contains namespace prefixes. When parameter `namespace` is provided, it must provide an explicit declaration for the default namespace in addition to the prefixed namespaces, unless the default namespace is the `noNamespace` namespace. When parameter `namespace` is *not* provided, Oracle XML DB makes the following assumptions about the XPath expression:

- If the content of the `XMLType` instance is *not* based on a registered XML schema, then any term in the XPath expression that does include a namespace prefix is assumed to be in the `noNamespace` namespace.
- If the content of the `XMLType` is based on a registered XML schema, then any term in the XPath expression that does not include a namespace prefix is assumed to be in the `targetNamespace` declared by the XML schema, if any. If the XML schema does not declare a `targetnamespace`, then names `noNamespace` is used.

Failing to correctly define the namespaces required to resolve XPath expressions results in XPath-based operations not working as expected. When the namespace declarations are incorrect or missing, the result of the operation is normally *null*, rather than an error. To avoid confusion, whenever any namespaces other than `noNamespace` are present in either the XPath expression or the target XML document, pass the *complete set of namespace declarations*, including the declaration for the *default* namespace.

Processing XMLType Methods and XML-Specific SQL Functions

Oracle XML DB processes SQL functions such as `extract`, `extractValue`, and `existsNode`—and their equivalent `XMLType` methods—using DOM-based or SQL-based techniques:

- DOM-based `XMLType` processing – Oracle XML DB performs the required processing by constructing a DOM from the contents of the `XMLType` object. It uses methods provided by the DOM API to perform the required operation on the DOM. If the operation involves updating the DOM tree, then the entire XML document has to be written back to disk when the operation is completed. The process of using DOM-based operations on `XMLType` data is referred to as **functional evaluation**.

  The advantage of functional evaluation is that it can be used regardless of the storage model (structured, binary XML, or unstructured) used for the `XMLType` instance. The disadvantage of functional evaluation is that it much more *expensive* than XPath rewrite, and *does not scale* across large numbers of XML documents.

- SQL-based `XMLType` processing – Oracle XML DB constructs a SQL statement that performs the processing required to complete the function or method. The SQL statement works directly against the object-relational data structures that underlie a schema-based `XMLType`. This process is referred to as **XPath rewrite**. See Chapter 7, "XPath Rewrite".

  The advantage of XPath rewrite is that it lets Oracle XML DB evaluate XPath-based SQL functions and methods at near *relational speeds*. This lets these operations scale across *large numbers of XML documents*. The disadvantage of XPath rewrite is that since it relies on direct access and updating the objects used to store the XML document, it can be used only when the `XMLType` instance is stored using XML *schema-based object-relational* storage techniques.

- Streaming evaluation of binary XML data – If you use binary XML as the storage model, then XPath expressions used in SQL functions such as `XMLQuery`, `XMLTable`, `XMLExists`, `XMLCast`, `extract`, and `extractValue` are evaluated in a streaming fashion, without recourse to building a DOM.

Understanding and Optimizing XPath Rewrite

XPath rewrite improves the performance of SQL statements containing XPath-based functions by converting the functions into conventional relational SQL statements. This insulates the database optimizer from having to understand the XPath notation and the XML data model. The database optimizer processes the rewritten SQL statement in the same manner as any other SQL statement. In this way, it can derive an execution plan based on conventional relational algebra. This results in the execution of SQL statements with XPath-based functions with near relational performance.

For XPath rewrite to take place the following conditions must be satisfied:

- The `XMLType` column or table must be stored using *structured* (object-relational) storage techniques.
- The `XMLType` column or table containing the XML documents must be based on a *registered XML schema*.
- It must be possible to map the nodes referenced by the XPath expression to attributes of the underlying SQL object model.

Understanding the concept of XPath rewrite and the conditions under which XPath rewrite takes place is key to developing Oracle XML DB applications that deliver satisfactory levels of scalability and performance.

See Also: Chapter 7, "XPath Rewrite"

Using EXPLAIN PLAN to Tune XPath Rewrite

XPath rewrite on its own cannot guarantee scalable and performant applications. The performance of SQL statements generated by XPath rewrite is ultimately determined by the available indexes and the way data is stored on disk. Also, as with any other SQL application, a DBA must monitor the database and optimize storage and indexes if the application is to perform well.

The good news, from a DBA perspective, is that this information is nothing new. The same skills are required to tune an XML application as for any other database application. All of the tools that DBAs typically use with SQL-based applications can be applied to XML-based applications using Oracle XML DB functions.

Example 3–40 Using EXPLAIN PLAN to Analyze the Selection of PurchaseOrders

This example shows how to use an `EXPLAIN PLAN` to look at the execution plan for selecting the set of `PurchaseOrders` created by user `SBELL`.

```
EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') "Reference"
    FROM purchaseorder
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[User="SBELL"]') = 1;

Explained.

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------------------
Plan hash value: 713050960

-------------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                      | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                           |     1 |    24 |     2   (0)| 00:00:01 |
|   1 |  TABLE ACCESS BY INDEX ROWID| PURCHASEORDER             |     1 |    24 |     2   (0)| 00:00:01 |
|*  2 |   INDEX RANGE SCAN           | PURCHASEORDER_USER_INDEX |     1 |       |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("PURCHASEORDER"."SYS_NC00022$"='SBELL')

Note
-----
   - dynamic sampling used for this statement

18 rows selected.
```

Using Indexes to Improve the Performance of XPath-Based Functions

Oracle XML DB supports the creation of the following kinds of index on XML content:

- `XMLIndex` indexes (unstructured and binary XML storage only)
- B-tree indexes other than function-based (structured storage only)
- Function-based indexes

- Oracle Text-based indexes (CONTEXT)

XMLIndex indexes can be created on XML fragments that are stored in CLOB instances, even when the rest of the XML document is stored object-relationally—this is sometimes called **hybrid** storage. XMLIndex indexes do not require you to know in advance which XPath expressions you will use in queries. XPath rewrite applies only to structured storage, and XMLIndex does not apply to structured storage.

With structured storage of an XMLType table or column, B-tree indexes can be created on the underlying SQL types. Oracle Text-based indexes and function-based indexes can be created on any XMLType table or column, no matter how it is stored.

With structured storage, XPath-rewrite analysis determines whether it is possible to map the nodes referenced in the XPath expression used in a CREATE INDEX statement to object attributes of the underlying SQL data types. If so, then a B-tree index is created on the underlying SQL objects. Otherwise, a function-based index is created. Function-based indexes are typically based on SQL function extractValue, although you sometimes base them on other functions, such as existsNode.

Example 3–41 Creating an Index on a Text Node

This example shows creation of index purchaseorder_user_index on the value of the User element text node. Table purchaseorder, in standard database schema OE, is stored object-relationally.

```
CREATE INDEX purchaseorder_user_index
  ON purchaseorder (extractValue(OBJECT_VALUE, '/PurchaseOrder/User'));
```

At first glance, the index appears to be function-based (based on function extractValue). However, because the XMLType table being indexed is stored object-relationally, XPath-rewrite analysis determines that a B-tree index can be created on the underlying SQL data types. In this example, the index is created on the userid attribute of the purchaseorder_t object.

Example 3–42 shows the EXPLAIN PLAN that is generated when the query used in Example 3–40 is executed after the index has been created as in Example 3–41. The query plan makes use of the newly created B-tree index, and is much more scalable than the query plan of Example 3–40.

Example 3–42 Explain Plan Showing Use of a B-Tree Index

```
EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') "Reference"
    FROM purchaseorder
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[User="SBELL"]') = 1;

Explained.

PLAN_TABLE_OUTPUT
-----------------------------------------------------------------------------------------------------
Plan hash value: 713050960

-----------------------------------------------------------------------------------------------------
| Id  | Operation                   | Name                       | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT            |                            |     1 |    24 |     3   (0)| 00:00:01 |
|   1 |  TABLE ACCESS BY INDEX ROWID| PURCHASEORDER              |     1 |    24 |     3   (0)| 00:00:01 |
|*  2 |   INDEX RANGE SCAN          | PURCHASEORDER_USER_INDEX   |     1 |       |     1   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
```

```
   2 - access("PURCHASEORDER"."SYS_NC00022$"='SBELL')

18 rows selected.
```

See Also: "XPath Rewrite for EXTRACTVALUE Indexes on Singleton Elements or Attributes" on page 5-7

Accessing Members of Collections of Repeating Elements

Most XML documents contain collections of repeating elements. For Oracle XML DB to efficiently process the collection members, it is important that the storage model for managing the collection provide an efficient way of accessing the individual members of the collection. The storage model used determines whether it is possible to index individual elements within the collection and perform direct operations on them.

- If a collection is stored as an ordered collection table or an `XMLType` instance, then you can directly access members of the collection. Each member of the collection becomes a row in a table, so you can access it directly with SQL.
- If a collection is stored as a LOB, then you *cannot* directly access members of the collection. If a collection is stored as XML text in a `CLOB` value, then any operation on it requires parsing the `CLOB` contents and then using functional evaluation to perform the required operation. This is costly, in terms of performance.

  If you convert a collection into a set of SQL objects that are serialized into a LOB, then this removes the parsing cost. However, the collection must still be loaded into memory before any operations on individual collection members can be performed.

Using Indexes to Tune Queries on Collections Stored as OCTs

Example 3–43 shows the execution plan for a query to find the `Reference` elements in documents that contain an order for part number 717951002372 (`Part` element with an `Id` attribute of value `717951002372`). The collection of `LineItem` elements is stored as rows in the ordered collection table `lineitem_table`.

Example 3–43 EXPLAIN PLAN for a Selection of Collection Elements

```
EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') "Reference"
    FROM purchaseorder
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem/Part[@Id="717951002372"]') = 1;

Explained.

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 28173485

-------------------------------------------------------------------------------------------
| Id  | Operation             | Name               | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT      |                    |    21 |   966 |    20  (10)| 00:00:01 |
|*  1 |  HASH JOIN RIGHT SEMI |                    |    21 |   966 |    20  (10)| 00:00:01 |
|   2 |   TABLE ACCESS FULL   | PURCHASEORDER      |   132 |  3564 |     5   (0)| 00:00:01 |
|*  3 |   TABLE ACCESS FULL   | LINEITEM_TABLE     |    22 |   418 |    14   (8)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
```

```
   1 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")
   3 - filter("SYS_NC00011$"='717951002372')

Note
-----
   - dynamic sampling used for this statement

20 rows selected.
```

The execution plan shows a full scan of ordered collection table `lineitem_table`. This might be acceptable if there are only a few hundred documents in the `purchaseorder` table, but it would be unacceptable if there were thousands or millions of documents in the table.

To improve the performance of such a query, you can create an index that provides direct access to pseudocolumn `NESTED_TABLE_ID`, given the value of attribute `Id`. Unfortunately, Oracle XML DB does not allow indexes on collections to be created using XPath expressions directly. To create the index, you must understand the structure of the SQL object that is used to manage the `LineItem` elements. Given this information, you can create the required index using conventional object-relational SQL.

In this case, element `LineItem` is stored as an instance of object type `lineitem_t`. Element `Part` is stored as an instance of SQL data type `part_t`. XML attribute `Id` is mapped to object attribute `part_number`. Given this information, you can create a *composite index* on attribute `part_number` and pseudocolumn `NESTED_TABLE_ID`, as shown in Example 3–44. This index provides direct access to those purchase-order documents that have `LineItem` elements that reference the required part.

Example 3–44 Creating an Index for Direct Access to an Ordered Collection Table

```
CREATE INDEX lineitem_part_index ON lineitem_table l (l.part.part_number, l.NESTED_TABLE_ID);

Index created.

EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') "Reference"
    FROM purchaseorder
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem/Part[@Id="717951002372"]') = 1;

Explained.

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------------------
Plan hash value: 1849679771

-------------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                    | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                         |    22 |  1012 |     4  (25)| 00:00:01 |
|   1 |  NESTED LOOPS                |                         |       |       |            |          |
|   2 |   NESTED LOOPS               |                         |    22 |  1012 |     4  (25)| 00:00:01 |
|   3 |    SORT UNIQUE               |                         |    22 |   418 |     2   (0)| 00:00:01 |
|*  4 |     INDEX RANGE SCAN         | LINEITEM_PART_INDEX     |    22 |   418 |     2   (0)| 00:00:01 |
|*  6 |    INDEX UNIQUE SCAN         | LINEITEM_TABLE_MEMBERS  |     1 |       |     0   (0)| 00:00:01 |
|*  7 |   TABLE ACCESS BY INDEX ROWID| PURCHASEORDER           |     1 |   530 |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   4 - access("SYS_NC00011$"='717951002372')
   5 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")
```

```
19 rows selected.
```

The EXPLAIN PLAN output shows that the same query as in Example 3–44 now makes use of the newly created index. The query is resolved by using index lineitem_part_index to determine which documents in table purchaseorder satisfy the condition in the XPath-expression argument to function existsNode.

The query is now much more scalable, with no change to its syntax. XPath rewrite lets the optimizer analyze the query, and this analysis determines that indexes purchaseorder_user_index and lineitem_part_index provide a more efficient way to resolve the queries.

EXPLAIN PLAN with ACL-Based Security Enabled: SYS_CHECKACL Filter

The EXPLAIN PLAN output for a query on an XMLType table created as a result of calling PL/SQL procedure DBMS_XMLSCHEMA.register_schema contains a filter similar to the following:

```
3 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype(''<privilege
              xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
              xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
              http://xmlns.oracle.com/xdb/acl.xsd
              DAV:http://xmlns.oracle.com/xdb/dav.xsd">
                        <read-properties/><read-contents/></privilege>''))=1)
```

This shows that ACL-based security is implemented for this table. In this example, the filter checks that the user performing the SQL query has read-contents privilege on each of the documents to be accessed.

Oracle XML DB Repository uses an ACL-based security mechanism that provides control of access to XML content document by document, rather than only table by table. When XML content is accessed using a SQL statement, a call to sys_checkACL is automatically added to the WHERE clause to ensure that the security defined is enforced at the SQL level.

However, enforcing ACL-based security adds overhead to the SQL query. If ACL-based security is *not* required, use procedure disable_hierarchy in package DBMS_XDBZ to turn *off* ACL checking. After calling this procedure, the sys_checkACL filter no longer appears in the output generated by EXPLAIN PLAN.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about procedure DBMS_XDBZ.disable_hierarchy

Example 3–45 shows the kind of EXPLAIN PLAN output that is generated when Oracle XML DB cannot perform XPath rewrite. Function existsNode appears in the output (line 3), indicating that the query is not rewritten.

Example 3–45 EXPLAIN PLAN Generated When XPath Rewrite Does Not Occur

```
Predicate Information (identified by operation id):
---------------------------------------------------
   1 - access("NESTED_TABLE_ID"=:B1)
   2 - access("NESTED_TABLE_ID"=:B1)
   3 - filter(EXISTSNODE(SYS_MAKEXML('C0A5497E8DCF110BE034080020E5CF39',
                                     3044, "SYS_ALIAS_4". "XMLEXTRA",
                                     "SYS_ALIAS_4"."XMLDATA"),
                         '/PurchaseOrder[User="SBELL"]')
              =1)
```

```
5 - access("NESTED_TABLE_ID"=:B1)
6 - access("NESTED_TABLE_ID"=:B1)
```

In this situation, Oracle XML DB constructs a pre-filtered result set based on any other conditions specified in the query `WHERE` clause. It then filters the rows in this potential result set to determine which rows belong in the result set. The filtering is performed by *constructing a DOM on each document* and performing a *functional evaluation* (using the methods defined by the DOM API) to determine whether or not each document is a member of the result set.

Performance can be poor when there are many documents in the potential result set. However, when the use of additional predicates in the `WHERE` clause leads to a small number of documents in the potential result set, this may be not be a problem.

`XMLType` and XPath abstractions make it possible for you to develop applications that are independent of the underlying storage technology. As in conventional relational applications, creating and dropping indexes makes it possible to tune the performance of an application without having to rewrite it.

Accessing Relational Database Content Using XML

Oracle XML DB provides a number of ways to generate XML from relational data. The most powerful and flexible method is based on the evolving SQL/XML standard. This ANSI standard defines a set of SQL functions that allow XML to be generated directly from a `SELECT` statement. Using these functions, a query can generate one or more XML documents, rather than a traditional tabular result set. The SQL/XML standard functions allow almost any shape of XML data to be generated. These functions include the following:

- `XMLElement` creates a element
- `XMLAttributes` adds attributes to an element
- `XMLForest` creates forest of elements
- `XMLAgg` creates a single element from a collection of elements

See Also: Chapter 17, "Generating XML Data from the Database"

Example 3–46 Using SQL/XML Functions to Generate XML

This query generates an XML document that contains information from the tables `departments`, `locations`, `countries`, `employees`, and `jobs`:

```
SELECT XMLElement(
         "Department",
         XMLAttributes(d.Department_id AS "DepartmentId"),
         XMLForest(d.department_name AS "Name"),
         XMLElement(
           "Location",
           XMLForest(street_address AS "Address",
                     city AS "City",
                     state_province AS "State",
                     postal_code AS "Zip",
                     country_name AS "Country")),
           XMLElement(
             "EmployeeList",
             (SELECT XMLAgg(
                       XMLElement(
                         "Employee",
                         XMLAttributes(e.employee_id AS "employeeNumber"),
```

```
                        XMLForest(
                          e.first_name AS "FirstName",
                          e.last_name AS "LastName",
                          e.email AS "EmailAddress",
                          e.phone_number AS "PHONE_NUMBER",
                          e.hire_date AS "StartDate",
                          j.job_title AS "JobTitle",
                          e.salary AS "Salary",
                          m.first_name || ' ' || m.last_name AS "Manager"),
                        XMLElement("Commission", e.commission_pct)))
                FROM hr.employees e, hr.employees m, hr.jobs j
                WHERE e.department_id = d.department_id
                  AND j.job_id = e.job_id
                  AND m.employee_id = e.manager_id)))
  AS XML
  FROM hr.departments d, hr.countries c, hr.locations l
  WHERE department_name = 'Executive'
    AND d.location_id = l.location_id
    AND l.country_id  = c.country_id;
```

The query returns the following XML:

```
XML
--------------------------------------------------------------------------------
<Department DepartmentId="90"><Name>Executive</Name><Location><Address>2004
 Charade Rd</Address><City>Seattle</City><State>Washingto
n</State><Zip>98199</Zip><Country>United States of
 America</Country></Location><EmployeeList><Employee
 employeeNumber="101"><FirstNa
me>Neena</FirstName><LastName>Kochhar</LastName><EmailAddress>NKOCHHAR</EmailAdd
ess><PHONE_NUMBER>515.123.4568</PHONE_NUMBER><Start
Date>1989-09-21</StartDate><JobTitle>Administration Vice
 President</JobTitle><Salary>17000</Salary><Manager>Steven King</Manager><Com
mission></Commission></Employee><Employee
 employeeNumber="102"><FirstName>Lex</FirstName><LastName>De
 Haan</LastName><EmailAddress>L
DEHAAN</EmailAddress><PHONE_NUMBER>515.123.4569</PHONE
NUMBER><StartDate>1993-01-13</StartDate><JobTitle>Administration Vice Presiden
t</JobTitle><Salary>17000</Salary><Manager>Steven
 King</Manager><Commission></Commission></Employee></EmployeeList></Department>
```

This query generates element `Department` for each row in the `departments` table.

- Each `Department` element contains attribute `DepartmentID`. The value of `DepartmentID` comes from the `department_id` column. The `Department` element contains sub-elements `Name`, `Location`, and `EmployeeList`.
- The text node associated with the `Name` element will come from the `name` column in the `departments` table.
- The `Location` element will have child elements `Address`, `City`, `State`, `Zip`, and `Country`. These elements are constructed by creating a forest of named elements from columns in the `locations` and `countries` tables. The values in the columns become the text node for the named element.
- The `EmployeeList` element will contain an aggregation of `Employee` Elements. The content of the `EmployeeList` element is created by a subquery that returns the set of rows in the `employees` table that correspond to the current department. Each `Employee` element will contain information about the employee. The contents of the elements and attributes for each `Employee` element is taken from tables `employees` and `jobs`.

The output generated by the SQL/XML functions is *not* pretty-printed. This lets these functions avoid creating a full DOM when generating the required output, and reduce the size of the generated document. This lack of pretty-printing by SQL/XML functions will not matter to most applications. However, it makes verifying the generated output manually more difficult.

Example 3–47 Creating XMLType Views Over Conventional Relational Tables

```
CREATE OR REPLACE VIEW department_xml OF XMLType
  WITH OBJECT ID (substr(extractValue(OBJECT_VALUE, '/Department/Name'), 1, 128))
  AS
  SELECT XMLElement(
           "Department",
           XMLAttributes(d.department_id AS "DepartmentId"),
           XMLForest(d.department_name AS "Name"),
           XMLElement("Location", XMLForest(street_address AS "Address",
                                            city AS "City",
                                            state_province AS "State",
                                            postal_code AS "Zip",
                                            country_name AS "Country")),
           XMLElement(
             "EmployeeList",
             (SELECT XMLAgg(
                       XMLElement(
                         "Employee",
                         XMLAttributes (e.employee_id AS "employeeNumber" ),
                         XMLForest(e.first_name AS "FirstName",
                                   e.last_name AS "LastName",
                                   e.email AS "EmailAddress",
                                   e.phone_number AS "PHONE_NUMBER",
                                   e.hire_date AS "StartDate",
                                   j.job_title AS "JobTitle",
                                   e.salary AS "Salary",
                                   m.first_name || ' ' ||
                                   m.last_name AS "Manager"),
                         XMLElement("Commission", e.commission_pct)))
                FROM hr.employees e, hr.employees m, hr.jobs j
                WHERE e.department_id = d.department_id
                  AND j.job_id = e.job_id
                  AND m.employee_id = e.manager_id))).extract('/*')
    AS XML
    FROM hr.departments d, hr.countries c, hr.locations l
    WHERE d.location_id = l.location_id
      AND l.country_id  = c.country_id;

View created.
```

The `XMLType` view lets relational data be persisted as XML content. Rows in `XMLType` views can be persisted as documents in Oracle XML DB Repository. The contents of an `XMLType` view can be queried, as shown in Example 3–48.

Example 3–48 Querying XMLType Views

This example shows a simple query against an `XMLType` view. The XPath expression passed to SQL function `existsNode` restricts the result set to the node that contains the `Executive` department information. The result is shown pretty-printed here for clarity.

```
SELECT OBJECT_VALUE FROM department_xml
  WHERE existsNode(OBJECT_VALUE, '/Department[Name="Executive"]') = 1;
```

```
OBJECT_VALUE
------------------------------------------------
<Department DepartmentId="90">
  <Name>Executive</Name>
  <Location>
    <Address>2004 Charade Rd</Address>
    <City>Seattle</City>
    <State>Washington</State>
    <Zip>98199</Zip>
    <Country>United States of America</Country>
  </Location>
  <EmployeeList>
    <Employee employeeNumber="101">
      <FirstName>Neena</FirstName>
      <LastName>Kochhar</LastName>
      <EmailAddress>NKOCHHAR</EmailAddress>
      <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
      <StartDate>1989-09-21</StartDate>
      <JobTitle>Administration Vice President</JobTitle>
      <Salary>17000</Salary>
      <Manager>Steven King</Manager>
      <Commission/>
    </Employee>
    <Employee employeeNumber="102">
      <FirstName>Lex</FirstName>
      <LastName>De Haan</LastName>
      <EmailAddress>LDEHAAN</EmailAddress>
      <PHONE_NUMBER>515.123.4569</PHONE_NUMBER>
      <StartDate>1993-01-13</StartDate>
      <JobTitle>Administration Vice President</JobTitle>
      <Salary>17000</Salary>
      <Manager>Steven King</Manager>
      <Commission/>
    </Employee>
  </EmployeeList>
</Department>

1 row selected.
```

As can be seen from the following `EXPLAIN PLAN` output, Oracle XML DB is able to correctly rewrite the XPath-expression argument in the `existsNode` expression into a `SELECT` statement on the underlying relational tables.

```
EXPLAIN PLAN FOR
SELECT OBJECT_VALUE FROM department_xml
  WHERE existsNode(OBJECT_VALUE, '/Department[Name="Executive"]') = 1;

Explained.

PLAN_TABLE_OUTPUT
-----------------------------------------------------------------------------------------------------
Plan hash value: 2414180351

-----------------------------------------------------------------------------------------------
| Id  | Operation                     | Name              | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |                   |     1 |    80 |     3   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE               |                   |     1 |   114 |            |          |
|*  2 |   HASH JOIN                   |                   |    10 |  1140 |     7  (15)| 00:00:01 |
|*  3 |    HASH JOIN                  |                   |    10 |   950 |     5  (20)| 00:00:01 |
|   4 |     TABLE ACCESS BY INDEX ROWID| EMPLOYEES         |    10 |   680 |     2   (0)| 00:00:01 |
```

```
|*  5 |      INDEX RANGE SCAN          | EMP_DEPARTMENT_IX |    10 |       |     1   (0)| 00:00:01 |
|   6 |     TABLE ACCESS FULL          | JOBS              |    19 |   513 |     2   (0)| 00:00:01 |
|   7 |    TABLE ACCESS FULL           | EMPLOYEES         |   107 |  2033 |     2   (0)| 00:00:01 |
|   8 |  NESTED LOOPS                  |                   |     1 |    80 |     3   (0)| 00:00:01 |
|   9 |   NESTED LOOPS                 |                   |     1 |    68 |     3   (0)| 00:00:01 |
|* 10 |    TABLE ACCESS FULL           | DEPARTMENTS       |     1 |    19 |     2   (0)| 00:00:01 |
|  11 |    TABLE ACCESS BY INDEX ROWID | LOCATIONS         |     1 |    49 |     1   (0)| 00:00:01 |
|* 12 |     INDEX UNIQUE SCAN          | LOC_ID_PK         |     1 |       |     0   (0)| 00:00:01 |
|* 13 |   INDEX UNIQUE SCAN            | COUNTRY_C_ID_PK   |     1 |    12 |     0   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("M"."EMPLOYEE_ID"="E"."MANAGER_ID")
   3 - access("J"."JOB_ID"="E"."JOB_ID")
   5 - access("E"."DEPARTMENT_ID"=:B1)
  10 - filter("D"."DEPARTMENT_NAME"='Executive')
  12 - access("D"."LOCATION_ID"="L"."LOCATION_ID")
  13 - access("L"."COUNTRY_ID"="C"."COUNTRY_ID")

30 rows selected.
```

Note: XPath rewrite on XML expressions that operate on `XMLType` views is only supported when nodes referenced in the XPath expression are *not* descendants of an element created using SQL function `XMLAgg`.

Generating XML From Relational Tables Using DBURIType

Another way to generate XML from relational data is with SQL function `DBURIType`. Function `DBURIType` exposes one or more rows in a given table or view as a single XML document. The name of the root element is derived from the name of the table or view. The root element contains a set of `ROW` elements. There is one `ROW` element for each row in the table or view. The children of each `ROW` element are derived from the columns in the table or view. Each child element contains a text node with the value of the column for the given row.

Example 3–49 Accessing DEPARTMENTS Table XML Content Using DBURIType and getXML()

This example shows how to use SQL function `DBURIType` to access the contents of the `departments` table in schema `hr`. The example uses method `getXML()` to return the resulting document as an `XMLType` instance.

```
SELECT DBURIType('/HR/DEPARTMENTS').getXML() FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS').GETXML()
-------------------------------------------------------
<?xml version="1.0"?>
<DEPARTMENTS>
 <ROW>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
  <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>
  <MANAGER_ID>200</MANAGER_ID>
  <LOCATION_ID>1700</LOCATION_ID>
 </ROW>
...
 <ROW>
  <DEPARTMENT_ID>20</DEPARTMENT_ID>
```

```
  <DEPARTMENT_NAME>Marketing</DEPARTMENT_NAME>
  <MANAGER_ID>201</MANAGER_ID>
  <LOCATION_ID>1800</LOCATION_ID>
 </ROW>
</DEPARTMENTS>
```

SQL function `DBURIType` lets XPath notation be used to control how much of the data in the table or view is returned when the table or view is accessed using `DBURIType`. Predicates in the XPath expression allow control over which of the rows in the table are included in the generated document.

Example 3–50 Using a Predicate in the XPath Expression to Restrict Which Rows Are Included

This example demonstrates how to use a predicate in an XPath expression to restrict the rows that are included in the generated XML document. Here, the XPath expression restricts the XML document to `DEPARTMENT_ID` columns with value `10`.

```
SELECT DBURIType('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]').getXML()
  FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]').GETXML()
--------------------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
  <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>
  <MANAGER_ID>200</MANAGER_ID>
  <LOCATION_ID>1700</LOCATION_ID>
 </ROW>

1 row selected.
```

As can be seen from the examples in this section, SQL function `DBURIType` provides a simple way to expose some or all rows in a relational table as one or more XML documents. The URL passed to function `DBURIType` can be extended to return a single column from the view or table, but in that case the URL must also include predicates that identify a single row in the target table or view. For example, the following URI would return just the value of the `department_name` column for the `departments` row where the `department_id` column has value `10`.

```
SELECT DBURIType(
         '/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]/DEPARTMENT_NAME').getXML()
  FROM DUAL;

DBURITYPE('/HR/DEPARTMENTS/ROW[DEPARTMENT_ID="10"]/DEPARTMENT_NAME').GETXML()
--------------------------------------------------------------------------------
<?xml version="1.0"?>
 <DEPARTMENT_NAME>Administration</DEPARTMENT_NAME>

1 row selected.
```

SQL function `DBURIType` does not provide the flexibility of the SQL/XML functions: `DBURIType` provides no way to control the shape of the generated document. The data can only come from a single table or view. The generated document consists of one or more `ROW` elements. Each `ROW` element contains a child for each column in the target table. The names of the child elements are derived from the column names.

To control the names of the XML elements, to include columns from more than one table, or to control which columns from a table appear in the generated document,

create a relational view that exposes the desired set of columns as a single row, and then use function DBURIType to generate an XML document from the contents of that view.

XSL Transformation and Oracle XML DB

The W3C XSLT Recommendation defines an XML language for specifying how to transform XML documents from one form to another. Transformation can include mapping from one XML schema to another or mapping from XML to some other format such as HTML or WML.

> **See Also:** http://www.w3.org/XML/Schema for information about the XSLT standard

XSL transformation is typically expensive in terms of the amount of memory and processing required. Both the source document and the style sheet need to be parsed and loaded into memory structures that allow random access to different parts of the documents. Most XSL processors use DOM to provide the in-memory representation of both documents. The XSL processor then applies the style sheet to the source document, generating a third document.

Oracle XML DB includes an XSLT processor that lets XSL transformations be performed *inside the database*. In this way, Oracle XML DB can provide XML-specific memory optimizations that significantly reduce the memory required to perform the transformation. It can also eliminate overhead associated with parsing the documents. These optimizations are only available when the source for the transformation is a *schema-based* XML document, however.

Oracle XML provides three ways to invoke the XSL processor:

- SQL function XMLtransform
- XMLType method transform()
- PL/SQL package DBMS_XSLPROCESSOR

Of these different ways to transform XML data, DBMS_XSLPROCESSOR has the best performance, because the style sheet is parsed only once.

Each of these XML transformation methods takes as input a source XML document and an XSL style sheet in the form of XMLType instances. For SQL function XMLtransform and XMLType method transform(), the result of the transformation can be an XML document or a non-XML document, such as HTML. However, for PL/SQL package DBMS_XSLPROCESSOR, the result of the transformation is expected to be a valid XML document. This means that any HTML generated by a transformation using package DBMS_XSLPROCESSOR must be XHTML, which is both valid XML and valid HTML.

Example 3–51 XSLT Style Sheet Example: PurchaseOrder.xsl

This example shows *part* of an XSLT style sheet, PurchaseOrder.xsl. The complete style sheet is given in "XSL Style Sheet Example, PurchaseOrder.xsl" on page A-34.

```
<?xml version="1.0" encoding="WINDOWS-1252"?>
<xsl:stylesheet version="1.0"
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:xdb="http://xmlns.oracle.com/xdb"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:template match="/">
    <html>
      <head/>
```

```
<body bgcolor="#003333" text="#FFFFCC" link="#FFCC00" vlink="#66CC99" alink="#669999">
  <FONT FACE="Arial, Helvetica, sans-serif">
    <xsl:for-each select="PurchaseOrder"/>
    <xsl:for-each select="PurchaseOrder">
      <center>
        <span style="font-family:Arial; font-weight:bold">
          <FONT COLOR="#FF0000">
            <B>PurchaseOrder </B>
          </FONT>
        </span>
      </center>
      <br/>
      <center>
        <xsl:for-each select="Reference">
          <span style="font-family:Arial; font-weight:bold">
            <xsl:apply-templates/>
          </span>
        </xsl:for-each>
      </center>
    </xsl:for-each>
    <P>
      <xsl:for-each select="PurchaseOrder">
        <br/>
      </xsl:for-each>
      <P/>
      <P>
        <xsl:for-each select="PurchaseOrder">
          <br/>
        </xsl:for-each>
      </P>
    </P>
    <xsl:for-each select="PurchaseOrder"/>
    <xsl:for-each select="PurchaseOrder">
      <table border="0" width="100%" BGCOLOR="#000000">
        <tbody>
          <tr>
            <td WIDTH="296">
              <P>
                <B>
                  <FONT SIZE="+1" COLOR="#FF0000" FACE="Arial, Helvetica, sans-serif">Internal</FONT>
                </B>
              </P>

              ...

            </td>
            <td width="93"/>
            <td valign="top" WIDTH="340">
              <B>
                <FONT COLOR="#FF0000">
                  <FONT SIZE="+1">Ship To</FONT>
                </FONT>
              </B>
              <xsl:for-each select="ShippingInstructions">
                <xsl:if test="position()=1"/>
              </xsl:for-each>
              <xsl:for-each select="ShippingInstructions">
              </xsl:for-each>

                ...
```

These is nothing Oracle XML DB-specific about this style sheet. The style sheet can be stored in an `XMLType` table or column, or stored as non-schema-based XML inside Oracle XML DB Repository.

Performing transformations inside the database lets Oracle XML DB optimize features such as memory usage, I/O operations, and network traffic. These optimizations are particularly effective when the transformation operates on a *small subset* of the nodes in the source document.

In traditional XSL processors, the entire source document must be parsed and loaded into memory before XSL processing can begin. This process requires significant amounts of memory and processor. When only a small part of the document is processed this is inefficient.

When Oracle XML DB performs XSL transformations on a *schema-based* XML document there is no need to parse the document before processing can begin. The lazily loaded virtual DOM eliminates the need to parse the document, by loading content directly from disk as the nodes are accessed. The lazy load also reduces the amount of memory required to perform the transformation, because only the parts of the document that are processed are loaded into memory.

Example 3–52 Applying a Style Sheet Using TRANSFORM

This example shows how to use SQL function `XMLtransform` to apply an XSL style sheet to a document stored in an `XMLType` table, producing HTML code. SQL function `XDBURIType` reads the XSL style sheet from Oracle XML DB Repository.

In the interest of brevity, only part of the result of the transformation is shown here; omitted parts are indicated with an ellipsis (`. . .`). Figure 3–7 shows what the transformed result looks like in a Web browser.

```
SELECT
  XMLtransform(
    OBJECT_VALUE,
    XDBURIType('/source/schemas/poSource/xsl/purchaseOrder.xsl').getXML())
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]')=1;

XMLTRANSFORM(OBJECT_VALUE, XDBURITYPE('/SOURCE/SCHEMAS/POSOURCE/XSL/PURCHASEORDER.XSL').GET
--------------------------------------------------------------------------------------------
<html>
  <head/>
  <body bgcolor="#003333" text="#FFFFCC" link="#FFCC00" vlink="#66CC99" alink="#669999">
    <FONT FACE="Arial, Helvetica, sans-serif">
      <center>
        <span style="font-family:Arial; font-weight:bold">
          <FONT COLOR="#FF0000">
            <B>PurchaseOrder </B>
          </FONT>
        </span>
      </center>
      <br/>
      <center>
        <span style="font-family:Arial; font-weight:bold">SBELL-2002100912333601PDT</span>
      </center>
      <P>
        <br/>
        <P/>
        <P>
          <br/>
        </P>
      </P>
      <table border="0" width="100%" BGCOLOR="#000000">
        <tbody>
          <tr>
            <td WIDTH="296">
              <P>
```

```
                  <B>
                    <FONT SIZE="+1" COLOR="#FF0000" FACE="Arial, Helvetica,
                          sans-serif">Internal</FONT>
                  </B>
                </P>
                <table border="0" width="98%" BGCOLOR="#000099">
                                                                  . . .
                </table>
              </td>
              <td width="93"/>
              <td valign="top" WIDTH="340">
                <B>
                  <FONT COLOR="#FF0000">
                    <FONT SIZE="+1">Ship To</FONT>
                  </FONT>
                </B>
                <table border="0" BGCOLOR="#999900">
                  . . .
                </table>
              </td>
            </tr>
          </tbody>
        </table>
        <br/>
        <B>
          <FONT COLOR="#FF0000" SIZE="+1">Items:</FONT>
        </B>
        <br/>
        <br/>
        <table border="0">
          . . .
        </table>
      </FONT>
    </body>
</html>

1 row selected.
```

See Also: Chapter 10, "Transforming and Validating XMLType Data"

Using Oracle XML DB Repository

Oracle XML DB Repository makes it possible to organize XML content using a file/folder metaphor. This lets you use a URL to uniquely identify XML documents stored in the database. This approach appeals to XML developers used to using constructs such as URLs and XPath expressions to identify content.

Oracle XML DB Repository is modelled on the DAV standard. The DAV standard uses the term **resource** to describe any file or folder managed by a WebDAV server. A resource consists of a combination of metadata and content. The DAV specification defines the set of (system-defined) metadata properties that a WebDAV server is expected to maintain for each resource and the set of XML documents that a DAV server and DAV-enabled client uses to exchange metadata.

Although Oracle XML DB Repository can manage any kind of content, it provides specialized capabilities and optimizations related to managing resources where the content is XML.

Installing and Uninstalling Oracle XML DB Repository

All of the metadata and content managed by Oracle XML DB Repository is stored using a set of tables in the database schema owned by database schema (user account) `XDB`. User `XDB` is a locked account that is installed using DBCA or by running script `catqm.sql`. Script `catqm.sql` is located in the directory `ORACLE_HOME/rdbms/admin`. The repository can be uninstalled using DBCA or by running the script `catnoqm.sql`. Great care should be taken when running `catnoqm.sql` as this will drop all content stored in Oracle XML DB Repository and invalidate any `XMLType` tables or columns associated with registered XML schemas.

> **See Also:** *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Oracle XML DB Provides Name-Level Locking

When using a relational database to maintain hierarchical folder structures, ensuring a high degree of concurrency when adding and removing items in a folder is a challenge. In conventional file system there is no concept of a transaction. Each operation (add a file, create a subfolder, rename a file, delete a file, and so on) is treated as an atomic transaction. Once the operation has completed the change is immediately available to all other users of the file system.

> **Note:** As a consequence of transactional semantics enforced by the database, folders created using SQL statements will *not* be visible to other database users until the transaction is committed. *Concurrent* access to Oracle XML DB Repository is controlled by the same mechanism used to control concurrency in Oracle Database. The integration of the repository with Oracle Database provides *strong management options for XML content*.

One key advantage of Oracle XML DB Repository is the ability to use SQL for repository operations in the context of a logical transaction. Applications can create long-running transactions that include updates to one or more folders. In this situation, a conventional locking strategy that takes an exclusive lock on each updated folder or directory tree would quickly result in significant concurrency problems.

Queued Folder Modifications are Locked Until Committed

Oracle XML DB solves this by providing for name-level locking rather than folder-level locking. Repository operations such as creating, renaming, moving, or deleting a sub-folder or file do not require that your operation be granted an exclusive write lock on the target folder. The repository manages concurrent folder operations by locking the name within the folder rather than the folder itself. The name and the modification type are put on a queue.

Only when the transaction is committed is the folder locked and its contents modified. Hence Oracle XML DB lets multiple applications perform concurrent updates on the contents of a folder. The queue is also used to manage folder concurrency by preventing two applications from creating objects with the same name.

Queuing folder modifications until commit time also minimizes I/O when a number of changes are made to a single folder in the same transaction.

This is useful when several applications generate files quickly in the same directory, for example when generating trace or log files, or when maintaining a spool directory for printing or email delivery.

Use Protocols or SQL to Access and Process Repository Content

You can work with content stored in Oracle XML DB Repository in these ways:

- Using industry standard protocols such as HTTP(S), WebDAV, and FTP to perform document-level operations such as insert, update, and delete.
- By directly accessing Oracle XML DB Repository content at the table or row level, using SQL.
- Using Oracle XML DB Content Connector—see Chapter 31, "Using Oracle XML DB Content Connector".

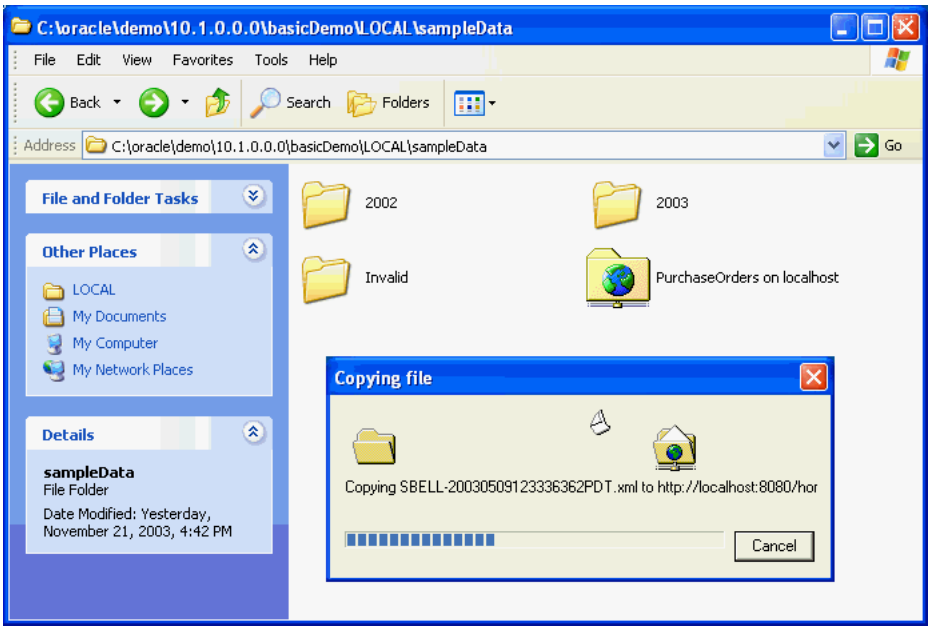
Using Standard Protocols to Store and Retrieve Content

Oracle XML DB supports industry-standard internet protocols such as HTTP(S), WebDav, and FTP. The combination of protocol support and URL-based access makes it possible to insert, retrieve, update, and delete content stored in Oracle Database from standard desktop applications such as Windows Explorer, Microsoft Word, and XMLSpy.

Figure 3–4 shows Windows Explorer used to insert a folder from the local hard drive into Oracle Database. Windows Explorer includes support for the WebDAV protocol. WebDAV extends the HTTP standard, adding additional verbs that allow an HTTP server to act as a file server.

When a Windows Explorer copy operation or FTP input command is used to transfer a number of documents into Oracle XML DB Repository, each `put` or `post` command is treated as a separate atomic operation. This ensures that the client does not get confused if one of the file transfers fails. It also means that changes made to a document through a protocol are visible to other users as soon as the request has been processed.

Figure 3–4 Copying Files into Oracle XML DB Repository



Uploading Content to Oracle XML DB Using FTP

The following example shows commands issued and output generated when a standard command line FTP tool loads documents into Oracle XML DB Repository:

Example 3–53 Uploading Content into the Repository Using FTP

```
$ ftp mdrake-sun 2100
Connected to mdrake-sun.
220 mdrake-sun FTP Server (Oracle XML DB/Oracle Database 10g Enterprise Edition
Release 10.1.0.1.0 - Beta) ready.
Name (mdrake-sun:oracle10): QUINE
331 pass required for QUINE
Password:
230 QUINE logged in
ftp> cd /source/schemas
250 CWD Command successful
ftp> mkdir PurchaseOrders
257 MKD Command successful
ftp> cd PurchaseOrders
250 CWD Command successful
ftp> mkdir 2002
257 MKD Command successful
ftp> cd 2002
250 CWD Command successful
ftp> mkdir "Apr"
257 MKD Command successful
ftp> put "Apr/AMCEWEN-20021009123336171PDT.xml"
"Apr/AMCEWEN-20021009123336171PDT.xml"
200 PORT Command successful
150 ASCII Data Connection
226 ASCII Transfer Complete
local: Apr/AMCEWEN-20021009123336171PDT.xml remote:
Apr/AMCEWEN-20021009123336171PDT.xml
4718 bytes sent in 0.0017 seconds (2683.41 Kbytes/s)
ftp> put "Apr/AMCEWEN-20021009123336271PDT.xml"
"Apr/AMCEWEN-20021009123336271PDT.xml"
200 PORT Command successful
150 ASCII Data Connection
226 ASCII Transfer Complete
local: Apr/AMCEWEN-20021009123336271PDT.xml remote:
Apr/AMCEWEN-20021009123336271PDT.xml
4800 bytes sent in 0.0014 seconds (3357.81 Kbytes/s)
.....
ftp> cd "Apr"
250 CWD Command successful
ftp> ls -l
200 PORT Command successful
150 ASCII Data Connection
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 AMCEWEN-20021009123336171PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 AMCEWEN-20021009123336271PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 EABEL-20021009123336251PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 PTUCKER-20021009123336191PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 PTUCKER-20021009123336291PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SBELL-20021009123336231PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SBELL-20021009123336331PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SKING-20021009123336321PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SMCCAIN-20021009123336151PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 SMCCAIN-20021009123336341PDT.xml
-rw-r--r1 QUINE oracle 0 JUN 24 15:41 VJONES-20021009123336301PDT.xml
226 ASCII Transfer Complete
```

```
remote: -l
959 bytes received in 0.0027 seconds (349.45 Kbytes/s)
ftp> cd ".."
250 CWD Command successful
....
ftp> quit
221 QUIT Goodbye.
$
```

The key point demonstrated by both of these examples is that neither Windows Explorer nor the FTP tool is aware that it is working with Oracle XML DB. Since the tools and Oracle XML DB both support open Internet protocols they work with each other out of the box.

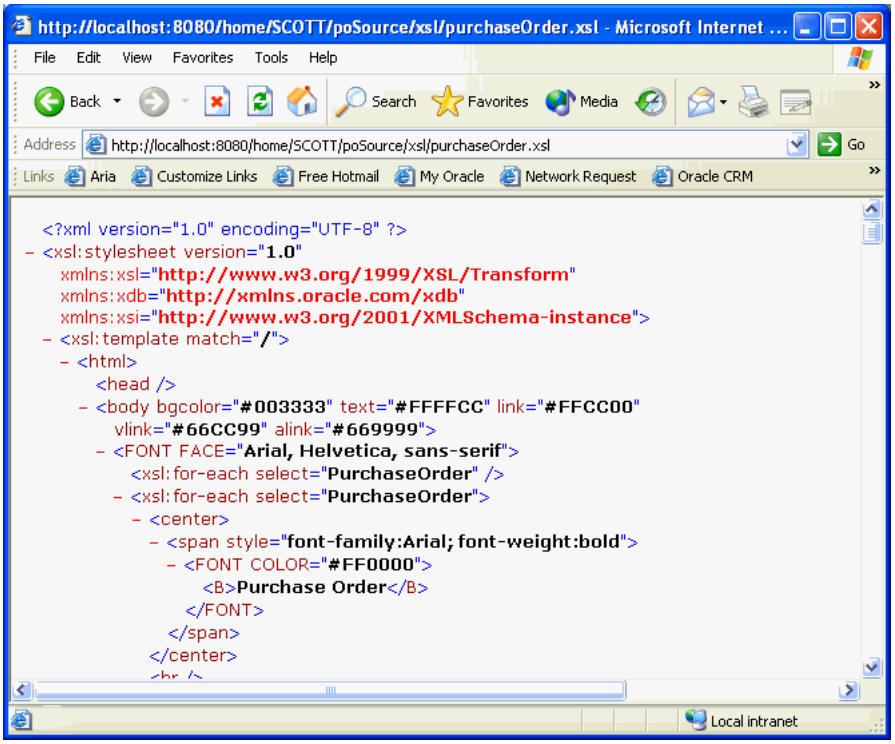
Any tool that understands the WebDAV or FTP protocol can be used to create content managed by Oracle XML DB Repository. No additional software has to installed on the client or the mid-tier.

When the contents of the folders are viewed using a tool such as Windows Explorer or FTP, the length of any schema-based XML documents contained in the folder is shown as zero (0) bytes. This was designed as such for two reasons:

- It is not clear what the size of the document should be. Is it the size of the `CLOB` instance generated by printing the document, or the number of bytes required to store the objects used to persist the document inside the database?
- Regardless of which definition is chosen, calculating and maintaining this information is costly.

Figure 3–5 shows Internet Explorer using a URL and the HTTP protocol to view an XML document stored in the database.

Figure 3–5 Path-Based Access Using HTTP and a URL



Accessing Oracle XML DB Repository Programmatically

Oracle XML DB Repository can be accessed and updated directly from SQL. This means that any application or programming language that can use SQL to interact with Oracle Database can also access and update content stored in the repository. Oracle XML DB includes PL/SQL package `DBMS_XDB`, which provides methods that allow resources to be created, modified, and deleted programmatically.

Example 3–54 Creating a Text Document Resource Using DBMS_XDB

This example shows how to create a resource using `DBMS_XDB`. Here the resource will be a simple text document containing the supplied text.

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB.createResource('/home/QUINE/NurseryRhyme.txt',
                                 bfilename('XMLDIR', 'tdadxdb-03-01.txt'),
                                 nls_charset_id('AL32UTF8'));
END;
/
```

Accessing and Updating XML Content in the Repository

This section describes features for accessing and updating Oracle XML DB Repository content.

Access XML Documents Using SQL

Content stored in the repository can be accessed and updated from SQL and PL/SQL. You can interrogate the structure of the repository in complex ways. For example, you can query to determine how many files with extension `.xsl` are under a location other than `/home/mystylesheetdir`.

You can also mix path-based repository access with content-based access. You can, for example, ask "How many documents not under `/home/purchaseOrders` have a node identified by the XPath `/PurchaseOrder/User/text()` with a value of `KING`?"

All of the *metadata* for managing the repository is stored in a database schema owned by database schema (user account) `XDB`. User `XDB` is created during Oracle XML DB installation. The primary table in this schema is an `XMLType` table called `XDB$RESOURCE`. This contains one row for each resource (file or folder) in the repository. Documents in this table are referred to as **resource documents**. The XML schema that defines the structure of an Oracle XML DB resource document is registered under URL, `"http://xmlns.oracle.com/xdb/XDBResource.xsd`.

> **See Also:** *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Repository Content is Exposed Through RESOURCE_VIEW and PATH_VIEW

Table `XDB$RESOURCE` is not directly exposed to SQL programmers. Instead, the contents of the repository are exposed through two public views, `RESOURCE_VIEW` and `PATH_VIEW`. Through these views, you can access and update both the metadata and the content of documents stored in the repository.

Both views contain a virtual column, RES. Use RES to access and update resource documents with SQL statements using a path notation. Operations on the views use underlying tables in the repository.

Use EXISTS_PATH and UNDER_PATH to Include Path-Based Predicates in the WHERE Clause

Oracle XML DB includes two repository-specific SQL functions: exists_path and under_path. Use these functions to include path-based predicates in the WHERE clause of a SQL statement. SQL operations can select repository content based on the location of the content in the repository folder hierarchy. The hierarchical repository index ensures that path-based queries are executed efficiently.

When *XML schema-based* XML documents are stored in the repository, the document content is stored as an object in the default table identified by the XML schema. The repository contains only *metadata* about the document and a *pointer* (REF of XMLType) that identifies the row in the default table that contains the content.

Documents Other Than XML Can Be Stored In the Repository

It is also possible to store other kinds of documents in the repository. When a document that is not XML or is not schema-based XML is stored in the repository, the document *content* is stored in a LOB along with the metadata about the document.

PL/SQL Packages to Create, Delete, Rename, Move,... Folders and Documents

Since Oracle XML DB repository can be accessed and updated using SQL, any application capable of calling a PL/SQL procedure can use the repository. All SQL and PL/SQL repository operations are transactional, and access to the repository and its contents is subject to database security, as well as the repository access control lists (ACLs).

With supplied PL/SQL packages DBMS_XDB, DBMS_XDBZ, and DBMS_XDB_VERSION, you can create, delete, and rename documents and folders, move a file or folder within the folder hierarchy, set and change the access permissions on a file or folder, and initiate and manage versioning.

Example 3–55 Using PL/SQL Package DBMS_XDB To Create Folders

This example uses PL/SQL package DBMS_XDB to create a set of subfolders beneath folder /public.

```
DECLARE
  RESULT BOOLEAN;
BEGIN
  IF (NOT DBMS_XDB.existsResource('/public/mysource')) THEN
     result := DBMS_XDB.createFolder('/public/mysource');
  END IF;
  IF (NOT DBMS_XDB.existsResource('/public/mysource/schemas')) THEN
     result := DBMS_XDB.createFolder('/public/mysource/schemas');
  END IF;
  IF (NOT DBMS_XDB.existsResource('/public/mysource/schemas/poSource')) THEN
     result := DBMS_XDB.createFolder('/public/mysource/schemas/poSource');
  END IF;
  IF (NOT DBMS_XDB.existsResource('/public/mysource/schemas/poSource/xsd')) THEN
     result := DBMS_XDB.createFolder('/public/mysource/schemas/poSource/xsd');
  END IF;
  IF (NOT DBMS_XDB.existsResource('/public/mysource/schemas/poSource/xsl')) THEN
     result := DBMS_XDB.createFolder('/public/mysource/schemas/poSource/xsl');
  END IF;
END;
```

```
/
```

Accessing the Content of Documents Using SQL

You can access the content of documents stored in Oracle XML DB Repository in several ways. The easiest way is to use `XDBURIType`. `XDBURIType` uses a URL to specify which resource to access. The URL passed to the `XDBURIType` is assumed to start at the root of the repository. Data type `XDBURIType` provides methods `getBLOB()`, `getCLOB()`, and `getXML()` to access the different kinds of content that can be associated with a resource.

Example 3–56 Using XDBURIType to Access a Text Document in the Repository

This example shows how to use `XDBURIType` to access the content of the text document:

```
SELECT XDBURIType('/home/QUINE/NurseryRhyme.txt').getCLOB() FROM DUAL;

XDBURITYPE('/HOME/QUINE/NURSERYRHYME.TXT').GETCLOB()
--------------------------------------------------
Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go

1 row selected.
```

Example 3–57 Using XDBURIType and a Repository Resource to Access Content

The contents of a document can also be accessed using the resource document. This example shows how to access the content of a text document:

```
SELECT
  DBMS_XMLGEN.convert(
    extract(RES,
            '/Resource/Contents/text/text()',
            'xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"').getCLOBVal(),
    1)
  FROM RESOURCE_VIEW r
  WHERE equals_path(RES, '/home/QUINE/NurseryRhyme.txt') = 1;

DBMS_XMLGEN.CONVERT(EXTRACT(RES,'/RESOURCE/CONTENTS/TEXT/TEXT()','XMLNS="HTTP://
--------------------------------------------------------------------------------
Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go

1 row selected.
```

SQL function `extract`, rather than `extractValue`, is used to access the text node. This returns the content of the text node as an `XMLType` instance, which makes it possible to access the content of the node using `XMLType` method `getCLOBVal()`. Hence, you can access the content of documents larger than 4K. Here, `DBMS_XMLGEN.convert` removes any entity escaping from the text.

Example 3–58 Accessing XML Documents Using Resource and Namespace Prefixes

The content of non-schema-based and schema-based XML documents can also be accessed through the resource. This example shows how to use an XPath expression that includes nodes from the resource document and nodes from the XML document to access the contents of a `PurchaseOrder` document using the resource.

```
SELECT des.description
  FROM RESOURCE_VIEW rv,
       XMLTable(XMLNAMESPACES ('http://xmlns.oracle.com/xdb/XDBResource.xsd' AS "r"),
                '/r:Resource/r:Contents/PurchaseOrder/LineItems/LineItem'
                PASSING rv.RES
                COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE
    equals_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml') = 1;

DES.DESCRIPTION
--------------------------------
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz

3 rows selected.
```

In this case, a namespace prefix, `r`, was used to identify which nodes in the XPath expression are members of the resource namespace. This is necessary, because the purchase-order XML schema does not define a namespace, and it is not possible to apply a namespace prefix to nodes in the `PurchaseOrder` document. Namespace prefix `r` is defined using the `XMLNAMESPACES` clause of SQL function `XMLTable`.

> **See Also:** Chapter 18, "Using XQuery with Oracle XML DB" for more information about the `XMLNAMESPACES` clause of `XMLTable`

Accessing the Content of XML Schema-Based Documents

The content of a schema-based XML document can be accessed in two ways.

- In the same manner as for non-schema-based XML documents, by using the resource document. This lets `RESOURCE_VIEW` be used to query different types of schema-based XML documents with a single SQL statement.
- As a row in the default table that was defined when the XML schema was registered with Oracle XML DB.

Using Element XMLRef in Joins to Access Resource Content

The `XMLRef` element in the resource document provides the join key required when a SQL statement needs to access or update metadata and content as part of a single operation.

The following queries use joins based on the value of the `XMLRef` to access resource content.

Example 3–59 Querying Repository Resource Data Using SQL Function REF and Element XMLRef

This example locates a row in the `defaultTable` based on a path in Oracle XML DB Repository. SQL function `ref` locates the target row in the default table, based on the value of the `XMLRef` element in the resource document, `RES`.

```
SELECT des.description
  FROM RESOURCE_VIEW rv,
```

```
      purchaseorder p,
      XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
               COLUMNS description VARCHAR2(256) PATH 'Description') des
  WHERE equals_path(res, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml') = 1
    AND ref(p) = extractValue(rv.RES, '/Resource/XMLRef');

DES.DESCRIPTION
--------------------------------
A Night to Remember
The Unbearable Lightness Of Being
The Wizard of Oz

3 rows selected.
```

Example 3–60 Selecting XML Document Fragments Based on Metadata, Path, and Content

This example shows how to select fragments from XML documents based on metadata, path, and content. The query returns the value of element `Reference` for documents under `/home/QUINE/PurchaseOrders/2002/Mar` that contain orders for part number 715515009058.

```
SELECT extractValue(p.OBJECT_VALUE, '/PurchaseOrder/Reference')
  FROM RESOURCE_VIEW rv, purchaseorder p
  WHERE under_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar') = 1
    AND ref(p) = extractValue(rv.RES, '/Resource/XMLRef')
    AND existsNode(p.OBJECT_VALUE,
                   '/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]')
        = 1;

EXTRACTVALUE(P.OBJECT_VALUE,'/
------------------------------
CJOHNSON-20021009123335851PDT
LSMITH-2002100912333661PDT
SBELL-2002100912333601PDT

3 rows selected.
```

In general, when accessing the content of schema-based XML documents, joining `RESOURCE_VIEW` or `PATH_VIEW` with the default table is more efficient than using `RESOURCE_VIEW` or `PATH_VIEW` on its own. An explicit join between the resource document and the default table tells Oracle XML DB that the SQL statement will only work on one type of XML document. This lets XPath rewrite be used to optimize the operation on the default table as well as the operation on the resource.

Updating the Content of Documents Stored in the Repository

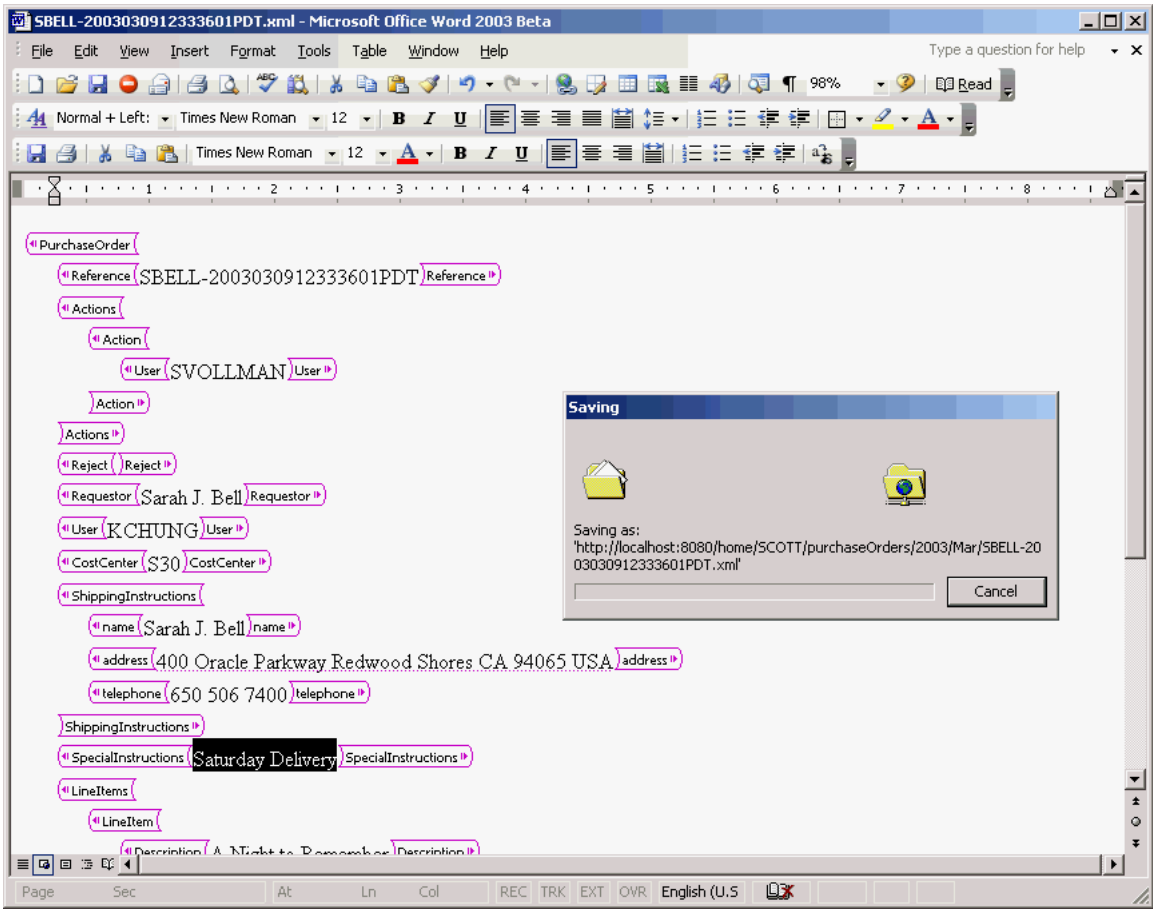
You can update the content of documents stored in Oracle XML DB Repository using protocols or SQL.

Updating Repository Content Using Protocols

The most popular content authoring tools now support HTTP, FTP, and WebDAV protocols. These tools can use a URL and the HTTP verb `get` to access the content of a document, and the HTTP verb `put` to save the contents of a document. Hence, given the appropriate access permissions, a simple URL is all you need to access and edit content stored in Oracle XML DB Repository.

Figure 3–6 shows how, with the WebDAV support included in Microsoft Word, you can use Microsoft Word to update and edit a document stored in Oracle XML DB Repository.

Figure 3–6 Using Microsoft Word to Update and Edit Content Stored in Oracle XML DB



When an editing application such as Microsoft Word updates an XML document stored in Oracle XML DB, the database receives an input stream containing the new content of the document. Unfortunately, products such as Word do not provide Oracle XML DB with any way of identifying which changes have taken place in the document. This means that partial updates are not possible, and it is necessary to re-parse the entire document, replacing all the objects derived from the original document with objects derived from the new content.

Updating Repository Content Using SQL

SQL functions such as `updateXML` can be used to update the content of any document stored in Oracle XML DB Repository. The content of the document can be modified by updating the resource document or by updating the default table that holds the content of the document.

Example 3–61 Updating a Document Using UPDATE and UPDATEXML on the Resource

This example shows how to update the contents of a simple text document using the SQL `UPDATE` statement and SQL function `updateXML` on the resource document. An XPath expression is passed to `updateXML` as the target of the update operation, identifying the text node belonging to element `/Resource/Contents/text`.

```
DECLARE
  file         BFILE;
  contents     CLOB;
  dest_offset  NUMBER := 1;
  src_offset   NUMBER := 1;
  lang_context NUMBER := 0;
  conv_warning NUMBER := 0;
BEGIN
  file := bfilename('XMLDIR', 'tdadxdb-03-02.txt');
  DBMS_LOB.createTemporary(contents, true, DBMS_LOB.SESSION);
  DBMS_LOB.fileopen(file, DBMS_LOB.file_readonly);
  DBMS_LOB.loadClobfromFile(contents,
                            file,
                            DBMS_LOB.getLength(file),
                            dest_offset,
                            src_offset,
                            nls_charset_id('AL32UTF8'),
                            lang_context,
                            conv_warning);
  DBMS_LOB.fileclose(file);
  UPDATE RESOURCE_VIEW
    SET res = updateXML(res,
                        '/Resource/Contents/text/text()',
                        contents,
                        'xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"')
      WHERE equals_path(res, '/home/QUINE/NurseryRhyme.txt') = 1;
  DBMS_LOB.freeTemporary(contents);
END;
/
```

The technique for updating the content of a document by updating the associated resource has the advantage that it can be used to update any kind of document stored in Oracle XML DB Repository.

Example 3–62 Updating a Node in the XML Document Using UPDATE and UPDATEXML

This example shows how to update a node in an XML document by performing an update on the resource document. Here, SQL function `updateXML` changes the value of the text node associated with element `User`.

```
UPDATE RESOURCE_VIEW
  SET res = updateXML(res,
                      '/r:Resource/r:Contents/PurchaseOrder/User/text()',
                      'SKING',
                      'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"')
  WHERE equals_path(
          res,
          '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
        = 1;

1 row updated.

SELECT extractValue(res,
                    '/r:Resource/r:Contents/PurchaseOrder/User/text()',
                    'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"')
  FROM RESOURCE_VIEW
  WHERE equals_path(
          res,
          '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
        = 1;
```

```
EXTRACTVALUE(RES, '/R:RESOURCE/R:CONTENTS/PURCHASEORDER/USER/TEXT()',
             'XMLNS:R="HTTP://XMLNS.ORACLE.COM/XDB/XDBRESOURCE.XSD"')
--------------------------------------------------------------------
SKING

1 row selected.
```

Updating XML Schema-Based Documents in the Repository

You can update XML schema-based XML documents by performing the update operation directly on the default table that is used to manage the content of the document. If the document must be located by a `WHERE` clause that includes a path or conditions based on metadata, then the `UPDATE` statement must use a join between the resource and the default table.

In general, when updating the contents of XML schema-based XML documents, joining the `RESOURCE_VIEW` or `PATH_VIEW` with the default table is more efficient than using the `RESOURCE_VIEW` or `PATH_VIEW` on its own. The explicit join between the resource document and the default table tells Oracle XML DB that the SQL statement will work on only one type of XML document. This lets a partial update be used on the default table and resource.

Example 3–63 Updating XML Schema-Based Documents in the Repository

In this example, SQL function `updateXML` operates on the default table, with the target row identified by a path. The row to be updated is identified by a `REF`. The `REF` is identified by a repository path using SQL function `equals_path`. This limits the update to the row corresponding to the resource identified by the specified path.

```
UPDATE purchaseorder p
  SET p.OBJECT_VALUE = updateXML(p.OBJECT_VALUE, '/PurchaseOrder/User/text()', 'SBELL')
    WHERE ref(p) =
      (SELECT extractValue(rv.RES,'/Resource/XMLRef')
         FROM RESOURCE_VIEW rv
         WHERE equals_path(rv.RES,
                           '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
               = 1);

1 row updated.

SELECT extractValue(p.OBJECT_VALUE, '/PurchaseOrder/User/text()')
  FROM purchaseorder p, RESOURCE_VIEW rv
  WHERE ref(p) = extractValue(rv.RES, '/Resource/XMLRef')
    AND equals_path(rv.RES, '/home/QUINE/PurchaseOrders/2002/Mar/SBELL-2002100912333601PDT.xml')
        = 1;

EXTRACTVAL
----------
SBELL

1 row selected.
```

Controlling Access to Repository Data

You can control access to the resources in Oracle XML DB Repository by using access control lists (ACLs). An ACL is a list of access control entries (ACEs), each of which grants or denies a set of privileges to a specific principal. The principal can be a database user, a database role, an LDAP user, an LDAP group or the special principal `dav:owner`, which refers to the owner of the resource. Each resource in the repository

is protected by an ACL. The ACL determines what privileges, such as `read-properties` and `update`, a user has on the resource. Each repository operation includes a check of the ACL to determine if the current user is allowed to perform the operation.

By default, a new resource inherits the ACL of its parent folder. But you can set the ACL of a resource using procedure `DBMS_XDB.setACL()`. For more details on Oracle XML DB resource security, see Chapter 27, "Repository Resource Security".

In the following example, the current user is `QUINE`. The query gives the number of resources in the folder `/public`. Assume that there are only two resources in this folder: `f1` and `f2`. Also assume that the ACL on `f1` grants the `read-properties` privilege to `QUINE` while the ACL on `f2` does not grant `QUINE` any privileges. A user needs the `read-properties` privilege on a resource for it to be visible to the user. The result of the query is `1`, because only `f1` is visible to `QUINE`.

```
SELECT count(*) FROM RESOURCE_VIEW r WHERE under_path(r.res, '/public') = 1;

COUNT(*)
--------
       1
```

Oracle XML DB Transactional Semantics

When working from SQL, normal transactional behavior is enforced. Multiple calls to SQL functions such as `updateXML` can be used within a single logical unit of work. Changes made through functions like `updateXML` are not visible to other database users until the transaction is committed. At any point, `ROLLBACK` can be used to back out the set of changes made since the last commit.

Querying Metadata and the Folder Hierarchy

In Oracle XML DB, the system-defined metadata for each resource is preserved as an XML document. The structure of these resource documents is defined by the `XDBResource.xsd` XML schema. This schema is registered as a global XML schema at URL `http://xmlns.oracle.com/xdb/XDBResource.xsd`.

Oracle XML DB gives you access to metadata and information about the folder hierarchy using two public views, `RESOURCE_VIEW` and `PATH_VIEW`.

RESOURCE_VIEW and PATH_VIEW

`RESOURCE_VIEW` contains one entry for each file or folder stored in Oracle XML DB Repository. Column `RES` of `RESOURCE_VIEW` contains the resource, an XML document that manages the metadata properties associated with the resource content. Column `ANY_PATH` contains a valid URL that the current user can pass to `XDBURIType` to access the resource content. If this content is not binary data, then the resource itself also contains the content.

Oracle XML DB supports the concept of **linking**. Linking makes it possible to define multiple paths to a given document. A separate XML document, called the **link-properties document**, maintains metadata properties that are specific to the path, rather than to the resource. Whenever a resource is created, an initial link is also created.

`PATH_VIEW` exposes the link-properties documents. There is one entry in `PATH_VIEW` for each possible path to a document. Column `RES` of `PATH_VIEW` contains the resource document pointed to by this link. Column `PATH` contains the path that the

link lets you use to access the resource. Column LINK contains the link-properties document (metadata) for this PATH.

Example 3–64 Viewing RESOURCE_VIEW and PATH_VIEW Structures

The following example shows the description of public views RESOURCE_VIEW and PATH_VIEW:

```
DESCRIBE RESOURCE_VIEW

Name      Null?    Type
----------------------------------------------------------------
RES                SYS.XMLTYPE(XMLSchema
                               "http://xmlns.oracle.com/xdb/XDBResource.xsd"
                               Element
                               "Resource")
ANY_PATH           VARCHAR2(4000)
RESID              RAW(16)


DESCRIBE PATH_VIEW

Name      Null?    Type
----------------------------------------------------------------
PATH               VARCHAR2(1024)
RES                SYS.XMLTYPE(XMLSchema
                               "http://xmlns.oracle.com/xdb/XDBResource.xsd"
                               Element
                               "Resource")
LINK               SYS.XMLTYPE
RESID              RAW(16)
```

See Also:

- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"
- *Oracle Database Reference* for more information about view PATH_VIEW
- *Oracle Database Reference* for more information about view RESOURCE_VIEW

Querying Resources in RESOURCE_VIEW and PATH_VIEW

Oracle XML DB provides two SQL functions, equals_path and under_path, that can be used to perform **folder-restricted queries**. Such queries limit SQL statements that operate on the RESOURCE_VIEW or PATH_VIEW to documents that are at a particular location in Oracle XML DB folder hierarchy. Function equals_path restricts the statement to a single document identified by the specified path. Function under_path restricts the statement to those documents that exist beneath a certain point in the hierarchy.

The following examples demonstrate simple folder-restricted queries against resource documents stored in RESOURCE_VIEW and PATH_VIEW.

Example 3–65 Accessing Resources Using EQUALS_PATH and RESOURCE_VIEW

The following query uses SQL function equals_path and RESOURCE_VIEW to access the resource created in Example 3–64.

```
SELECT r.RES.getCLOBVal()
  FROM RESOURCE_VIEW r
  WHERE equals_path(res, '/home/QUINE/NurseryRhyme.txt') = 1;

R.RES.GETCLOBVAL()
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"
          Hidden="false"
          Invalid="false"
          Container="false"
          CustomRslv="false"
          VersionHistory="false"
          StickyRef="true">
  <CreationDate>2005-06-13T13:19:20.566623</CreationDate>
  <ModificationDate>2005-06-13T13:19:22.997831</ModificationDate>
  <DisplayName>NurseryRhyme.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description=
         "Private:All privileges to OWNER only and not accessible to others"
         xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
         http://xmlns.oracle.com/xdb/acl.xsd"
         shared="true">
      <ace>
        <grant>true</grant>
        <principal>dav:owner</principal>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>QUINE</Owner>
  <Creator>QUINE</Creator>
  <LastModifier>QUINE</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
  <Contents>
    <text>Hickory Dickory Dock
The Mouse ran up the clock
The clock struck one
The Mouse ran down
Hickory Dickory Dock
    </text>
  </Contents>
</Resource>

1 row selected.
```

As Example 3–65 shows, a resource document is an XML document that captures the set of metadata defined by the DAV standard. The metadata includes information such as `CreationDate`, `Creator`, `Owner`, `ModificationDate`, and `DisplayName`. The content of the resource document can be queried and updated just like any other XML document, using SQL functions such as `extract`, `extractValue`, `existsNode`, and `updateXML`.

Example 3–66 Determining the Path to XSL Style Sheets Stored in the Repository

The first query finds a path to each of the XSL style sheets stored in Oracle XML DB Repository. It performs a search based on the `DisplayName` ending in `.xsl`.

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE extractValue(RES, '/Resource/DisplayName') LIKE '%.xsl';

ANY_PATH
----------------------------------------
/source/schemas/poSource/xsl/empdept.xsl
/source/schemas/poSource/xsl/purchaseOrder.xsl

2 rows selected.
```

Example 3–67 Counting Resources Under a Path

This example counts the number of resources (files and folders) under the path `/home/QUINE/PurchaseOrders`. Using `RESOURCE_VIEW` rather than `PATH_VIEW` ensures that any resources that are the target of multiple links are only counted once. SQL function `under_path` restricts the result set to documents that can be accessed using a path that starts from `/home/QUINE/PurchaseOrders`.

```
SELECT count(*)
   FROM RESOURCE_VIEW
   WHERE under_path(RES, '/home/QUINE/PurchaseOrders') = 1;

  COUNT(*)
----------
       145

1 row selected.
```

Example 3–68 Listing the Folder Contents in a Path

This query lists the contents of the folder identified by path `/home/QUINE/PurchaseOrders/2002/Apr`. This is effectively a directory listing of the folder.

```
SELECT PATH
  FROM PATH_VIEW
  WHERE under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336191PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336291PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336231PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336331PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SKING-20021009123336321PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336151PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336341PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/VJONES-20021009123336301PDT.xml

11 rows selected.
```

Example 3–69 Listing the Links Contained in a Folder

This query lists the set of links contained in the folder identified by the path `/home/QUINE/PurchaseOrders/2002/Apr` where the `DisplayName` element in the associated resource starts with an `S`.

```
SELECT PATH
  FROM PATH_VIEW
  WHERE extractValue(RES, '/Resource/DisplayName') like 'S%'
    AND under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336231PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SBELL-20021009123336331PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SKING-20021009123336321PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336151PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/SMCCAIN-20021009123336341PDT.xml

5 rows selected.
```

Example 3–70 Finding Paths to Resources that Contain Purchase-Order XML Documents

This query finds a path to each resource in Oracle XML DB Repository that contains a `PurchaseOrder` document. The documents are identified based on the metadata property `SchemaElement` that identifies the XML schema URL and global element for schema-based XML data stored in the repository.

```
SELECT ANY_PATH
  FROM RESOURCE_VIEW
  WHERE existsNode(RES,
                   '/Resource[SchemaElement=
                      "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd#PurchaseOrder"]')
        = 1;
```

This returns the following paths, each of which contains a `PurchaseOrder` document:

```
ANY_PATH
--------------------------------------------------------------------------------
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
/home/QUINE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336191PDT.xml

...

132 rows selected.
```

Oracle XML DB Hierarchical Repository Index

In a conventional relational database, path-based access and folder-restricted queries would have to be implemented using `CONNECT BY` operations. Such queries are expensive, so path-based access and folder-restricted queries would become inefficient as the number of documents and depth of the folder hierarchy increase.

To address this issue, Oracle XML DB introduces a new index type, the **hierarchical repository index**. This lets the database resolve folder-restricted queries without relying on a `CONNECT BY` operation. Because of this, Oracle XML DB can execute path-based and folder-restricted queries efficiently. The hierarchical repository index is

implemented as an Oracle domain index. This is the same technique used to add Oracle Text indexing support and many other advanced index types to the database.

Example 3–71 EXPLAIN Plan Output for a Folder-Restricted Query

This example shows the `EXPLAIN PLAN` output generated for a folder-restricted query. As shown, the hierarchical repository index `XDBHI_IDX` is used to resolve the query.

```
EXPLAIN PLAN FOR
  SELECT PATH
    FROM PATH_VIEW
    WHERE extractValue(RES, '/Resource/DisplayName') LIKE 'S%'
      AND under_path(RES, '/home/QUINE/PurchaseOrders/2002/Apr') = 1;

Explained.

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------------------
Plan hash value: 2568289845

-------------------------------------------------------------------------------------------------------
| Id  | Operation                           | Name          | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                    |               |   254 | 46736 |    34   (6)| 00:00:01 |
|   1 |  NESTED LOOPS                       |               |   254 | 46736 |    34   (6)| 00:00:01 |
|   2 |   NESTED LOOPS                      |               |   254 | 42418 |    34   (6)| 00:00:01 |
|   3 |    NESTED LOOPS                     |               |   254 | 35306 |    34   (6)| 00:00:01 |
|*  4 |     TABLE ACCESS BY INDEX ROWID     | XDB$RESOURCE  |     1 |   137 |     3   (0)| 00:00:01 |
|*  5 |      DOMAIN INDEX                   | XDBHI_IDX     |       |       |            |          |
|   6 |     COLLECTION ITERATOR PICKLER FETCH|               |       |       |            |          |
|*  7 |    INDEX UNIQUE SCAN                | XDB_PK_H_LINK |     1 |    28 |     0   (0)| 00:00:01 |
|*  8 |   INDEX UNIQUE SCAN                 | SYS_C003728   |     1 |    17 |     0   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   4 - filter("P"."SYS_NC00011$" LIKE 'S%')
   5 - access("XDB"."UNDER_PATH"(SYS_MAKEXML('8758D485E6004793E034080020B242C6',734,"XMLEXTRA"
              ,"XMLDATA"),'/home/QUINE/PurchaseOrders/2002/Apr',9999)=1)
   7 - access("H"."PARENT_OID"=SYS_OP_ATG(VALUE(KOKBF$),3,4,2) AND
              "H"."NAME"=SYS_OP_ATG(VALUE(KOKBF$),2,3,2))
   8 - access("R2"."SYS_NC_OID$"=SYS_OP_ATG(VALUE(KOKBF$),3,4,2))

25 rows selected.
```

How Documents are Stored in the Repository

Oracle XML DB provides special handling for XML documents. The rules for storing the contents of schema-based XML document are defined by the XML schema. The content of the document is stored in the default table associated with the global element definition.

Oracle XML DB Repository also stores files that do not contain XML data, such as JPEG images or Word documents. The XML schema for each resource defines which elements are allowed, and specifies whether the content of these files is to be stored as `BLOB` or `CLOB` instances. The content of a non-schema-based XML document is stored as a `CLOB` instance in the repository.

There is one resource and one link-properties document for each file or folder in the repository. If there are multiple access paths to a given document, there will be a link-properties document for each possible link. Both the resource document and the

link-properties are stored as XML documents. All these documents are stored in tables in the repository.

When an XML file is loaded into the repository, the following sequence of events takes place:

1. Oracle XML DB examines the root element of the XML document to see if it is associated with a known (registered) XML schema. This involves looking to see if the document includes a namespace declaration for the `XMLSchema-instance` namespace, and then looking for a `schemaLocation` or `noNamespaceSchemaLocation` attribute that identifies which XML schema the document is associated with.
2. If the document is based on a known XML schema, then the metadata for the XML schema is loaded from the XML schema cache.
3. The XML document is parsed and decomposed into a set of SQL objects derived from the XML schema.
4. The SQL objects created from the XML file are stored in the default table defined when the XML schema was registered with the database.
5. A resource document is created for each document processed. This lets the content of the document be accessed using the repository. The resource document for a schema-based `XMLType` includes an element `XMLRef`. This contents of this element is a `REF` of `XMLType` that can be used to locate the row in the default table containing the content associated with the resource.

Viewing Relational Data as XML From a Browser

The HTTP server built into Oracle XML DB makes it possible to use a browser to access any document stored in Oracle XML DB Repository. Since a resource can include a `REF` to a row in an `XMLType` table or view, it is possible to use a path to access this type of content.

Using DBUri Servlet to Access Any Table or View From a Browser

Oracle XML DB includes the DBUri servlet, which makes it possible to access the content of any table or view directly from a browser. DBUri servlet uses the facilities of the `DBURIType` to generate a simple XML document from the contents of the table. The servlet is C-language based and installed in the Oracle XML DB HTTP server. By default, the servlet is installed under the virtual directory `/oradb`.

The URL passed to the `DBUri` Servlet is an extension of the URL passed to the `DBURIType`. The URL is extended with the address and port number of the Oracle XML DB HTTP server and the virtual root that directs HTTP(S) requests to the `DBUri` servlet. The default configuration for this is `/oradb`.

This means that the URL `http://localhost:8080/oradb/HR/DEPARTMENTS` would return an XML document containing the contents of the `DEPARTMENTS` table in the HR database schema. This assumes that the Oracle XML DB HTTP server is running on port 8080, the virtual root for the DBUri servlet is `/oradb`, and that the user making the request has access to the `HR` database schema.

`DBUri` servlet accepts parameters that allow you to specify the name of the `ROW` tag and MIME-type of the document that is returned to the client.

Content in `XMLType` table or view can also be accessed through the DBUri servlet. When the URL passed to the DBUri servlet references an `XMLType` table or `XMLType` view the URL can be extended with an XPath expression that can determine which

documents in the table or row are returned. The XPath expression appended to the URL can reference any node in the document.

XML generated by DBUri servlet can be transformed using the XSLT processor built into Oracle XML DB. This lets XML that is generated by DBUri servlet be presented in a more legible format such as HTML.

See Also: "DBUriServlet" on page 20-25

Style sheet processing is initiated by specifying a transform parameter as part of the URL passed to DBUri servlet. The style sheet is specified using a URI that references the location of the style sheet within database. The URI can either be a `DBURIType` value that identifies a `XMLType` column in a table or view, or a path to a document stored in Oracle XML DB Repository. The style sheet is applied directly to the generated XML before it is returned to the client. When using DBUri servlet for XSLT processing, it is good practice to use the `contenttype` parameter to explicitly specify the MIME type of the generated output.

If the XML document being transformed is stored as an XML schema-based `XMLType` instance, then Oracle XML DB can reduce the overhead associated with XSL transformation by leveraging the capabilities of the lazily loaded virtual DOM.

The root of the URL is `/oradb`, so the URL is passed to the DBUri servlet that accesses the `purchaseorder` table in the `SCOTT` database schema, rather than as a resource in Oracle XML DB Repository. The URL includes an XPath expression that restricts the result set to those documents where node `/PurchaseOrder/Reference/text()` contains the value specified in the predicate. The `contenttype` parameter sets the MIME type of the generated document to `text/xml`.

XSL Transformation Using DBUri Servlet

Figure 3–7 shows how an XSL transformation can be applied to XML content generated by the DBUri servlet. In this example the URL passed to the DBUri includes the transform parameter. This causes the DBUri servlet to use SQL function `XMLtransform` to apply the style sheet `/home/SCOTT/xsl/purchaseOrder.xsl` to the `PurchaseOrder` document identified by the main URL, before returning the document to the browser. This style sheet transforms the XML document to a more user-friendly HTML page. The URL also uses `contentType` parameter to specify that the MIME-type of the final document will be `text/html`.

Figure 3–7 Database XSL Transformation of a PurchaseOrder Using DBUri Servlet

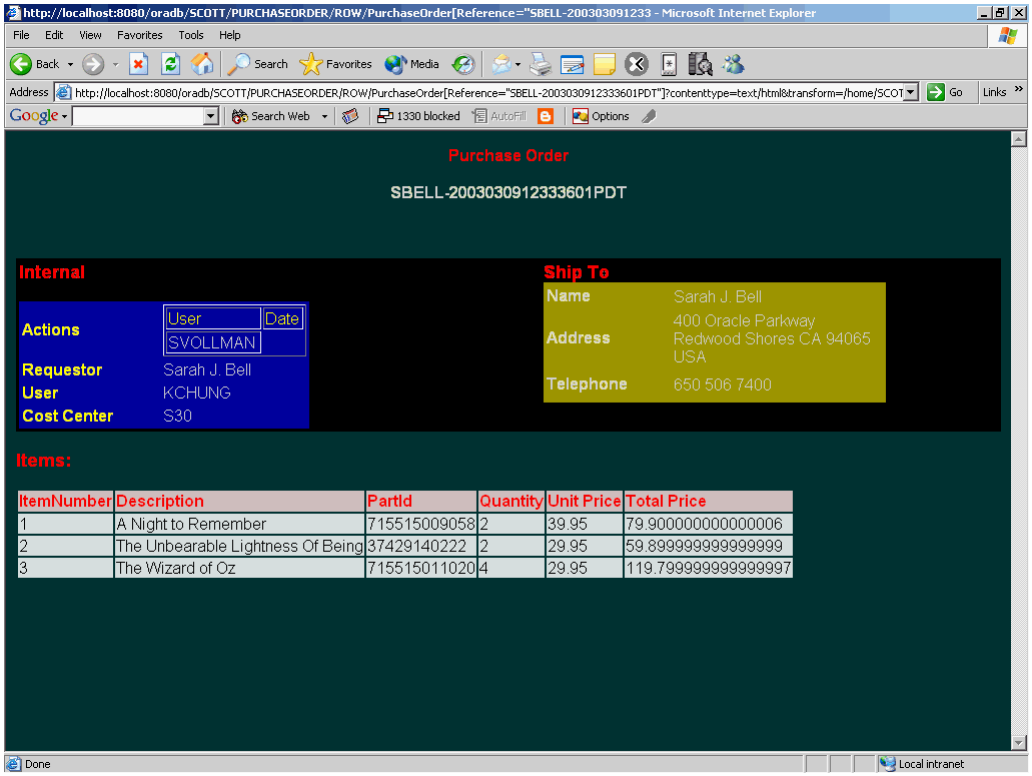
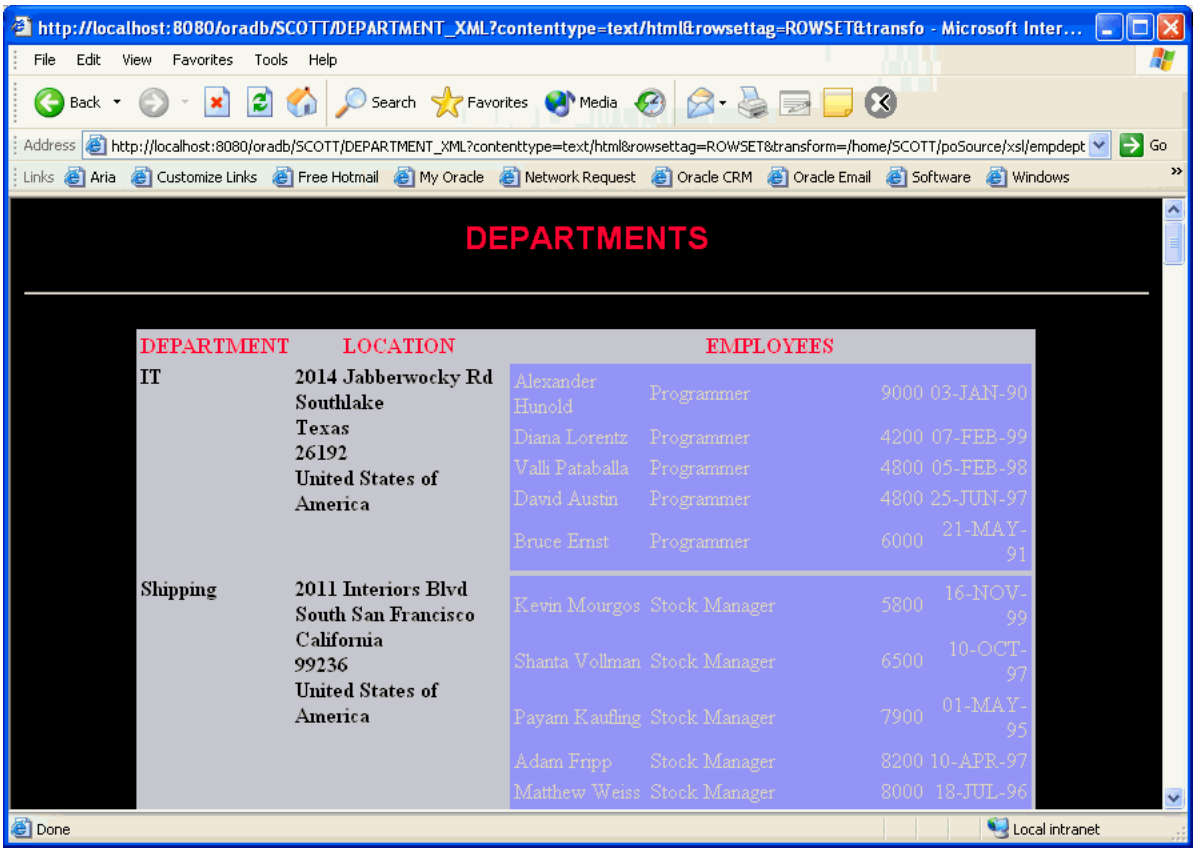


Figure 3–8 shows the `departments` table displayed as an HTML document. You need no code to achieve this, you only need an `XMLType` view, based on SQL/XML functions, an industry-standard XSL style sheet, and `DBUri` servlet.

Figure 3–8 Database XSL Transformation of Departments Table Using DBUri Servlet



Part II

Storing and Retrieving XML Data in Oracle XML DB

Part II of this manual introduces you to ways you can store, retrieve, validate, and transform XML data using Oracle XML DB. It contains the following chapters:

4

XMLType Operations

This chapter describes XMLType operations for XML applications (schema-based and non-schema-based). It includes guidelines for creating, manipulating, updating, and querying XMLType columns and tables.

This chapter contains these topics:

- Selecting and Querying XML Data
- Updating XML Instances and XML Data in Tables

See Also:

- Chapter 3, "Using Oracle XML DB" for XMLType storage recommendations
- Chapter 6, "XML Schema Storage and Query: Basic" for how to work with XML schema-based XMLType tables and columns

Selecting and Querying XML Data

You can query XML data from XMLType columns in the following ways:

- Select XMLType columns in SQL, PL/SQL, or Java.
- Query XMLType columns directly or using XMLType methods extract() and existsNode().
- Use Oracle Text operators to query the XML content. See Chapter 5, "Indexing XMLType Data" and Chapter 11, "Full-Text Search Over XML Data".
- Use the XQuery language. See "Using XQuery with XMLType Data" on page 18-20

Searching XML Documents with XPath Expressions

The XPath language is a W3C Recommendation for navigating XML documents. XPath models an XML document as a tree of nodes. It provides a rich set of operations that walk this tree and apply predicates and node-test functions. Applying an XPath expression to an XML document can result in a set of nodes. For example, the expression /PO/PONO selects all PONO child elements under the PO root element of the document.

Note: Oracle SQL functions and `XMLType` methods respect the W3C XPath recommendation, which states that if an XPath expression targets *no nodes* when applied to XML data, then an empty sequence must be returned; an error must *not* be raised.

The specific semantics of an Oracle SQL function or `XMLType` method that applies an XPath-expression to XML data determines what is returned. For example, SQL function `extract` returns `NULL` if its XPath-expression argument targets no nodes, and the updating SQL functions, such as `deleteXML`, return the input XML data unchanged. An error is never raised if no nodes are targeted, but updating SQL functions may raise an error if an XPath-expression argument targets inappropriate nodes, such as attribute nodes or text nodes.

Table 4–1 lists some common constructs used in XPath.

Table 4–1 Common XPath Constructs

XPath Construct	Description
`/`	Denotes the root of the tree in an XPath expression. For example, `/PO` refers to the child of the root node whose name is `PO`.
`/`	Also used as a path separator to identify the children node of any given node. For example, `/PurchaseOrder/Reference` identifies the purchase-order name element `Reference`, a child of the root element.
`//`	Used to identify all descendants of the current node. For example, `PurchaseOrder//ShippingInstructions` matches any `ShippingInstructions` element under the `PurchaseOrder` element.
`*`	Used as a wildcard to match any child node. For example, `/PO/*/STREET` matches any street element that is a grandchild of the `PO` element.
`[ ]`	Used to denote predicate expressions. XPath supports a rich list of binary operators such as `or`, `and`, and `not`. For example, `/PO[PONO = 20 and PNAME = "PO_2"]/SHIPADDR` selects the shipping address element of all purchase orders whose purchase-order number is `20` and whose purchase-order name is `PO_2`. Brackets are also used to denote a position (index). For example, `/PO/PONO[2]` identifies the second purchase-order number element under the `PO` root element.
Functions	XPath supports a set of built-in functions such as `substring()`, `round()`, and `not()`. In addition, XPath provides for extension functions through the use of namespaces. In the Oracle namespace, `http://xmlns.oracle.com/xdb`, Oracle XML DB additionally supports the function `ora:contains()`. This functions behaves like the equivalent SQL function.

The XPath must identify a single node, or a set of element, text, or attribute nodes. The result of the XPath cannot be a Boolean expression.

Oracle Extension XPath Function Support

Oracle supports the XPath extension function `ora:contains()`. This function provides text searching functionality with XPath.

See Also: Chapter 11, "Full-Text Search Over XML Data"

Selecting XML Data Using XMLType Methods

You can select `XMLType` data using PL/SQL, C, or Java. You can also use the `XMLType` methods `getCLOBVal()`, `getStringVal()`, `getNumberVal()`, and

getBLOBVal(csid) to retrieve XML data as a CLOB, VARCHAR, NUMBER, and BLOB value, respectively.

Example 4–1 Selecting XMLType Columns Using Method getCLOBVal()

This example shows how to select an XMLType column using method getCLOBVal():

```
CREATE TABLE xml_table OF XMLType;

Table created.

CREATE TABLE table_with_xml_column (filename VARCHAR2(64), xml_document XMLType);

Table created.

INSERT INTO xml_table
  VALUES (XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
          nls_charset_id('AL32UTF8')));

1 row created.

INSERT INTO table_with_xml_column (filename, xml_document)
  VALUES ('purchaseOrder.xml',
          XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'),
          nls_charset_id('AL32UTF8')));

1 row created.

SELECT x.OBJECT_VALUE.getCLOBVal() FROM xml_table x;

X.OBJECT_VALUE.GETCLOBVAL()
--------------------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNames
paceSchemaLocation="http://localhost:8080/source/schemas/poSource/xsd/purchaseOr
der.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
      Redwood Shores
...

1 row selected.

--
SELECT x.xml_document.getCLOBVal() FROM table_with_xml_column x;

X.XML_DOCUMENT.GETCLOBVAL()
--------------------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNames
paceSchemaLocation="http://localhost:8080/source/schemas/poSource/xsd/purchaseOr
```

```
der.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
      Redwood Shores
...

1 row selected.
```

> **Note:** In some circumstances, `XMLType` method `getCLOBVal()` returns a *temporary* `CLOB` value. If you call `getCLOBVal()` programmatically, you must explicitly *free* such a temporary `CLOB` value when finished with it. You can do this by calling PL/SQL method `DBMS_LOB.freeTemporary()` or its equivalent in Java or C (OCI). You can use method `DBMS_LOB.isTemporary()` to test whether a `CLOB` value is temporary.

Querying XMLType Data with SQL Functions

You can query `XMLType` data and extract portions of it using SQL functions, including the following:

- SQL/XML standard functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`
- Oracle functions `existsNode`, `extract`, and `extractValue`

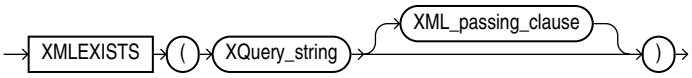
The Oracle functions use a subset of the W3C XPath recommendation to navigate the document. See Chapter 18, "Using XQuery with Oracle XML DB" for information about functions `XMLQuery` and `XMLTable`. The other functions are described in the following sections.

- XMLEXISTS SQL Function
- EXISTSNODE SQL Function
- EXTRACT SQL Function
- XMLCAST SQL Function
- EXTRACTVALUE SQL Function

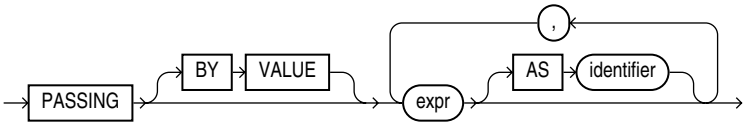
XMLEXISTS SQL Function

Figure 4–2 describes the syntax for SQL/XML standard function `XMLExists`. This function checks whether a given XQuery expression returns a non-empty XQuery sequence. If so, the function returns `TRUE`; otherwise, it returns `FALSE`.

Figure 4–1 XMLExists Syntax



XML_passing_clause::=



- *XQuery_string* is a complete XQuery expression, possibly including a prolog, as a literal string. It can contain XQuery variables that you bind using the XQuery PASSING clause (*XML_passing_clause* in the syntax diagram). The predefined namespace prefixes recognized for SQL function XMLQuery are also recognized in *XQuery_string*—see "Predefined Namespaces and Prefixes" on page 18-9.
- The *XML_passing_clause* is the keyword PASSING followed by one or more SQL expressions (*expr*) that each return an XMLType instance or an instance of a SQL scalar data type. All but possibly one of the expressions must each be followed by the keyword AS and an XQuery *identifier*. The result of evaluating each *expr* is bound to the corresponding *identifier* for the evaluation of *XQuery_string*. If there is an *expr* that is not followed by an AS clause, then the result of evaluating that *expr* is used as the *context* item for evaluating *XQuery_string*. Oracle XML DB supports only passing BY VALUE, not passing BY REFERENCE, so the clause BY VALUE is implicit and can be omitted.

Standard function XMLExists is similar to Oracle function existsNode, but it differs in these ways:

- XMLExists accepts an arbitrary XQuery expression (possibly including a prolog); existsNode accepts only an XPath expression (XPath is a proper subset of XQuery).
- XMLExists tests whether its XQuery-expression argument returns a non-empty sequence; existsNode tests whether its XPath-expression argument targets at least one element node or text node. The set of XPath expressions is a proper subset of the XQuery expressions.
- XMLExists returns a Boolean value, TRUE or FALSE; existsNode returns 1 or 0.

Oracle recommends that you use XMLExists instead of existsNode.

If an XQuery expression such as /PurchaseOrder/Reference or /PurchaseOrder/Reference/text() targets a single node, then XMLExists returns true for that expression. If XMLExists is called with an XQuery expression that locates no nodes, then XMLExists returns false.

Function XMLExists can be used in queries, and it can be used to create function-based indexes to speed up evaluation of queries.

Note: Oracle XML DB limits the use of XMLExists to a SQL WHERE clause or CASE expression. If you need to use XMLExists in a SELECT list, then wrap it in a CASE expression:

```
CASE WHEN XMLExists(...) THEN 'TRUE' ELSE 'FALSE' END
```

Example 4–2 Using XMLExists to Find a node

This example uses SQL/XML standard function `XMLExists` to select rows with `SpecialInstructions` set to `Expedite`. Compare Example 4–3, which uses Oracle SQL function `existsNode` to do the same thing.

```
SELECT OBJECT_VALUE
  FROM purchaseorder
  WHERE XMLExists('/PurchaseOrder[SpecialInstructions="Expedite"]'
                  PASSING OBJECT_VALUE);

OBJECT_VALUE
--------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

13 rows selected.
```

You can create function-based indexes using SQL function `XMLExists` to speed up the execution. You can also create an `XMLIndex` index to help speed up arbitrary XQuery searching.

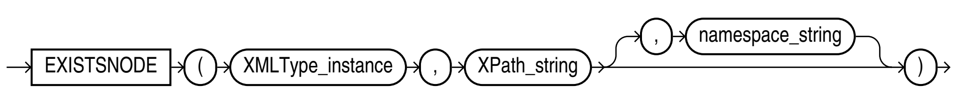
See Also:

- "Function-Based Indexes on XMLType Data" on page 5-5
- "XMLIndex" on page 5-10

EXISTSNODE SQL Function

Figure 4–2 describes the syntax for SQL function `existsNode`.

Figure 4–2 EXISTSNODE Syntax



Oracle SQL function `existsNode` checks whether the given XPath path targets at least one XML element node or text node. If so, the function returns `1`; otherwise, it returns `0`. Optional parameter *`namespace_string`* is used to map the namespace prefixes specified in parameter *`XPath_string`* to the corresponding namespaces.

Oracle function `existsNode` predates the SQL/XML standard function `XMLExists`. Oracle recommends that you use `XMLExists` instead of `existsNode` in new code. Function `existsNode` differs from `XMLExists` in these ways:

- `XMLExists` accepts an arbitrary XQuery expression (possibly including a prolog); `existsNode` accepts only an XPath expression (XPath is a proper subset of XQuery).

- `XMLExists` tests whether its XQuery-expression argument returns a non-empty sequence; `existsNode` tests whether its XPath-expression targets at least one element node or text node.
- `XMLExists` returns an XQuery Boolean value; `existsNode` returns `1` or `0`.

If an XPath expression such as `/PurchaseOrder/Reference` or `/PurchaseOrder/Reference/text()` targets a single node, then `existsNode` returns `1` for that expression. If `existsNode` is called with an XPath expression that locates no nodes, then `existsNode` returns `0`.

Function `existsNode` can be used in queries, and it can be used to create function-based indexes to speed up evaluation of queries.

Note: When using SQL function `existsNode` in a query, always use it in the `WHERE` clause, never in the `SELECT` list.

Example 4–3 Using EXISTSNODE to Find a node

This example uses SQL function `existsNode` to select rows with `SpecialInstructions` set to `Expedite`. Compare Example 4–2, which uses SQL/XML standard function `XMLExists` to do the same thing.

```
SELECT OBJECT_VALUE
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[SpecialInstructions="Expedite"]')
        = 1;

OBJECT_VALUE
--------------------------------------------------------------------------------
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

13 rows selected.
```

You can create function-based indexes using SQL function `existsNode` to speed up the execution. You can also create an `XMLIndex` index to help speed up arbitrary XPath searching.

See Also:

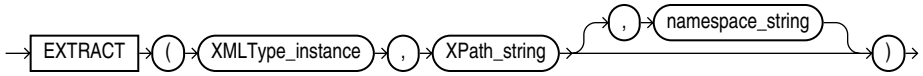
- "Function-Based Indexes on XMLType Data" on page 5-5
- "XMLIndex" on page 5-10

EXTRACT SQL Function

SQL function `extract` is similar to `existsNode`. It accepts a `VARCHAR2` XPath string that targets a node set and an optional `namespace` parameter. It returns an `XMLType` instance containing an XML fragment. The syntax is described in Figure 4–3:

```
extract(XMLType_instance IN XMLType,
        XPath_string IN VARCHAR2,
        namespace_string In VARCHAR2 := NULL) RETURN XMLType;
```

Figure 4–3 EXTRACT Syntax



> **Note:** You can use SQL/XML function `XMLQuery` as an alternative to `extract`. Using `XMLQuery` is generally recommended, because it is a standard function, not Oracle-specific.

Applying `extract` to an `XMLType` value extracts the node or a set of nodes from the document identified by the XPath expression. The XPath argument must target a node set. So, for example, XPath expression `/a/b/c[count('//d')=4]` can be used, but `count('//d')` cannot, because it returns a scalar value (number).

The extracted nodes can be element, attribute, or text nodes. If multiple text nodes are referenced in the XPath expression, the text nodes are collapsed into a single text node value. `Namespace` can be used to supply namespace information for prefixes in the XPath expression.

The `XMLType` instance returned from `extract` need not be a well-formed XML document. It can contain a set of nodes or simple scalar data. You can use `XMLType` methods `getStringVal()` and `getNumberVal()` to extract the scalar data.

For example, the XPath expression `/PurchaseOrder/Reference` identifies the `Reference` element inside the XML document shown previously. The expression `/PurchaseOrder/Reference/text()`, on the other hand, refers to the text node of this `Reference` element.

> **Note:** A text node is considered an instance of `XMLType`. In other words, the following expression returns an `XMLtype` instance even though the instance may contain only text:
>
> ```
> extract(OBJECT_VALUE, '/PurchaseOrder/Reference/text()')
> ```
>
> You can use method `getStringVal()` to retrieve the text from the `XMLType` instance as a `VARCHAR2` value.

Use the `text()` node test to identify text nodes in elements before using the `getStringVal()` or `getNumberVal()` to convert them to SQL data. Not having the `text()` node test would produce an XML fragment.

For example:

- XPath `/PurchaseOrder/Reference` identifies the fragment `<Reference> ... </Reference>`
- XPath `/PurchaseOrder/Reference/text()` identifies the value of the text node of the `Reference` element.

You can use XPath position predicates (sometimes called indexes) to identify individual elements in case of repeated elements in an XML document. If you have an XML document such as that in Example 4–4, then you can use:

- XPath expression `//LineItem[1]` to identify the first `LineItem` element.
- XPath expression `//LineItem[2]` to identify the second `LineItem` element.

Example 4–4 Purchase-Order XML Document

```
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation=
    "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
      Redwood Shores
      CA
      94065
      USA</address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
</PurchaseOrder>
```

The result of SQL function `extract` is always an `XMLType` instance. If applying the XPath path produces an empty set, then `extract` returns a `NULL` value.

SQL function `extract` can be used in a number of ways. You can extract:

- Numerical values on which function-based indexes can be created to speed up processing
- Collection expressions for use in the `FROM` clause of SQL statements
- Fragments for later aggregation to produce different documents

Example 4–5 Using EXTRACT to Extract the Value of a Node

This example uses SQL function `extract` to retrieve the `Reference` children of `PurchaseOrder` nodes whose `SpecialInstructions` attribute has value `Expedite`.

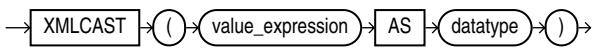
```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Reference') "REFERENCE"
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[SpecialInstructions="Expedite"]')
        = 1;

REFERENCE
--------------------------------------------------------------
<Reference>AMCEWEN-20021009123336271PDT</Reference>
<Reference>SKING-20021009123336321PDT</Reference>
<Reference>AWALSH-20021009123337303PDT</Reference>
<Reference>JCHEN-20021009123337123PDT</Reference>
<Reference>AWALSH-20021009123336642PDT</Reference>
<Reference>SKING-20021009123336622PDT</Reference>
<Reference>SKING-20021009123336822PDT</Reference>
<Reference>AWALSH-20021009123336101PDT</Reference>
<Reference>WSMITH-20021009123336412PDT</Reference>
<Reference>AWALSH-20021009123337954PDT</Reference>
<Reference>SKING-20021009123338294PDT</Reference>
<Reference>WSMITH-20021009123338154PDT</Reference>
<Reference>TFOX-20021009123337463PDT</Reference>

13 rows selected.
```

> **Note:** SQL function `extractValue` and `XMLType` method `getStringVal()` differ in their treatment of entity encoding. Function `extractValue` *unescapes* any encoded entities; method `getStringVal()` returns the data with entity encoding intact.

XMLCAST SQL Function

Figure 4–2 describes the syntax for SQL/XML standard function `XMLCast`.

Figure 4–4 XMLCast Syntax



SQL/XML standard function `XMLCast` casts its first argument to the scalar SQL data type specified by its second argument. The first argument is a SQL expression that is evaluated. Data types `NUMBER`, `VARCHAR2`, and any of the date and time data types can be used as the second argument.

> **Note:** Unlike the SQL/XML standard, Oracle XML DB limits the use of `XMLCast` to cast XML to a SQL scalar data type; it does not support casting XML to XML or from a scalar SQL type to XML.

The result of evaluating the first `XMLCast` argument is an XML value. It is converted to the target SQL data type by using the XQuery atomization process and then casting the XQuery atomic values to the target data type. If this conversion fails, then an error

is raised. If conversion succeeds, the result returned is an instance of the target data type.

Standard function `XMLCast` is similar to Oracle function `extractValue`, but it differs in that `extractValue` does not allow or require you to specify a target data type. In this, `extractValue` can sometimes be more convenient. `XMLCast` gives you the advantage of control over the data type, in addition to portability. If the SQL scalar data type cannot be determined at compile time, `extractValue` returns a value of time `VARCHAR2(4000)`, which might not always be what you expect or want. You can work around this obstacle by using the SQL function `cast`, but `XMLCast` is a better choice in this case.

Example 4–6 Extracting the Scalar Value of an XML Fragment Using XMLCAST

This query extracts the scalar value of the `Reference` node. Compare Example 4–7, which uses Oracle SQL function `extractValue` to do the same thing. This extraction of the scalar value of the node is in contrast to Example 4–5, where function `extract` retrieves the `<Reference>` node itself.

```
SELECT XMLCast(XMLQuery('/PurchaseOrder/Reference' PASSING OBJECT_VALUE
                                                   RETURNING CONTENT)
               AS VARCHAR2(100)) "REFERENCE"
  FROM purchaseorder
  WHERE XMLExists('/PurchaseOrder[SpecialInstructions="Expedite"]'
                  PASSING OBJECT_VALUE);

REFERENCE
----------------------------
AMCEWEN-20021009123336271PDT
SKING-20021009123336321PDT
AWALSH-20021009123337303PDT
JCHEN-20021009123337123PDT
AWALSH-20021009123336642PDT
SKING-20021009123336622PDT
SKING-20021009123336822PDT
AWALSH-20021009123336101PDT
WSMITH-20021009123336412PDT
AWALSH-20021009123337954PDT
SKING-20021009123338294PDT
WSMITH-20021009123338154PDT
TFOX-20021009123337463PDT

13 rows selected.
```

You can create function-based indexes using SQL function `existsNode` to speed up the execution. You can also create an `XMLIndex` index to help speed up arbitrary XPath searching.

See Also:

- "Function-Based Indexes on XMLType Data" on page 5-5
- "XMLIndex" on page 5-10

EXTRACTVALUE SQL Function

SQL function `extractValue` takes as parameters an `XMLType` instance and an XPath expression that targets a node set. It returns a scalar SQL value corresponding to the result of the XPath evaluation for the `XMLType` instance.

- XML schema-based documents – For documents based on XML schema, if Oracle Database can infer the type of the return value, then a scalar value of the appropriate type is returned. Otherwise, the result is of type `VARCHAR2`.
- Non-schema-based documents – If the query containing `extractValue` can be rewritten, such as when the query is over a SQL/XML view, then a scalar value of the appropriate type is returned. Otherwise, the result is of type `VARCHAR2`.

Figure 4–5 describes the `extractValue` syntax.

Figure 4–5 EXTRACTVALUE Syntax

SQL function `extractValue` attempts to determine the proper return type from the XML schema associated with the document, or from other information such as the SQL/XML view. If the proper return type cannot be determined, then Oracle XML DB returns a `VARCHAR2`. With XML schema-based content, `extractValue` returns the underlying data type in most cases. `CLOB` values are returned directly.

If a specific data type is desired, then you can apply a conversion function such as `to_char` or `to_date` to the result of `extractValue` or `extract.getStringVal()`. This can help maintain consistency between different queries, regardless of whether the queries can be rewritten.

Use EXTRACTVALUE for Convenience SQL function `extractValue` lets you extract the desired value more easily than `extract`; it is a convenience function. You can use it in place of `extract().getStringVal()` or `extract().getnumberval()`.

For example, you can replace `extract(x, 'path/text()').getStringVal()` with `extractValue(x, 'path/text()')`. If the node at `path` has only one child and that child is a text node, then you can leave the `text()` test off of the XPath argument: `extractValue(x, 'path')`. If not, an error is raised if you leave off `text()`.

SQL function `extractValue` has the same syntax as function `extract`.

EXTRACTVALUE Characteristics SQL function `extractValue` has the following characteristics:

- It returns only a scalar value (`NUMBER`, `VARCHAR2`, and so on). It cannot return XML nodes or mixed content. An error is raised if extractValue cannot return a scalar value.
- By default, it returns a `VARCHAR2` value. If the length is greater than 4K, a run-time error is raised.
- If XML schema information is available at query compile time, then the data type of the returned value is based on the XML schema information. For instance, if the XML schema information for the XPath `/PurchaseOrder/LineItems/LineItem[1]/Part/@Quantity` indicates a number, then `extractValue` returns a `NUMBER`.
- If `extractValue` is applied to a SQL/XML view and the data type of the column can be determined from the view definition at compile time, the appropriate type is returned.

- If the XPath argument identifies a node, then the node must have exactly one text child (or an error is raised). The text child is returned. For example, this expression extracts the text child of the `Reference` node:

  ```
  extractValue(xmlinstance, '/PurchaseOrder/Reference')
  ```

- The XPath argument must target a node set. So, for example, XPath expression `/a/b/c[count('//d')=4]` can be used, but `count('//d')` cannot, because it returns a scalar value (number).

Example 4–7 Extracting the Scalar Value of an XML Fragment Using EXTRACTVALUE

This query extracts the scalar value of the `Reference` node. Compare Example 4–6, which uses SQL/XML standard function `XMLCast` to do the same thing.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') "REFERENCE"
  FROM purchaseorder
  WHERE XMLExists('/PurchaseOrder[SpecialInstructions="Expedite"]'
                  PASSING OBJECT_VALUE);

REFERENCE
----------------------------
AMCEWEN-20021009123336271PDT
SKING-20021009123336321PDT
AWALSH-20021009123337303PDT
JCHEN-20021009123337123PDT
AWALSH-20021009123336642PDT
SKING-20021009123336622PDT
SKING-20021009123336822PDT
AWALSH-20021009123336101PDT
WSMITH-20021009123336412PDT
AWALSH-20021009123337954PDT
SKING-20021009123338294PDT
WSMITH-20021009123338154PDT
TFOX-20021009123337463PDT

13 rows selected.
```

> **Note:** Function `extractValue` and `XMLType` method `getStringVal()` differ in their treatment of entity encoding. Function `extractValue` *unescapes* any encoded entities; method `getStringVal()` returns the data with entity encoding intact.

EXTRACTVALUE XPath Expression Must Match A Single Leaf Node Example 4–8 shows some incorrect uses of SQL function `extractValue`. In the first query, the XPath expression identifies a *parent* node, not a *leaf* node (text node or attribute value). In the second query, the XPath expression matches *three* nodes in the document—it must match only *one*. Which error is raised for the second query depends on whether or not XPath rewrite takes place.

Example 4–8 Invalid Uses of EXTRACTVALUE

```
SELECT extractValue(OBJECT_VALUE,'/PurchaseOrder/LineItems/LineItem[1]')
  FROM purchaseorder;
  FROM purchaseorder
     *
ERROR at line 3:
```

```
ORA-19026: EXTRACTVALUE can only retrieve value of leaf node


SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Description')
  FROM purchaseorder;
SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Description')
 *
ERROR at line 1:
ORA-01427: single-row subquery returns more than one row
```

If XPath rewrite does not occur, then this query can instead raise the following error:

```
ORA-19025: EXTRACTVALUE returns value of only one node
```

Querying XML Data With SQL

The following examples illustrate ways you can query XML data with SQL.

Example 4–9 Querying XMLType Using EXTRACTVALUE and EXISTSNODE

This example inserts two rows into the `purchaseorder` table, then queries data in those rows using `extractValue`.

```
INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'SMCCAIN-2002091213000000PDT.xml'),
                  nls_charset_id('AL32UTF8')));

1 row created.

INSERT INTO purchaseorder
  VALUES (XMLType(bfilename('XMLDIR', 'VJONES-20020916140000000PDT.xml'),
                  nls_charset_id('AL32UTF8')));

1 row created.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') REFERENCE,
       extractValue(OBJECT_VALUE, '/PurchaseOrder/*//User') USERID,
       CASE
         WHEN existsNode(OBJECT_VALUE, '/PurchaseOrder/Reject/Date') = 1
           THEN 'Rejected'
           ELSE 'Accepted'
       END "STATUS",
       extractValue(OBJECT_VALUE, '//Date') STATUS_DATE
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,'//Date') = 1
  ORDER BY extractValue(OBJECT_VALUE,'//Date');

REFERENCE                       USERID   STATUS   STATUS_DATE
------------------------------- -------- -------- ------------
VJONES-20020916140000000PDT     SVOLLMAN Accepted 2002-10-11
SMCCAIN-2002091213000000PDT     SKING    Rejected 2002-10-12

2 rows selected.
```

Example 4–10 Querying Transient XMLType Data

This example uses a PL/SQL cursor to query XML data. A local `XMLType` instance is used to store transient data.

```
DECLARE
  xNode          XMLType;
  vText          VARCHAR2(256);
  vReference     VARCHAR2(32);
  CURSOR getPurchaseOrder(reference IN VARCHAR2) IS
           SELECT OBJECT_VALUE XML
             FROM purchaseorder
             WHERE existsNode(OBJECT_VALUE,
                              '/PurchaseOrder[Reference="'|| reference || '"]')
                   = 1;
BEGIN
  vReference := 'EABEL-20021009123335791PDT';
  FOR c IN getPurchaseOrder(vReference) LOOP
    xNode := c.XML.extract('//Requestor');
    vText := xNode.extract('//text()').getStringVal();
    DBMS_OUTPUT.put_line('The Requestor for Reference '
                         || vReference || ' is '|| vText);
  END LOOP;
  vReference := 'PTUCKER-20021009123335430PDT';
  FOR c IN getPurchaseOrder(vReference) LOOP
    xNode := c.XML.extract('//LineItem[@ItemNumber="1"]/Description');
    vText := xNode.extract('//text()').getStringVal();
    DBMS_OUTPUT.put_line('The Description of LineItem[1] for Reference '
                         || vReference || ' is '|| vText);
  END LOOP;
END;
/
The Requestor for Reference EABEL-20021009123335791PDT is Ellen S. Abel
The Description of LineItem[1] for Reference PTUCKER-20021009123335430PDT is
Picnic at Hanging Rock

PL/SQL procedure successfully completed.
```

Example 4–11 Extracting XML Data with XMLTable, and Inserting It into a Database Table

This example uses SQL function `XMLTable` to extract data from an XML purchase-order document, and then inserts that data into a database table.

```
CREATE TABLE purchaseorder_table (reference           VARCHAR2(28) PRIMARY KEY,
                                  requestor           VARCHAR2(48),
                                  actions             XMLType,
                                  userid              VARCHAR2(32),
                                  costcenter          VARCHAR2(3),
                                  shiptoname          VARCHAR2(48),
                                  address             VARCHAR2(512),
                                  phone               VARCHAR2(32),
                                  rejectedby          VARCHAR2(32),
                                  daterejected        DATE,
                                  comments            VARCHAR2(2048),
                                  specialinstructions VARCHAR2(2048));

CREATE TABLE purchaseorder_lineitem (reference,
                                     FOREIGN KEY ("REFERENCE")
                                       REFERENCES "PURCHASEORDER_TABLE" ("REFERENCE") ON DELETE CASCADE,
                                     lineno      NUMBER(10), PRIMARY KEY ("REFERENCE", "LINENO"),
                                     upc         VARCHAR2(14),
                                     description VARCHAR2(128),
                                     quantity    NUMBER(10),
                                     unitprice   NUMBER(12,2));

INSERT INTO purchaseorder_table (reference, requestor, actions, userid, costcenter, shiptoname, address,
                                 phone, rejectedby, daterejected, comments, specialinstructions)
  SELECT t.reference, t.requestor, t.actions, t.userid, t.costcenter, t.shiptoname, t.address,
```

```
          t.phone, t.rejectedby, t.daterejected, t.comments, t.specialinstructions
    FROM purchaseorder p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS reference           VARCHAR2(28)   PATH 'Reference',
                          requestor           VARCHAR2(48)   PATH 'Requestor',
                          actions             XMLType        PATH 'Actions',
                          userid              VARCHAR2(32)   PATH 'User',
                          costcenter          VARCHAR2(3)    PATH 'CostCenter',
                          shiptoname          VARCHAR2(48)   PATH 'ShippingInstructions/name',
                          address             VARCHAR2(512)  PATH 'ShippingInstructions/address',
                          phone               VARCHAR2(32)   PATH 'ShippingInstructions/telephone',
                          rejectedby          VARCHAR2(32)   PATH 'Rejection/User',
                          daterejected        DATE           PATH 'Rejection/Date',
                          comments            VARCHAR2(2048) PATH 'Rejection/Comments',
                          specialinstructions VARCHAR2(2048) PATH 'SpecialInstructions') t
    WHERE t.reference = 'EABEL-20021009123336251PDT';

1 row created.

INSERT INTO purchaseorder_lineitem (reference, lineno, upc, description, quantity, unitprice)
  SELECT t.reference, li.lineno, li.upc, li.description, li.quantity, li.unitprice
    FROM purchaseorder p,
         XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                  COLUMNS reference VARCHAR2(28) PATH 'Reference',
                          lineitem XMLType PATH 'LineItems/LineItem') t,
         XMLTable('LineItem' PASSING t.lineitem
                  COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                          upc         VARCHAR2(14)  PATH 'Part/@Id',
                          description VARCHAR2(128) PATH 'Description',
                          quantity    NUMBER(10)    PATH 'Part/@Quantity',
                          unitprice   NUMBER(12,2)  PATH 'Part/@UnitPrice') li
    WHERE t.reference = 'EABEL-20021009123336251PDT';

3 rows created.

SELECT reference, userid, shiptoname, specialinstructions FROM purchaseorder_table;

REFERENCE                      USERID   SHIPTONAME                                      SPECIALINSTRUCTIONS
------------------------------ -------- ----------------------------------------------- -------------------
EABEL-20021009123336251PDT     EABEL    Ellen S. Abel                                   Counter to Counter

1 row selected.

SELECT reference, lineno, upc, description, quantity FROM purchaseorder_lineitem;

REFERENCE                         LINENO UPC           DESCRIPTION                          QUANTITY
------------------------------ ---------- ------------- ---------------------------------- ----------
EABEL-20021009123336251PDT              1 37429125526   Samurai 2: Duel at Ichijoji Temple          3
EABEL-20021009123336251PDT              2 37429128220   The Red Shoes                               4
EABEL-20021009123336251PDT              3 715515009058  A Night to Remember                         1

3 rows selected.
```

Example 4–12 Extracting XML Data with EXTRACTVALUE, and Inserting It into a Table

This example extracts data from an XML purchase-order document, and inserts it into a relational table using SQL function `extractValue`.

```
CREATE OR REPLACE PROCEDURE insertPurchaseOrder(purchaseorder XMLType) AS reference VARCHAR2(28);
BEGIN
  INSERT INTO purchaseorder_table (reference, requestor, actions, userid, costcenter, shiptoname, address,
                                   phone, rejectedby, daterejected, comments, specialinstructions)
    VALUES (extractValue(purchaseorder, '/PurchaseOrder/Reference'),
            extractValue(purchaseorder, '/PurchaseOrder/Requestor'),
            extract(purchaseorder,      '/PurchaseOrder/Actions'),
            extractValue(purchaseorder, '/PurchaseOrder/User'),
```

```
           extractValue(purchaseorder, '/PurchaseOrder/CostCenter'),
           extractValue(purchaseorder, '/PurchaseOrder/ShippingInstructions/name'),
           extractValue(purchaseorder, '/PurchaseOrder/ShippingInstructions/address'),
           extractValue(purchaseorder, '/PurchaseOrder/ShippingInstructions/telephone'),
           extractValue(purchaseorder, '/PurchaseOrder/Rejection/User'),
           extractValue(purchaseorder, '/PurchaseOrder/Rejection/Date'),
           extractValue(purchaseorder, '/PurchaseOrder/Rejection/Comments'),
           extractValue(purchaseorder, '/PurchaseOrder/SpecialInstructions'))
   RETURNING reference INTO reference;

  INSERT INTO purchaseorder_lineitem (reference, lineno, upc, description, quantity, unitprice)
    SELECT reference, li.lineno, li.upc, li.description, li.quantity, li.unitprice
      FROM XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING purchaseorder
                    COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                            upc         VARCHAR2(14)  PATH 'Part/@Id',
                            description VARCHAR2(128) PATH 'Description',
                            quantity    NUMBER(10)    PATH 'Part/@Quantity',
                            unitprice   NUMBER(12,2)  PATH 'Part/@UnitPrice') li;
END;
/
Procedure created.

CALL insertPurchaseOrder(XMLType(bfilename('XMLDIR', 'purchaseOrder.xml'), nls_charset_id('AL32UTF8')));

Call completed.

SELECT reference, userid, shiptoname, specialinstructions FROM purchaseorder_table;

REFERENCE                      USERID   SHIPTONAME                                         SPECIALINSTRUCTIONS
------------------------------ -------- -------------------------------------------------- --------------------
SBELL-20021009123336O1PDT      SBELL    Sarah J. Bell                                      Air Mail

1 row selected.

SELECT reference, lineno, upc, description, quantity FROM purchaseorder_lineitem;

REFERENCE                LINENO UPC          DESCRIPTION                       QUANTITY
------------------------ ------ ------------ --------------------------------- --------
SBELL-20021009123336O1PDT      1 715515009058 A Night to Remember                       2
SBELL-20021009123336O1PDT      2 37429140222  The Unbearable Lightness Of Being         2
SBELL-20021009123336O1PDT      3 715515011020 Sisters                                   4

3 rows selected.
```

Example 4–13 Searching XML Data with XMLType Methods extract() and existsNode()

This example extracts the purchase-order name from the `PurchaseOrder` element, for customers with "`ll`" (double L) in their names and the word "`Shores`" in the shipping instructions. It uses `XMLType` methods `extract()` and `existsNode()` instead of SQL functions `extract and existsNode`.

```
SELECT p.OBJECT_VALUE.extract('/PurchaseOrder/Requestor/text()').getStringVal() NAME,
       count(*)
  FROM purchaseorder p
  WHERE p.OBJECT_VALUE.existsNode
          ('/PurchaseOrder/ShippingInstructions[ora:contains(address/text(),"Shores")>0]',
           'xmlns:ora="http://xmlns.oracle.com/xdb"') = 1
    AND p.OBJECT_VALUE.extract('/PurchaseOrder/Requestor/text()').getStringVal() LIKE '%ll%'
  GROUP BY p.OBJECT_VALUE.extract('/PurchaseOrder/Requestor/text()').getStringVal();

NAME                   COUNT(*)
---------------------- ----------
Allan D. McEwen                 9
Ellen S. Abel                   4
Sarah J. Bell                  13
```

```
William M. Smith             7

4 rows selected.
```

Example 4–14 Searching XML Data with EXTRACTVALUE

This example shows the query of Example 4–13 rewritten to use SQL function `extractValue`.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME, count(*)
  FROM purchaseorder
  WHERE existsNode
          (OBJECT_VALUE,
           '/PurchaseOrder/ShippingInstructions[ora:contains(address/text(), "Shores")>0]',
           'xmlns:ora="http://xmlns.oracle.com/xdb') = 1
    AND extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor/text()') LIKE '%ll%'
  GROUP BY extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor');

NAME                   COUNT(*)
-------------------- ----------
Allan D. McEwen               9
Ellen S. Abel                 4
Sarah J. Bell                13
William M. Smith              7

4 rows selected.
```

Example 4–15 uses SQL function `extract` to extract nodes identified by an XPath expression. An `XMLType` instance containing the XML fragment is returned by `extract`. The result may be a set of nodes, a singleton node, or a text value. You can determine whether the result is a fragment using the `isFragment()` method on the `XMLType` instance.

> **Note:** You cannot insert fragments into `XMLType` columns. You can use SQL function `sys_XMLGen` to convert a fragment into a well-formed document by adding an enclosing tag. See "Generating XML Using SQL Function SYS_XMLGEN" on page 17-49. You can, however, query further on the fragment using the various `XMLType` functions.

Example 4–15 Extracting Fragments From an XMLType Instance Using EXTRACT

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') REFERENCE, count(*)
  FROM purchaseorder, XMLTable('//LineItem[Part/@Id="37429148327"]' PASSING OBJECT_VALUE)
  WHERE extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[Part/@Id="37429148327"]').isFragment() = 1
  GROUP BY extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference')
  ORDER BY extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference');

REFERENCE                        COUNT(*)
-------------------------------- ----------
AWALSH-20021009123337303PDT               1
AWALSH-20021009123337954PDT               1
DAUSTIN-20021009123337553PDT              1
DAUSTIN-20021009123337613PDT              1
LSMITH-2002100912333722PDT                1
LSMITH-20021009123337323PDT               1
PTUCKER-20021009123336291PDT              1
SBELL-20021009123335771PDT                1
SKING-20021009123335560PDT                1
SMCCAIN-20021009123336151PDT              1
SMCCAIN-20021009123336842PDT              1
SMCCAIN-2002100912333894PDT               1
TFOX-2002100912333681PDT                  1
```

```
TFOX-20021009123337784PDT                3
WSMITH-20021009123335650PDT              1
WSMITH-20021009123336412PDT              1

16 rows selected.
```

Updating XML Instances and XML Data in Tables

This section covers updating transient XML instances and XML data stored in tables. It details the use of SQL functions `updateXML`, `insertChildXML`, `insertXMLbefore`, `appendChildXML`, and `deleteXML`.

Updating an Entire XML Document

For unstructured storage (`CLOB`), an update effectively replaces the entire document. To update an entire XML document, use a SQL `UPDATE` statement. The right side of the `UPDATE` statement `SET` clause must be an `XMLType` instance. This can be created in any of the following ways:

- Use SQL functions or XML constructors that return an XML instance.
- Use the PL/SQL DOM APIs for `XMLType` that change and bind an existing XML instance.
- Use the Java DOM API that changes and binds an existing XML instance.

Updates for non-schema-based XML documents stored as `CLOB` values (unstructured storage) always update the entire XML document. Updates for non-schema-based documents stored as binary XML can be made in a piecewise manner. See "Updating XML Schema-Based and Non-Schema-Based XML Documents" on page 3-57.

Example 4–16 Updating XMLType Using SQL UPDATE Statement

This example updates an `XMLType` instance using a SQL `UPDATE` statement.

```
SELECT t.reference, li.lineno, li.description
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                COLUMNS reference VARCHAR2(28) PATH 'Reference',
                        lineitem  XMLType      PATH 'LineItems/LineItem') t
       XMLTable('/LineItem' PASSING t.lineitem
                COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                        description VARCHAR2(128) PATH 'Description') li
  WHERE t.reference = 'DAUSTIN-20021009123335811PDT' AND ROWNUM < 6;

REFERENCE                      LINENO DESCRIPTION
------------------------------ ------- -----------------
DAUSTIN-20021009123335811PDT         1 Nights of Cabiria
DAUSTIN-20021009123335811PDT         2 For All Mankind
DAUSTIN-20021009123335811PDT         3 Dead Ringers
DAUSTIN-20021009123335811PDT         4 Hearts and Minds
DAUSTIN-20021009123335811PDT         5 Rushmore

5 rows selected.

UPDATE purchaseorder
  SET OBJECT_VALUE = XMLType(bfilename('XMLDIR', 'NEW-DAUSTIN-20021009123335811PDT.xml'),
                             nls_charset_id('AL32UTF8'))
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="DAUSTIN-20021009123335811PDT"]') = 1;

1 row updated.

SELECT t.reference, li.lineno, li.description
```

```
  FROM purchaseorder p,
       XMLTable('/PurchaseOrder' PASSING p.OBJECT_VALUE
                COLUMNS reference VARCHAR2(28) PATH 'Reference',
                        lineitem  XMLType      PATH 'LineItems/LineItem') t
       XMLTable('/LineItem' PASSING t.lineitem
                COLUMNS lineno      NUMBER(10)    PATH '@ItemNumber',
                        description VARCHAR2(128) PATH 'Description') li
  WHERE t.reference = 'DAUSTIN-20021009123335811PDT';

REFERENCE                      LINENO DESCRIPTION
------------------------------ ------- --------------------------------
DAUSTIN-20021009123335811PDT           1 Dead Ringers
DAUSTIN-20021009123335811PDT           2 Getrud
DAUSTIN-20021009123335811PDT           3 Branded to Kill

3 rows selected.
```

SQL Functions to Update XML Data

There are several SQL functions that you can use to update XML data incrementally—that is, to replace, insert, or delete XML data without replacing the entire surrounding XML document. This is also called **partial updating**. These SQL functions are described in the following sections:

- `updateXML` – Replace XML nodes of any kind. See "UPDATEXML SQL Function" on page 4-21.
- `insertChildXML` – Insert XML element or attribute nodes as children of a given element node. See "INSERTCHILDXML SQL Function" on page 4-29.
- `insertXMLbefore` – Insert XML nodes of any kind immediately before a given node (other than an attribute node). See "INSERTXMLBEFORE SQL Function" on page 4-32.
- `appendChildXML` – Insert XML nodes of any kind as the last child nodes of a given element node. See "APPENDCHILDXML SQL Function" on page 4-33.
- `deleteXML` – Delete XML nodes of any kind. See "DELETEXML SQL Function" on page 4-35.

Use functions `insertChildXML`, `insertXMLbefore`, and `appendChildXML` to insert XML data; use `deleteXML` to delete XML data; use `updateXML` to replace XML data. In particular, do *not* use function `updateXML` to insert or delete XML data by replacing a parent node in its entirety; that will work, but it is less efficient than using one of the other functions, which perform more localized updates.

These functions do *not*, by themselves, change database data – they are all pure functions, without side effect. Each applies an XPath-expression argument to input XML data and returns a modified *copy* of the input XML data. You can then use that result with SQL DML operator `UPDATE` to modify database data. This is no different from the way you use SQL function `upper` to convert database data to uppercase: you must use a SQL DML operator such as `UPDATE` to change the stored data.

Each of these functions can be used on XML documents that are either schema-based or non-schema-based. For XML schema-based data, these SQL functions perform partial validation on the result, and, where appropriate, argument values are also checked for compatibility with the XML schema.

Note: Oracle SQL functions and `XMLType` methods respect the W3C XPath recommendation, which states that if an XPath expression targets *no nodes* when applied to XML data, then an empty sequence must be returned; an error must *not* be raised.

The specific semantics of an Oracle SQL function or `XMLType` method that applies an XPath-expression to XML data determines what is returned. For example, SQL function `extract` returns `NULL` if its XPath-expression argument targets no nodes, and the updating SQL functions, such as `deleteXML`, return the input XML data unchanged. An error is never raised if no nodes are targeted, but updating SQL functions may raise an error if an XPath-expression argument targets inappropriate nodes, such as attribute nodes or text nodes.

See Also: "Partial Validation" on page 3-31 for more information about partial validation against an XML schema

UPDATEXML SQL Function

SQL function `updateXML` replaces XML nodes of any kind. The XML document that is the target of the update can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned; the original data is unaffected. You can use that returned data with SQL operation `UPDATE` to modify database data.

Function `updateXML` has the following parameters (in order):

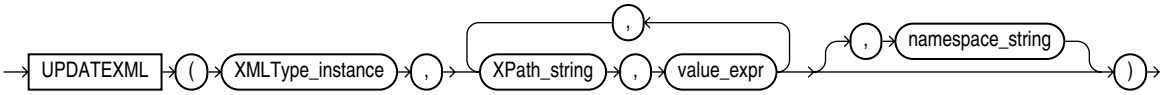
- ***target-data*** (`XMLType`) – The XML data containing the target node to replace.
- One or more *pairs* of *`xpath`* and *`replacement`* parameters:
  - ***xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates the nodes within *`target-data`* to replace; *each* targeted node is replaced by *`replacement`*. These can be nodes of any kind. If *`xpath`* matches an empty sequence of nodes, then no replacement is done; *`target-data`* is returned unchanged (and no error is raised).
  - ***replacement*** (`XMLType` or `VARCHAR2`) – The XML data that replaces the data targeted by *`xpath`*. The data type of *`replacement`* must correspond to the data to be replaced. If *`xpath`* targets an element node for replacement, then the data type must be `XMLType`; if *`xpath`* targets an attribute node or a text node, then it must be `VARCHAR2`. For an attribute node, *`replacement`* is only the replacement *value* of the attribute (for example, 23), not the complete attribute node including the name (for example, `my_attribute="23"`).
- ***namespace*** (`VARCHAR2`, *optional*) – The XML namespace for parameter *`xpath`*.

SQL function `updateXML` can be used to *replace* existing elements, attributes, and other nodes with new values. It is *not* an efficient way to insert new nodes or delete existing ones; you can only perform insertions and deletions with `updateXML` by using it to replace the entire node that is parent of the node to be inserted or deleted.

Function `updateXML` updates only the transient XML instance in memory. Use a SQL `UPDATE` statement to update data stored in tables.

Figure 4–6 illustrates the syntax.

Figure 4–6 UPDATEXML Syntax



****

Example 4–17 Updating XMLType Using UPDATE and UPDATEXML

This example uses `updateXML` on the right side of an `UPDATE` statement to update the XML document in a table instead of creating a new document. The entire document is updated, not just the part that is selected.

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Actions/Action[1]') ACTION FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

ACTION
--------------------------------
<Action>
  <User>SVOLLMAN</User>
</Action>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE, '/PurchaseOrder/Actions/Action[1]/User/text()', 'SKING')
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

1 row updated.

SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Actions/Action[1]') ACTION
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,'/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

ACTION
--------------------------------
<Action>
  <User>SKING</User>
</Action>

1 row selected.
```

Example 4–18 Updating Multiple Text Nodes and Attribute Values Using UPDATEXML

This example updates multiple nodes using SQL function `updateXML`.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

NAME            LINEITEMS
--------------- --------------------------------------------------------------------------
Sarah J. Bell   <LineItems>
                  <LineItem ItemNumber="1">
                    <Description>A Night to Remember</Description>
                    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="2">
                    <Description>The Unbearable Lightness Of Being</Description>
                    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                  </LineItem>
                  <LineItem ItemNumber="3">
```

```
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE,
                               '/PurchaseOrder/Requestor/text()', 'Stephen G. King',
                               '/PurchaseOrder/LineItems/LineItem[1]/Part/@Id', '786936150421',
                               '/PurchaseOrder/LineItems/LineItem[1]/Description/text()', 'The Rock',
                               '/PurchaseOrder/LineItems/LineItem[3]',
                               XMLType('<LineItem ItemNumber="99">
                                          <Description>Dead Ringers</Description>
                                          <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                                        </LineItem>'))
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>The Rock</Description>
                     <Part Id="786936150421" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Description>Dead Ringers</Description>
                     <Part Id="715515009249" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                 </LineItems>

1 row selected.
```

Example 4–19 Updating Selected Nodes Within a Collection Using UPDATEXML

This example uses SQL function `updateXML` to update selected nodes within a collection.

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
```

```
                  </LineItem>
                  <LineItem ItemNumber="3">
                    <Description>Sisters</Description>
                    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                  </LineItem>
                </LineItems>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
      updateXML(OBJECT_VALUE,
                '/PurchaseOrder/Requestor/text()', 'Stephen G. King',
                '/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity', 25,
                '/PurchaseOrder/LineItems/LineItem[Description/text()="The Unbearable Lightness Of Being"]',
                XMLType('<LineItem ItemNumber="99">
                           <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                           <Description>The Rock</Description>
                         </LineItem>'))
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

NAME             LINEITEMS
---------------- --------------------------------------------------------------------------
Stephen G. King  <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="25"/>
                   </LineItem>
                   <LineItem ItemNumber="99">
                     <Part Id="786936150421" Quantity="5" UnitPrice="29.95"/>
                     <Description>The Rock</Description>
                   </LineItem>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>

1 row selected.
```

UPDATEXML and NULL Values

If you update an XML *element* to `NULL`, the attributes and children of the element are removed, and the element becomes empty. The type and namespace properties of the element are retained. See Example 4–20.

If you update an *attribute* value to `NULL`, the value appears as the empty string. See Example 4–20.

If you update the *text* node of an element to `NULL`, the content (text) of the element is removed; the element itself remains, but is empty. See Example 4–21.

Example 4–20 NULL Updates With UPDATEXML – Element and Attribute

This example updates all of the following to `NULL`:

- The `Description` element and the `Quantity` attribute of the `LineItem` element whose `Part` element has attribute `Id` value 715515009058.

- The `LineItem` element whose `Description` element has the content (text) "The Unbearable Lightness Of Being".

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description>A Night to Remember</Description>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="2">
                     <Description>The Unbearable Lightness Of Being</Description>
                     <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
                   </LineItem>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
      updateXML(
        OBJECT_VALUE,
        '/PurchaseOrder/LineItems/LineItem[Part/@Id="715515009058"]/Description', NULL,
        '/PurchaseOrder/LineItems/LineItem/Part[@Id="715515009058"]/@Quantity', NULL,
        '/PurchaseOrder/LineItems/LineItem[Description/text()="The Unbearable Lightness Of Being"]', NULL)
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Requestor') NAME,
       extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') LINEITEMS
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

NAME             LINEITEMS
---------------- --------------------------------------------------------------------
Sarah J. Bell    <LineItems>
                   <LineItem ItemNumber="1">
                     <Description/>
                     <Part Id="715515009058" UnitPrice="39.95" Quantity=""/>
                   </LineItem>
                   <LineItem/>
                   <LineItem ItemNumber="3">
                     <Description>Sisters</Description>
                     <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
                   </LineItem>
                 </LineItems>

1 row selected.
```

Example 4–21 updates the text node of a `Part` element whose `Description` attribute has value "`A Night to Remember`" to `NULL`.

Example 4–21 NULL Updates With UPDATEXML – Text Node

The XML data for this example corresponds to a different, revised purchase-order XML schema – see "Scenario for Copy-Based Evolution" on page 9-2. In that XML schema, `Description` is an attribute of the `Part` element, not a sibling element.

```
SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]') PART
  FROM purchaseorder
  WHERE existsNode(object_value,'/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]') = 1;

PART
----
<Part Description="A Night to Remember" UnitCost="39.95">715515009058</Part>

UPDATE purchaseorder
  SET OBJECT_VALUE =
        updateXML(OBJECT_VALUE,
                  '/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]/text()', NULL)
  WHERE existsNode(object_value,'/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]') = 1;


SELECT extractValue(OBJECT_VALUE,
                    '/PurchaseOrder/LineItems/LineItem/Part[@Description="A Night to Remember"]') PART
  FROM purchaseorder
  WHERE existsNode(object_value,'/PurchaseOrder[@Reference="SBELL-2003030912333601PDT"]') = 1;


PART
----
<Part Description="A Night to Remember" UnitCost="39.95"/>
```

See Also: Example 7–2, Example 7–3, Example 3–35, and Example 3–35 for examples of rewriting `updateXML` expressions

Updating the Same XML Node More Than Once

You can update the same XML node more than once in an `updateXML` expression. For example, you can update both `/EMP[EMPNO=217]` and `/EMP[EMPNAME="Jane"]/EMPNO`, where the first XPath identifies the `EMPNO` node containing it as well. The order of updates is determined by the order of the XPath expressions in left-to-right order. Each successive XPath works on the result of the previous XPath update.

Preserving DOM Fidelity When Using UPDATEXML

Here are some guidelines for preserving DOM fidelity when using SQL function `updateXML`:

When DOM Fidelity is Preserved When you update an element to `NULL`, you make that element appear *empty* in its parent, such as in `<myElem/>`.

When you update a text node inside an element to `NULL`, you *remove* that text node from the element.

When you update an attribute node to `NULL`, you make the value of the attribute become the *empty* string, for example, `myAttr=""`.

When DOM Fidelity is Not Preserved When you update a `complexType` element to `NULL`, you make the element appear *empty* in its parent, for example, `<myElem/>`.

When you update a SQL-inlined `simpleType` element to `NULL`, you make the element *disappear* from its parent.

When you update a text node to `NULL`, you are doing the same thing as setting the parent `simpleType` element to `NULL`. Furthermore, text nodes can appear only inside `simpleType` elements when DOM fidelity is not preserved, since there is no positional descriptor with which to store mixed content.

When you update an attribute node to `NULL`, you *remove* the attribute from the element.

Determining Whether DOM Fidelity is Preserved You can determine whether or not DOM fidelity is preserved for particular parts of a given `XMLType` in a given XML schema by querying the schema metadata for attribute `maintainDOM`.

See Also:

- "Querying a Registered XML Schema to Obtain Annotations" on page 6-40 for an example of querying a schema to retrieve DOM fidelity values
- "DOM Fidelity" on page 6-15

Optimization of SQL Functions that Modify XML Data

In most cases, the SQL functions that modify XML data (`updateXML`, `insertChildXML`, `insertXMLbefore`, `appendChildXML`, and `deleteXML`) materialize a copy of the entire input XML document in memory, then update the copy. However, functions `updateXML`, `insertChildXML`, and `deleteXML` are optimized for SQL `UPDATE` operations on `XMLType` tables and columns that are stored object-relationally or as binary XML. For structured storage, if particular conditions are met, then the function call can be rewritten to update the object-relational columns directly with the values. For binary XML storage, data preceding the targeted update is not modified, and, if SecureFile LOBs are used, then sliding inserts are used to update only the portions of the data that need changing.

See Also:

- "Updating XML Schema-Based and Non-Schema-Based XML Documents" on page 3-57 for more about piecewise updating
- Chapter 3, "Using Oracle XML DB" and Chapter 7, "XPath Rewrite" for information about the conditions for XPath rewrite

As an example with object-relational storage, the XPath argument to `updateXML` in Example 4–22 is processed by Oracle XML DB and rewritten into the equivalent object relational SQL statement shown in Example 4–23.

Example 4–22 XPath Expressions in UPDATEXML Expression

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

EXTRACTVAL
----------
SBELL

1 row selected.

UPDATE purchaseorder
```

```
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE, '/PurchaseOrder/User/text()', 'SVOLLMAN')
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

EXTRACTVAL
----------
SVOLLMAN

1 row selected.
```

Example 4–23 Object Relational Equivalent of UPDATEXML Expression

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

EXTRACTVAL
----------
SBELL

1 row selected.

UPDATE purchaseorder p
   SET p."XMLDATA"."USERID" = 'SVOLLMAN'
   WHERE p."XMLDATA"."REFERENCE" = 'SBELL-2002100912333601PDT';

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

EXTRACTVAL
----------
SVOLLMAN

1 row selected.
```

Creating Views of XML With SQL Functions that Modify XML Data

You can use the SQL functions that modify XML data (`updateXML`, `insertChildXML`, `insertXMLbefore`, `appendChildXML`, and `deleteXML`) to create new views of XML data.

Example 4–24 Creating Views Using UPDATEXML

This example creates a view of the `purchaseorder` table using SQL function `updateXML`.

```
CREATE OR REPLACE VIEW purchaseorder_summary OF XMLType AS
  SELECT updateXML(OBJECT_VALUE,
                   '/PurchaseOrder/Actions', NULL,
                   '/PurchaseOrder/ShippingInstructions', NULL,
                   '/PurchaseOrder/LineItems', NULL) AS XML
  FROM purchaseorder p;

View created.

SELECT OBJECT_VALUE FROM purchaseorder_summary
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="DAUSTIN-20021009123335811PDT"]') = 1;
```

```
OBJECT_VALUE
--------------------------------------------------------------------------------
<PurchaseOrder
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>DAUSTIN-20021009123335811PDT</Reference>
  <Actions/>
  <Reject/>
  <Requestor>David L. Austin</Requestor>
  <User>DAUSTIN</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions/>
  <SpecialInstructions>Courier</SpecialInstructions>
  <LineItems/>
</PurchaseOrder>

1 row selected.
```

INSERTCHILDXML SQL Function

SQL function `insertChildXML` inserts new children (one or more elements of the same type or a single attribute) under parent XML elements. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned; the original data is unaffected. You can use that returned data with SQL operation `UPDATE` to modify database data.

Function `insertChildXML` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data containing the target parent element.
- ***parent-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates the parent elements within *`target-data`*; *`child-data`* is inserted under *each* parent element.

  If *`parent-xpath`* matches an empty sequence of element nodes, then no insertion is done; *`target-data`* is returned unchanged (and no error is raised). If *`parent-xpath`* does not match a sequence of element nodes (in particular, if *`parent-xpath`* matches one or more *attribute* or *text* nodes), then an error is raised.
- ***child-name*** (`VARCHAR2`) – The name of the child elements or attribute to insert. An attribute name is distinguished from an element name by having an at-sign (`@`) prefix as part of *`child-name`*, for example, `@my_attribute` versus `my_element`. (The at-sign is not part of the attribute name, but serves in the argument to indicate that *`child-name`* refers to an attribute.)
- ***child-data*** (`XMLType` or `VARCHAR2`) – The child XML data to insert:
  - If one or more *elements* are being inserted, then this is of data type `XMLType`, and it contains element nodes. *Each* of the top-level element nodes in *`child-data`* must have the same name (tag) as *`child-name`* (or else an error is raised).
  - If an *attribute* is being inserted, then this is of data type `VARCHAR2`, and it represents the (scalar) attribute value. If an attribute of the same name already exists at the insertion location, then an error is raised.
- ***namespace*** (`VARCHAR2`, *optional*) – The XML namespace for parameters *`parent-xpath`* and *`child-data`*.

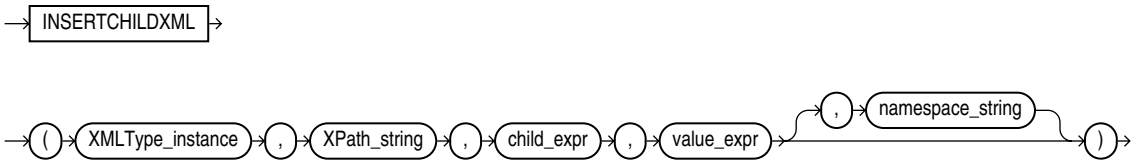
XML data *child-data* is inserted as one or more child elements, or a single child attribute, under *each* of the parent elements located at *parent-xpath*; the result is returned.

In order of decreasing precedence, function insertChildXML has the following behavior for NULL arguments:

- If *child-name* is NULL, then an error is raised.
- If *target-data* or *parent-xpath* is NULL, then NULL is returned.
- If *child-data* is NULL, then:
  - If *child-name* names an element, then no insertion is done; *target-data* is returned unchanged.
  - If *child-name* names an attribute, then an empty attribute value is inserted, for example, my_attribute = "".

Figure 4–7 shows the syntax.

Figure 4–7 INSERTCHILDXML Syntax



If *target-data* is XML *schema-based*, then the schema is consulted to determine the insertion positions. For example, if the schema constrains child elements named *child-name* to be the first child elements of a *parent-xpath*, then the insertion takes this into account. Similarly, if the *child-name* or *child-data* argument is inappropriate for an associated schema, then an error is raised.

If the parent element does *not* yet have a child corresponding in name and kind to *child-name* (and if such a child is permitted by the associated XML schema, if any), then *child-data* is inserted as new child elements, or a new attribute value, named *child-name*.

If the parent element already has a child *attribute* named *child-name* (without the at-sign), then an error is raised. If the parent element already has a child *element* named *child-name* (and if more than one child element is permitted by the associated XML schema, if any), then *child-data* is inserted so that its elements become the *last* child elements named *child-name*.

Example 4–25 Inserting a LineItem Element into a LineItems Element

```
SELECT extract(OBJECT_VALUE,
               '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER="222"]')
--------------------------------------------------------------------------------

1 row selected.

UPDATE purchaseorder
```

```
  SET OBJECT_VALUE =
        insertChildXML(OBJECT_VALUE,
                       '/PurchaseOrder/LineItems',
                       'LineItem',
                       XMLType('<LineItem ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413"
                                        UnitPrice="22.95"
                                        Quantity="1"/>
                                </LineItem>'))
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

1 row updated.

SELECT extract(OBJECT_VALUE,
               '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER="222"]')
--------------------------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

1 row selected.
```

If XML data to be updated is XML schema-based and it refers to a namespace, then the data to be inserted must also refer to the same namespace; otherwise, an error will be raised because the inserted data does not conform to the XML schema. For example, if the data in Example 4–25 used the namespace `films.xsd`, then the `UPDATE` statement would need to be as shown in Example 4–26.

Example 4–26 Inserting an Element that Uses a Namespace

This example is the same as Example 4–25, except that the `LineItem` element to be inserted refers to a namespace. This assumes that the XML schema requires a namespace for this element.

Note that this use of namespaces is different from the use of a namespace *argument* to function `insertChildXML` – namespaces supplied in that optional argument apply only to the XPath argument, not to the content to be inserted.

```
UPDATE purchaseorder
  SET OBJECT_VALUE =
        insertChildXML(OBJECT_VALUE,
                       '/PurchaseOrder/LineItems',
                       'LineItem',
                       XMLType('<LineItem xmlns="films.xsd" ItemNumber="222">
                                  <Description>The Harder They Come</Description>
                                  <Part Id="953562951413"
                                        UnitPrice="22.95"
                                        Quantity="1"/>
                                </LineItem>'))
  WHERE existsNode(OBJECT_VALUE,
```

```
                    '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

1 row updated.
```

INSERTXMLBEFORE SQL Function

SQL function `insertXMLbefore` inserts one or more nodes of any kind immediately before a target node that is not an attribute node. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned; the original data is unaffected. You can use that returned data with SQL operation `UPDATE` to modify database data.

Function `insertXMLbefore` has the following parameters (in order):

- ***target-data*** (`XMLType`) – The XML data that is the target of the insertion.
- ***successor-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more nodes in *`target-data`* of any kind *except* attribute nodes. *`XML-data`* is inserted immediately before *each* of these nodes; that is, the nodes in *`XML-data`* become preceding siblings of each of the *`successor-xpath`* nodes.

  If *`successor-xpath`* matches an empty sequence of nodes, then no insertion is done; *`target-data`* is returned unchanged (and no error is raised). If *`successor-xpath`* does not match a sequence of nodes that are not attribute nodes, then an error is raised.
- ***XML-data*** (`XMLType`) – The XML data to be inserted: one or more nodes of *any kind*. The order of the nodes is preserved after the insertion.
- ***namespace*** (*optional*, `VARCHAR2`) – The namespace for parameter *`successor-xpath`*.

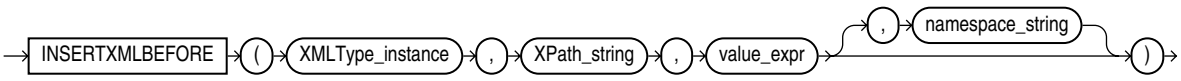
The *`XML-data`* nodes are inserted immediately before *each* of the non-attribute nodes located at *`successor-xpath`*; the result is returned.

Function `insertXMLbefore` has the following behavior for `NULL` arguments:

- If *`target-data`* or *`parent-xpath`* is `NULL`, then `NULL` is returned.
- Otherwise, if *`child-data`* is `NULL`, then no insertion is done; *`target-data`* is returned unchanged.

Figure 4–8 shows the syntax.

Figure 4–8 INSERTXMLBEFORE Syntax



****

Example 4–27 Inserting a LineItem Element Before the First LineItem ELement

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[1]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;
```

```
EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[1]')
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
      insertXMLbefore(OBJECT_VALUE,
                      '/PurchaseOrder/LineItems/LineItem[1]',
                      XMLType('<LineItem ItemNumber="314">
                                 <Description>Brazil</Description>
                                 <Part Id="314159265359"
                                       UnitPrice="69.95"
                                       Quantity="2"/>
                               </LineItem>'))
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem[position() <= 2]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[POSITION()<=2]')
------------------------------------------------------------------------
<LineItem ItemNumber="314">
  <Description>Brazil</Description>
  <Part Id="314159265359" UnitPrice="69.95" Quantity="2"/>
</LineItem>
<LineItem ItemNumber="1">
  <Description>Salesman</Description>
  <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
</LineItem>

1 row selected.
```

APPENDCHILDXML SQL Function

SQL function `appendChildXML` inserts one or more nodes of any kind as the last children of a given element node. The XML document that is the target of the insertion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned; the original data is unaffected. You can use that returned data with SQL operation `UPDATE` to modify database data.

Function `appendChildXML` has the following parameters (in order):

- ***target-data*** (`XMLType`)– The XML data containing the target parent element.
- ***parent-xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more *element* nodes in *`target-data`* that are the targets of the insertion operation; *`child-data`* is inserted as the last child or children of *each* of these parent elements.

If *parent-xpath* matches an empty sequence of element nodes, then no insertion is done; *target-data* is returned unchanged (and no error is raised). If *parent-xpath* does not match a sequence of element nodes (in particular, if *parent-xpath* matches one or more *attribute* or *text* nodes), then an error is raised.

- ***child-data*** (XMLType) – Child data to be inserted: one or more nodes of *any kind*. The order of the nodes is preserved after the insertion.
- ***namespace*** (*optional*, VARCHAR2) – The namespace for parameter *parent-xpath*.

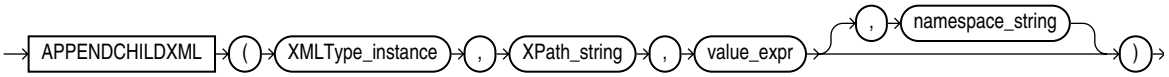
XML data *child-data* is inserted as the last child or children of *each* of the element nodes indicated by *parent-xpath*; the result is returned.

Function appendChildXML has the following behavior for NULL arguments:

- If *target-data* or *parent-xpath* is NULL, then NULL is returned.
- Otherwise, if *child-data* is NULL, then no insertion is done; *target-data* is returned unchanged.

Figure 4–8 shows the syntax.

Figure 4–9 APPENDCHILDXML Syntax



Example 4–28 Inserting a Date Element as the Last Child of an Action Element

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Actions/Action[1]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/ACTIONS/ACTION[1]')
--------------------------------------------------------
<Action>
  <User>KPARTNER</User>
</Action>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
      appendChildXML(OBJECT_VALUE,
                     '/PurchaseOrder/Actions/Action[1]',
                     XMLType('<Date>2002-11-04</Date>'))
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Actions/Action[1]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/ACTIONS/ACTION[1]')
```

```
------------------------------------------------------
<Action>
  <User>KPARTNER</User>
  <Date>2002-11-04</Date>
</Action>

1 row selected.
```

DELETEXML SQL Function

SQL function `deleteXML` deletes XML nodes of any kind. The XML document that is the target of the deletion can be schema-based or non-schema-based.

A *copy* of the input `XMLType` instance is modified and returned; the original data is unaffected. You can use that returned data with SQL operation `UPDATE` to modify database data.

Function `deleteXML` has the following parameters (in order):

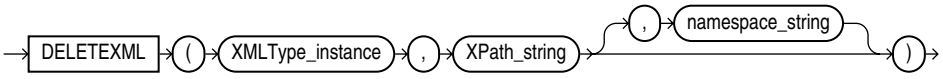
- ***target-data*** (`XMLType`) – The XML data containing the target nodes (to be deleted).
- ***xpath*** (`VARCHAR2`) – An XPath 1.0 expression that locates zero or more nodes in *`target-data`* that are the targets of the deletion operation; *each* of these nodes is deleted.

  If *`xpath`* matches an empty sequence of nodes, then no deletion is done; *`target-data`* is returned unchanged (and no error is raised). If *`xpath`* matches the top-level element node, then an error is raised.
- ***namespace*** (*optional*, `VARCHAR2`) – The namespace for parameter *`xpath`*.

The XML nodes located at *`xpath`* are deleted from *`target-data`*; the result is returned. Function `deleteXML` returns `NULL` if *`target-data`* or *`xpath`* is `NULL`.

Figure 4–8 shows the syntax.

Figure 4–10 DELETEXML Syntax



Example 4–29 Deleting LineItem Element Number 222

```
SELECT extract(OBJECT_VALUE,
               '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;
EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER="222"]')
--------------------------------------------------------------------------------
<LineItem ItemNumber="222">
  <Description>The Harder They Come</Description>
  <Part Id="953562951413" UnitPrice="22.95" Quantity="1"/>
</LineItem>

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE =
```

```
      deleteXML(OBJECT_VALUE,
                '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;

SELECT extract(OBJECT_VALUE,
               '/PurchaseOrder/LineItems/LineItem[@ItemNumber="222"]')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[Reference="AMCEWEN-20021009123336171PDT"]')
        = 1;
EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LINEITEMS/LINEITEM[@ITEMNUMBER="222"]')
--------------------------------------------------------------------------------

1 row selected.
```

5

Indexing XMLType Data

You can create indexes on your XML data, to focus on particular parts of it that you query often, and thus improve performance. This chapter includes guidelines for doing this. It describes various ways that you can index `XMLType` data, whether schema-based or non-schema-based, and regardless of the `XMLType` storage model you use (binary XML, unstructured, hybrid, or structured).

This chapter contains these topics:

Note: The explain plans shown here are for illustration only. If you run the examples presented here in your environment your explain plans might not be identical.

See Also:

- *Oracle Database Concepts* for an overview of indexing
- *Oracle Database Advanced Application Developer's Guide* for information about using indexes in application development

Oracle XML DB Tasks Involving Indexes

Table 5–1 identifies the documentation for some user tasks involving indexes.

Table 5–1 Oracle XML DB Tasks Involving Indexes

For information about how to...	See...
Create a function-based index on unstructured `XMLType` data	"Creating Function-Based Indexes on Unstructured XMLType Tables and Columns" on page 5-5
Create a function-based index on structured `XMLType` data	"Creating Function-Based Indexes on Structured XMLType Tables and Columns" on page 5-7
Create B-tree indexes on objects underlying structured `XMLType` data	"Using Indexes to Tune Queries on Collections Stored as OCTs" on page 3-62
Create an `XMLIndex` index	Example 5–9 on page 5-16, Example 5–14 on page 5-17, Example 5–16 on page 5-18
Name the path table when creating an `XMLIndex` index	Example 5–14 on page 5-17
Specify storage options when creating an `XMLIndex` index	Example 5–16 on page 5-18
Obtain the name of an `XMLIndex` index for a given table or column	Example 5–12 on page 5-17
Rename an XMLIndex index	Example 5–13 on page 5-17
Drop an XMLIndex index	Example 5–13 on page 5-17
Show all existing secondary indexes on an `XMLIndex` path table	Example 5–17 on page 5-18, Example 5–23 on page 5-20
Obtain the name of a path table for an `XMLIndex` index	Example 5–15 on page 5-17
Obtain the name of an `XMLIndex` index, given its path table	Example 5–25 on page 5-22
Create a secondary index on an `XMLIndex` path table	"Creating Additional Secondary Indexes on an XMLIndex Path Table" on page 5-19
Create a function-based index on a path-table `VALUE` column	Example 5–18 on page 5-19
Create a numeric index on a path-table `VALUE` column	Example 5–20 on page 5-19
Create a date index on a path-table `VALUE` column	Example 5–21 on page 5-20
Create an Oracle Text `CONTEXT` index on a path-table `VALUE` column	Example 5–22 on page 5-20
Show whether an `XMLIndex` index is used in evaluating a query	"How to Tell If XMLIndex is Used" on page 5-21
Turn off use of an `XMLIndex` index	"Turning Off Use of XMLIndex" on page 5-24
Extract an XML fragment using `XMLIndex`	Example 5–26 on page 5-22
Exclude or include particular XPath expressions from use by an `XMLIndex` index	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 5-25
Specify namespace prefixes for XPath expressions used for `XMLIndex`	"XMLIndex Path Subsetting: Specifying the Paths You Want to Index" on page 5-25
Create an `XMLIndex` on Oracle XML DB Repository	"Using XMLIndex on Oracle XML DB Repository" on page 5-26
Query Oracle XML DB Repository using `XMLIndex`	"Using XMLIndex on Oracle XML DB Repository" on page 5-26
Specify that an `XMLIndex` index should be created and maintained using parallel processes	"XMLIndex Parallelism" on page 5-29
Change the parallelism of an `XMLIndex` path table to tune index performance	"XMLIndex Parallelism" on page 5-29
Schedule maintenance for an `XMLIndex` index	"Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 5-30

Table 5–1 (Cont.) Oracle XML DB Tasks Involving Indexes

For information about how to...	See...
Manually synchronize an `XMLIndex` index and its base table	"Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 5-30
Collect statistics on a table or index for the cost-based optimizer	Example 5–37 on page 5-31
Create an Oracle Text `CONTEXT` index	Example 5–38 on page 5-36
Use an Oracle Text `CONTEXT` index for full-text search of XML data	Example 5–39 on page 5-36
Show whether an Oracle Text `CONTEXT` index is used in a query	Example 5–39 on page 5-36

Overview of Indexing XMLType Data

Database indexes improve performance by providing faster access to table data. The use of indexes is particularly recommended for online transaction processing (OLTP) environments involving few updates.

Problem: Fine-Grained Structure of XML Data

You can create indexes on one or more table columns, or on a functional expression. XML data, however, has its own, fine-grained structure, which is not necessarily reflected in the structure of the database tables used to store it. For this reason, effectively indexing XML data can be a bit different from indexing most database data.

B-tree Indexes Are Appropriate for Structured Storage

For *structured* XML storage, XML objects such as elements and attributes correspond to object-relational columns and tables, so creating *B-tree indexes* on those columns and tables provides an excellent way to effectively index the corresponding XML objects. Here, the storage model directly reflects the fine-grained structure of the XML data, so there is no special problem for indexing structured XML data.

Unstructured and Hybrid Storage Present an Indexing Problem for XML Data

For *unstructured* and *hybrid* XML storage, indexing a database column using the standard sorts of index (B-tree, bitmap) is generally not helpful for accessing particular parts of an XML document. If an `XMLType` column that contains an XML document is stored as a `CLOB` instance, then the details within that document are inaccessible to the column index—the entire document acts as a single unit as far as the column index is concerned. In **hybrid storage**, part of an XML document is broken up and stored object-relationally (structured storage), but one or more XML fragments are stored as `CLOB` instances (unstructured storage). A typical use case here is mapping an XML-schema `complexType` or a complex element to `CLOB` storage, because the entire fragment is generally accessed as a unit. For standard indexes, it acts as a unit for indexing as well.

Solution: XMLIndex

`XMLIndex` provides a general, XML-specific index that indexes the internal structure of XML data. One of its main purposes is to overcome the indexing limitation presented by unstructured and hybrid storage of XML data, that is, `CLOB` storage. It does this by indexing the XML *tags* of your document and identifying document fragments based on XPath expressions that target them. It can also index scalar node *values*, to provide quick lookup based on individual values or ranges of values. It also records document *hierarchy* information for each node it indexes: relations parent–child, ancestor–descendant, and sibling.

See Also: "XMLIndex" on page 5-10

Other Indexes for XML Data

In addition to `XMLIndex`, you can use function-based indexes and Oracle Text indexes with XML data. In releases prior to Oracle Database 11*g* Release 1 (11.1), `CTXXPath` indexes are also sometimes appropriate for use with XML data.

Function-Based Indexes

In many cases where an XPath expression targets a *singleton node*, a function-based index can be effective in increasing access performance. In particular, SQL functions `XMLQuery`, `XMLExists`, `XMLCast`, `extract`, `extractValue`, and `existsNode` are useful candidates for this kind of index on XML data. If a functional expression in a query `WHERE` clause matches a function-based index, then access to the corresponding data can sometimes be faster even than that provided by a more general `XMLIndex` index. In addition, for *structured* storage, defining an index based on SQL function `extractValue` often leads, by XPath rewrite, to automatic creation of (B-tree) indexes on the underlying objects. In this case also, the XPath target must be a singleton element or attribute.

See Also: "Function-Based Indexes on XMLType Data" on page 5-5

Oracle Text Indexes

Besides accessing XML nodes such as elements and attributes, it is sometimes important to provide fast access to particular passages of text within XML text nodes. This is the purpose of *Oracle Text indexes*: they index full-text strings. An Oracle Text `CONTEXT` index enables SQL function `contains` for full-text search over XML. With structured storage, XPath rewrite can often rewrite XPath function `ora:contains` to SQL function `contains`, so in those cases too an Oracle Text index can be employed. Full-text indexing is particularly useful for *document-centric* applications, which often contain a mix of XML elements and text-node content. Full-text searching can often be made more powerful, more focused, by combining it with structural XML searching, that is, by restricting it to certain parts of an XML document, which are identified by using XPath expressions.

See Also: "Oracle Text Indexes on XML Data" on page 5-36

CTXXPath Indexes

Another type of index that is available for indexing XML data, `CTXXPath`, is deprecated, starting with Oracle Database 11*g* Release 1 (11.1). It has been superseded by `XMLIndex`, and it is made available only for use with older database releases. It cannot help in extracting an XML fragment, and it acts only as a *preliminary filter* for equality predicates; after such filtering, XPath expressions are evaluated functionally (that is, without the benefit of XPath rewrite).

Note: The `CTXSYS.CTXXPath` index is *deprecated* in Oracle Database 11g Release 1 (11.1). The functionality that was provided by `CTXXPath` is now provided by `XMLIndex`.

Oracle recommends that you replace `CTXXPath` indexes with `XMLIndex` indexes. The intention is that `CTXXPath` will no longer be supported in a future release of the database.

Optimization Chooses Indexes

Which indexes are used when more than one might apply in a given case? Cost-based optimization determines the index or indexes to use, so that performance is maximized. Oracle Text indexes apply only to text, which, for XML data, means text nodes. Whenever text nodes are targeted and a corresponding Oracle Text index is defined, it is used. If other indexes are also appropriate in a particular context, then they can be used as well. However, just because an index is defined and might appear applicable in a given situation does not mean that it will be used—it will not be used if the cost-based optimizer deems that its use would not be cost-effective.

Function-Based Indexes on XMLType Data

You can create a function-based index on an `XMLType` table or column, whether the data is XML schema-based or not, and whether the `XMLType` storage is structured, unstructured, or binary XML. A **function-based** index is created by evaluating the specified functions for each row in the target table or column and storing the value in the index. You can create a function-based index as either a B-tree index or a bitmap index.

Creating Function-Based Indexes on Unstructured XMLType Tables and Columns

If a function-based index is defined on XML data that is *not* managed using structured storage, then the index is created by invoking the function on the XML content and indexing the result. (This is not necessarily what happens when you try to create a function-based index on XML data in structured storage—see "Creating Function-Based Indexes on Structured XMLType Tables and Columns" on page 5-7.)

Example 5–1 shows the creation of an index based on SQL function `extractValue`, where the XML data is in unstructured (`CLOB`) storage. The data is first copied to `CLOB`-based table `po_clob` from structured-storage table `purchaseorder` of standard database schema `OE`. Both of these tables will be used in examples throughout this chapter.

Example 5–1 Creating a Function-Based Index on a CLOB XMLType Instance

The `CREATE INDEX` statement in this example creates a function-based index on the value of the text node of element `Reference`. This index enforces the uniqueness constraint on the text-node value.

```
CREATE TABLE po_clob OF XMLType
  XMLTYPE STORE AS CLOB
  ELEMENT "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd#PurchaseOrder";

Table created.

INSERT INTO po_clob SELECT OBJECT_VALUE FROM OE.purchaseorder;

132 rows created.

CREATE UNIQUE INDEX po_fn_based_ix ON po_clob
  (extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference'));

Index created.

INSERT INTO po_clob
  VALUES (XMLType(bfilename('XMLDIR', 'EABEL-20021009123335791PDT.xml'),
                  nls_charset_id('AL32UTF8')));
INSERT INTO po_clob
```

```
*
ERROR at line 1:
ORA-00001: unique constraint (OE.PO_FN_BASED_IX) violated
```

The cost-based optimizer considers using a function-based index only when the function that is included in the `WHERE` clause is identical to the function that was used to *create* the index.

To see this, consider the queries and explain plans in Example 5–2. These queries each find a purchase-order document based on the text node of element `Reference`. The first query, which uses function `existsNode` to locate the document, does *not* use the index created in Example 5–1; the second query, which uses function `extractValue`, does use the index. This is because the index was created using `extractValue`.

Example 5–2 Function-Based Index Is Used Only by a Matching Query

```
EXPLAIN PLAN FOR
  SELECT OBJECT_VALUE FROM po_clob
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="EABEL-20021009123335791PDT"') = 1;

Explained.

--
SET ECHO OFF

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------
Plan hash value: 2803800196

------------------------------------------------------------------------------
| Id  | Operation         | Name    | Rows  | Bytes | Cost (%CPU)| Time     |
------------------------------------------------------------------------------
|   0 | SELECT STATEMENT  |         |    42 | 84084 |    23  (27)| 00:00:01 |
|*  1 |  TABLE ACCESS FULL| PO_CLOB |    42 | 84084 |    23  (27)| 00:00:01 |
------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(EXISTSNODE(SYS_MAKEXML('0BAD982DA615296BE040578CB00B1198',
              3460,"PO_CLOB"."XMLDATA"),'/PurchaseOrder[Reference="EABEL-2002100912333
              5791PDT"')=1)

15 rows selected.

EXPLAIN PLAN FOR
  SELECT OBJECT_VALUE FROM po_clob
    WHERE extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference') = 'EABEL-20021009123335791PDT';

Explained.

SET ECHO OFF

PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------------
Plan hash value: 2594805861

------------------------------------------------------------------------------------------------
| Id  | Operation                   | Name           | Rows  | Bytes | Cost (%CPU)| Time     |
------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT            |                |     1 |  2002 |     1   (0)| 00:00:01 |
|   1 |  TABLE ACCESS BY INDEX ROWID| PO_CLOB        |     1 |  2002 |     1   (0)| 00:00:01 |
|*  2 |   INDEX UNIQUE SCAN         | PO_FN_BASED_IX |     1 |       |     0   (0)| 00:00:01 |
------------------------------------------------------------------------------------------------
```

```
Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access(EXTRACTVALUE(SYS_MAKEXML('0BAD982DA615296BE040578CB00B1198',3460,"XMLDAT
              A"),'/PurchaseOrder/Reference')='EABEL-20021009123335791PDT')

Note
-----
   - dynamic sampling used for this statement

19 rows selected.
```

Creating Function-Based Indexes on Structured XMLType Tables and Columns

When you use structured `XMLType` storage, there are a few things to be aware of when creating a function-based index:

- The element or attribute being targeted by the function must be a *singleton*, that is, it must occur only once in the XML Document—a function-based index must not target a collection. See "No XPath Rewrite for EXTRACTVALUE Applied to a Collection" on page 5-8.
- If the function being indexed is `extractValue`, then Oracle XML DB tries to *rewrite* your function-based `CREATE INDEX` statement to a different `CREATE INDEX` statement that is *not* function-based and does not use the XPath-expression argument as such. Instead, the resulting index is a B-tree index that operates directly on the underlying objects. This B-tree index takes the place of the function-based index that you specify. See "XPath Rewrite for EXTRACTVALUE Indexes on Singleton Elements or Attributes" on page 5-7.
- If Oracle XML DB *cannot* rewrite the `CREATE INDEX` statement, then a function-based index is created, just as for unstructured storage. This is what happens if the function is not `extractValue`, and it can also happen in a few cases for `extractValue`.

XPath Rewrite for EXTRACTVALUE Indexes on Singleton Elements or Attributes

Example 5–3 shows a `CREATE INDEX` statement for a structured `XMLType` table, `purchaseorder`, in sample database schema `OE`. This statement tries to create a function-based index using SQL function `extractValue`, and it targets a singleton XML element, `Reference`—each purchase-order document has a single `Reference` element.

Example 5–3 CREATE INDEX with EXTRACTVALUE on a Singleton Element or Attribute

```
CREATE INDEX po_fn_based_ix ON purchaseorder
  (extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference'));

Index created.
```

Oracle XML DB *rewrites* this `CREATE INDEX` statement into the statement in Example 5–4. The index created is a B-tree index on the underlying object-relational columns. To see this, you can look at the `COLUMN_NAME` column for the index in table `USER_IND_COLUMNS`. This shows that the underlying object-relational column `REFERENCE` is used.

```
SELECT INDEX_NAME, TABLE_NAME, COLUMN_NAME FROM USER_IND_COLUMNS
  WHERE INDEX_NAME = 'PO_FN_BASED_IX' AND TABLE_NAME = 'PURCHASEORDER';

INDEX_NAME       TABLE_NAME       COLUMN_NAME
---------------- ---------------- ----------------------
```

```
PO_FN_BASED_IX    PURCHASEORDER     "XMLDATA"."REFERENCE"

1 row selected.
```

Example 5–4 XPath Rewrite of an EXTRACTVALUE Index on a Singleton Element or Attribute

```
CREATE INDEX po_fn_based_ix ON purchaseorder p (p."XMLDATA"."REFERENCE");

Index created.
```

Example 5–3 and Example 5–4 yield the same result; they are two ways of creating the same index.

```
SELECT INDEX_NAME, TABLE_NAME, COLUMN_NAME FROM USER_IND_COLUMNS
  WHERE INDEX_NAME = 'PO_FN_BASED_IX' AND TABLE_NAME = 'PURCHASEORDER';

INDEX_NAME       TABLE_NAME       COLUMN_NAME
---------------- ---------------- ----------------------
PO_FN_BASED_IX   PURCHASEORDER    "XMLDATA"."REFERENCE"

1 row selected.
```

No XPath Rewrite for EXTRACTVALUE Applied to a Collection

A function-based index must target a *singleton*, not a collection. This section demonstrates this for structured storage.

If a collection is stored in a `CLOB` instance, you cannot directly access its members. In structured storage, a collection is stored as an ordered collection table or an `XMLType` instance, which means that you can directly access its members. Because the structured storage model directly reflects the fine-grained structure of the XML data, you can create indexes that target collection members.

What you *cannot* do is create an index based on function `extractValue` that targets a collection with an XPath expression, and expect that Oracle XML DB will rewrite your `CREATE INDEX` statement, creating the necessary indexes on the underlying objects.

If you want such indexes, you must create them yourself. To do this, you must understand the structure of the SQL object that is used to manage the collection. Given this information, you can create the required (B-tree) indexes directly on the appropriate SQL-object attributes using conventional object-relational SQL.

The aim of this section is to show that you cannot count on XPath rewrite to create the appropriate indexes for you. Refer to "Using Indexes to Tune Queries on Collections Stored as OCTs" on page 3-62 for an example of how to create such indexes manually.

This section deliberately tries to create a function-based index on a repeating attribute in a collection, to see what happens. This is tried in a couple of ways, without success.

Suppose that you want to create an index on attribute `Id` of element `Part`. You might try to create the index as in Example 5–5. However, when an element or attribute being indexed occurs multiple times in a document, a `CREATE INDEX` operation on an XPath expression that targets it fails, because SQL function `extractValue` can return only a single value for each row that it processes. In this case, there can be multiple occurrences of attribute `Id` in a purchase-order document, because its ancestor element `LineItem` is a collection.

Example 5–5 Trying to Create a Function-Based Index on a Repeating Attribute

```
CREATE INDEX po_fn_based_ix ON purchaseorder
```

```
  (extractValue(OBJECT_VALUE, '/PurchaseOrder/LineItems/LineItem/Part/@Id'));
CREATE INDEX po_fn_based_ix ON purchaseorder
*
ERROR at line 1:
ORA-19025: EXTRACTVALUE returns value of only one node
```

You can instead create an index by replacing function `extractValue` with a combination of function `extract` and `XMLType` method `getStringVal()`, as shown in Example 5–6.

Example 5–6 Creating a Function-Based Index Using EXTRACT and getStringVal()

```
CREATE INDEX po_fn_based_ix
  ON purchaseorder (extract(OBJECT_VALUE,
                            'PurchaseOrder/LineItems/LineItem/Part/@Id').getStringVal());

Index created.
```

This `CREATE INDEX` operation succeeds in creating a function-based index, but the index is not what you might expect. The index is created by invoking SQL function `extract` and `XMLType` method `getStringVal()` for each row in the table, and then indexing that result against the rowid of the row.

The problem with this technique is that `extract` returns multiple nodes. The result of applying function `extract` is a single `XMLType` fragment that contains *all* of the matching nodes.

> **Note:** In general, avoid creating an index based on SQL function `extract`. It is unlikely that the index will be useful.

The result of then invoking method `getStringVal()` on the `XMLType` instance that contains this fragment is a *concatenation* of the nodes in the fragment. What is indexed is therefore the concatenation of the three UPC codes (attribute `Id`), and not, as intended, each of the individual UPC codes. This is shown in Example 5–7.

Example 5–7 Function-Based Index on Concatenated Nodes

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/LineItems') XML,
       extract(OBJECT_VALUE, 'PurchaseOrder/LineItems/LineItem/Part/@Id').getStringVal() INDEX_VALUE
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-2002100912333601PDT"]') = 1;

XML                                                                INDEX_VALUE
------------------------------------------------------------------ ----------------------------------
<LineItems>                                                        715515009058374291402227155150110 20
  <LineItem ItemNumber="1">
    <Description>A Night to Remember</Description>
    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>The Unbearable Lightness Of Being</Description>
    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>Sisters</Description>
    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
  </LineItem>
</LineItems>

1 row selected.
```

The way to resolve this problem is to use structured storage with *ordered collection tables* (OCTs), to force *each XML node* that is indexed to be stored as a *separate row*. The index can be created directly on the appropriate OCT, using object-relational SQL similar to that generated by XPath rewrite.

In sum, you can effectively index XML data that is stored object-relationally (structured storage) by indexing the database columns that correspond to XML nodes. In the singleton `extractValue` case, Oracle XML DB does this for you automatically as a convenience; you use the simple syntax of creating an index based on function `extractValue` with an XPath-expression argument, and Oracle XML DB does the rest.

> **See Also:** "Using Indexes to Tune Queries on Collections Stored as OCTs" on page 3-62 for an example of indexing an ordered collection table

XMLIndex

This section contains these topics:

B-tree indexes can be used advantageously with structured storage—they provide sharp focus by targeting the underlying objects directly. They are generally ineffective, however, in addressing the detailed structure (elements and attributes) of an XML document or fragment stored in a `CLOB` instance. That is the special domain of `XMLIndex`: unstructured and hybrid storage.

A typical use case for `XMLIndex` is where you generally expect to access certain portions of a document in their entirety, so you pack those portions into one or more `CLOB` instances. You might nevertheless sometimes need to query within these document portions. `XMLIndex` can help here, whereas XPath rewrite is ineffective in this case.

Another use case is where an XML schema contains `xsd:any` elements, for lack of any specific knowledge of the document structure and data types involved. The data

corresponding to these elements is stored in CLOB instances, and XMLIndex can be used to speed access to it.

In addition to CLOB storage of XML, you can also use XMLIndex to index binary XMLType data.

Unlike a B-tree index, which you define for a specific database column that represents an individual XML element or attribute, an XMLIndex index is, by default, very general: Unless you specify a more narrow focus by detailing specific XPath expressions to use or not to use in indexing, indexing with XMLIndex applies to *all possible XPath expressions* for your XML data.

Advantages of XMLIndex

An XMLIndex index can be used for SQL functions XMLQuery, XMLTable, XMLExists, XMLCast, extract, extractValue, and existsNode. It presents the following *advantages* over other indexing methods:

- An XMLIndex index is effective in any part of a query; it is not limited to use in a WHERE clause. This is not the case for any of the other kinds of indexes you might use with XML data.
- XMLIndex can thus speed access to both SELECT list data and FROM list data, making it useful for XML *fragment* extraction, in particular. Function-based indexes (and CTXXPath indexes, which are deprecated) cannot be used to extract document fragments.
- You need no prior knowledge of the XPath expressions that will be used in queries. XMLIndex is completely general. This is not the case for function-based indexes. If you do have such prior knowledge, then you can often improve performance by tailoring XMLIndex indexing to those paths most queried.
- You can use an XMLIndex index with either XML schema-based or non-schema-based data. It can be used with unstructured storage, hybrid storage, and binary XML storage. B-tree indexing is appropriate only for XML schema-based data that is stored object-relationally (structured storage); it is ineffective for XML schema-based data stored in a CLOB instance.
- For hybrid storage of XML schema-based data, XMLIndex can handle XPath expressions that target document fragments that are stored within a CLOB instance. XPath rewrite is ineffective in such cases.
- You can use an XMLIndex index for searches with XPath expressions that target *collections*, that is, nodes that occur multiple times within a document. This is not the case for function-based indexes.
- XMLIndex indexing—both index creation and index maintenance—can be carried out in parallel, using multiple database processes. This is not the case for function-based indexes (and CTXXPATH indexes, which are deprecated).
- Updating of XMLIndex indexes on binary XML storage can be accomplished in a piecewise manner, improving DML performance considerably. This is not the case for any of the other kinds of indexes you might use with XML data.

XPath Expressions Not Indexed by XMLIndex

The following types of XPath expressions are *not* indexed by XMLIndex:

- Applications of XPath functions, *except* ora:contains. In particular, user-defined XPath functions are *not* indexed.

- Axes other than `child`, `descendant`, and `attribute`, that is, axes `parent`, `ancestor`, `following-sibling`, `preceding-sibling`, `following`, `preceding`, and `ancestor-or-self`.
- Expressions using the union operator, `|` (vertical bar).

Components of an XMLIndex Index

`XMLIndex` is a *domain* index; it is designed specifically for the domain of XML data. It is a *logical* index, which has three components:

- A **path index** – This indexes the XML *tags* of a document and identifies its various document *fragments*.
- An **order index** – This indexes the hierarchical *positions* of the nodes in an XML document. It keeps track of parent–child, ancestor–descendant, and sibling relations.
- A **value index** – This indexes the *values* of an XML document. It provides lookup by either value equality or value range. A value index is used for values in query predicates (`WHERE` clause).

`XMLIndex` is implemented using a path table and a set of (local) secondary indexes corresponding to its components. These are all owned by the owner of the base table upon which the `XMLIndex` index is created. The path table contains one row for each indexed node in the XML document. For each indexed node, the **path table** stores:

- The corresponding *rowid* of the table that stores the document.
- A *locator*, which provides fast access to the corresponding document fragment. For binary XML storage of XML schema-based data, it also stores data-type information.
- An *order key*, to record the hierarchical position of the node in the document. You can think of this as a Dewey decimal key like that used in library cataloging and Internet protocol SNMP. In such a system, the key `3.21.5` represents the node position of the fifth child of the twenty-first child of the third child of the document root node.

Table 5–2 shows the main information[1] that is in the path table. The path index and the order index each use two columns of the path table. Together, columns `PATHID` and `RID` represent the path index; columns `ORDER_KEY` and `RID` represent the order index. Secondary indexes are created automatically for columns `PATHID` and `ORDER_KEY`.

Table 5–2 XMLIndex Path Table

Column	Data Type	Description
`PATHID`	`RAW(8)`	Unique identifier for the XPath path to the node.
`RID`	`ROWID`	Rowid of the table used to store the XML data.
`ORDER_KEY`	`RAW(1000)`	Decimal order key that identifies the hierarchical position of the node. (Document ordering is preserved.)
`LOCATOR`	`RAW(2000)`	Fragment-location information. Used for fragment extraction. For binary XML storage of XML schema-based data, data-type information is also stored here.
`VALUE`	`VARCHAR2(4000)`	Text of an attribute node or a simple element node.

[1] The actual path table implementation may be slightly different.

Example 5–8 explores the contents of the path table for two purchase-order documents.

Example 5–8 Path Table Contents for Two Purchase Orders

```
<PurchaseOrder>
 <Reference>SBELL-2002100912333601PDT</Reference>
 <Actions>
  <Action>
   <User>SVOLLMAN</User>
  </Action>
 </Actions>
 . . .
</PurchaseOrder>

<PurchaseOrder>
 <Reference>ABEL-20021127121040897PST</Reference>
 <Actions>
  <Action>
   <User>ZLOTKEY</User>
  </Action>
  <Action>
   <User>KING</User>
  </Action>
 </Actions>
 . . .
</PurchaseOrder>
```

An XMLIndex index on an XMLType table or column storing these purchase orders will include a path table that has one row for each indexed node in the XML documents. Suppose that the system assigns the following PATHIDs when indexing the nodes according to their XPath expressions:

PATHID	Indexed XPath
1	/PurchaseOrder
2	/PurchaseOrder/Reference
3	/PurchaseOrder/Actions
4	/PurchaseOrder/Actions/Action
5	/PurchaseOrder/Actions/Action/User

The resulting path table would then be something like this (column LOCATOR is not shown):

PATHID	RID	ORDER_KEY	VALUE
1	R1	1	——
2	R1	1.1	SBELL-2002100912333601PDT
3	R1	1.2	——
4	R1	1.2.1	——
5	R1	1.2.1.1	SVOLLMAN
1	R2	1	——
2	R2	1.1	ABEL-20021127121040897PST

PATHID	RID	ORDER_KEY	VALUE
3	R2	1.2	——
4	R2	1.2.1	——
5	R2	1.2.1.1	ZLOTKEY
4	R2	1.2.2	——
5	R2	1.2.2.1	KING

Ignore the Path Table; It Is Transparent

Though you might create secondary indexes on path-table columns, you can generally ignore the path table itself. You cannot access the path table, other than to `DESCRIBE` it and create (secondary) indexes on it. You need never explicitly gather statistics on the path table. You need only collect statistics on the `XMLIndex` index or the base table on which the `XMLIndex` index is defined; statistics are collected and maintained on the path table and its secondary indexes transparently.

> **See Also:** "Collecting Statistics on XMLIndex Objects For the Cost-Based Optimizer" on page 5-31

Column VALUE of the XMLIndex Path Table

A secondary index on column `VALUE` is used with XPath expressions in a `WHERE` clause that have predicates involving string matches. For example:

```
/PurchaseOrder[Reference/text() = "SBELL-2002100912333601PDT"]
```

Column `VALUE` stores the *effective* text value of a simple element node (no children) or an attribute node. For an element, this is obtained by concatenating all of the text nodes of the element—comments and processing instructions are ignored during indexing.

Column `VALUE` is a fixed size, `VARCHAR2(4000)`. Any overflow (beyond 4000 bytes) during index creation or update is truncated, but the `LOCATOR` value for that row is then flagged so that the full value can be retrieved from the base table when needed.

In addition to the 4000-byte limit for column `VALUE`, there is a limit on the size of a key for the secondary index created on this column. This is the case for B-tree and function-based indexes as well; it is not an `XMLIndex` limitation. The index-key size limit is a function of the block size for your database. It is this limit that determines how much of `VALUE` is indexed.

In sum, only the first 4000 bytes of the effective text value are stored in column `VALUE`, and only the first *N* bytes of column `VALUE` are indexed, where *N* is the index-key size limit ($N < 4000$). Because of the index-key size limit, the index on column `VALUE` acts only as a *preliminary filter* for the effective text value.

For example, suppose that your database block size requires that the `VALUE` index be no larger than 800 bytes, so that only the first 800 bytes of the effective text value is indexed. The first 800 bytes of the effective text value is first tested, using `XMLIndex`, and only if that text prefix matches the query value is the rest of the effective text value tested.

The secondary index on column `VALUE` is an index on SQL function `substr` (substring equality), because that function is used to test the text prefix. This function-based index is created automatically as part of the implementation of `XMLIndex` for column `VALUE`.

For example, the XPath expression `/PurchaseOrder[Reference/text() = :1]` in a query `WHERE` clause might, in effect, be rewritten to a test something like this:

```
substr(VALUE, 1 800) = substr(:1, 1, 800) AND VALUE = :1;
```

This conjunction contains two parts, which are processed from left to right. The first test uses the index on function `substr` as a preliminary filter, to eliminate text whose first 800 bytes do not match the first 800 bytes of the value of bind variable `:1`.

Only the first test uses an index—the full value of column `VALUE` is not indexed. After preliminary filtering by the first test, the second test checks the entire effective text value—that is, the full value of column `VALUE`—for full equality with the value of `:1`. This check does not use an index.

Even if only the first 800 bytes of text is indexed, it is important for query performance that up to 4000 bytes be stored in column `VALUE`, because that provides quick, direct access to the data, instead of requiring, for example, extracting it from deep within a `CLOB`-instance XML document. If the effective text value is greater than 4000 bytes, then the second test in the `WHERE`-clause conjunction will require accessing the base-table data.

Note that neither the `VALUE` column 4000-byte limit nor the index-key size affect query results in any way; they can affect only performance.

Default Text for XML Schema-Based Data As mentioned, `XMLIndex` can be used with XML schema-based data. If an XML schema specifies a `defaultValue` value for a given element or attribute, and a particular document does not specify a value for that element or attribute, then the `defaultValue` value is used for the `VALUE` column.

Creating Secondary Indexes on Column VALUE

If you do not specify a secondary index for column `VALUE` when you create the `XMLIndex` index, then a default secondary index is created on column `VALUE`. This default index has the default properties—in particular, it is an index for *text* (string-valued) data only.

You can, however, create a `VALUE` index of a different type. For example, you can create a number-valued index if that is appropriate for many of your queries. You can create multiple secondary indexes on the `VALUE` column. An index of a particular type is used only when it is appropriate. For example, a number-valued index is used only when the `VALUE` column is a number; it is ignored for other values. Secondary indexes on path-table columns are treated like any other secondary indexes—you can alter them, drop them, mark them unusable, and so on.

See Also:

- "Creating Additional Secondary Indexes on an XMLIndex Path Table" on page 5-19 for examples of creating secondary indexes on column `VALUE`
- "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 5-33 for the syntax of the `PARAMETERS` clause

Data Dictionary Static Public Views Related to XMLIndex

Information about the standard database indexes is available in static public views `USER_INDEXES`, `ALL_INDEXES`, and `DBA_INDEXES`. Similar information about `XMLIndex` indexes is available in static public views `USER_XML_INDEXES`, `ALL_XML_INDEXES`, and `DBA_XML_INDEXES`. Table 5–3 describes the columns in each of these views.

Table 5–3 XMLIndex Static Public Views

Column Name	Type	Description
INDEX_OWNER	VARCHAR2	Owner of the index. Not available for USER_XML_INDEXES.
INDEX_NAME	VARCHAR2	Name of the XMLIndex index.
TABLE_OWNER	VARCHAR2	Owner of the base table on which the index is defined.
TABLE_NAME	VARCHAR2	Name of the base table on which the index is defined.
PATH_TABLE_NAME	VARCHAR2	Name of the XMLIndex path table.
PARAMETERS	XMLType	Parameters specific to the index. These can include the set of XPath paths defining path-subsetting and the name of a scheduler job for synchronization.
ASYNC	VARCHAR2	Asynchronous index updating specification. See "Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 5-30.
PEND_TABLE_NAME	VARCHAR2	Name of the table that records base-table DML operations since the last index synchronization. See "Asynchronous (Deferred) Maintenance of XMLIndex Indexes" on page 5-30.

Creating, Dropping, Altering, and Examining an XMLIndex Index

You create an XMLIndex index by declaring the index type to be XDB.XMLIndex, as illustrated in Example 5–9.

Example 5–9 Creating an XMLIndex Index on XMLType Unstructured Storage

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex;

Index created.
```

This creates an XMLIndex index named po_xmlindex_ix on XMLType table po_clob.

> **Note:** Although you can partition an XMLType table or column, you cannot create an XMLIndex index on such a table or column.

You can create an XMLIndex index on CLOB portions of hybrid XMLType storage, that is, on CLOB data that is embedded within object-relational storage. Example 5–10 illustrates this. It assumes that the XML schema used maps the LineItems element to CLOB, such as is shown in Example 5–10.

Example 5–10 Creating an XMLIndex Index on XMLType Hybrid Storage

```
CREATE INDEX po_xmlindex_hybrid_ix ON li_clob
  (extract(OBJECT_VALUE, '/PurchaseOrder/LineItems'))
  INDEXTYPE IS XDB.XMLIndex;
```

Example 5–11 XML Schema Fragment that Maps LineItems to CLOB Storage

```
<xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"
            xdb:SQLType="CLOB"/>
```

You can obtain the name of an XMLIndex index on a particular XMLType table (or column), as shown in Example 5–12. You can also select INDEX_NAME from DBA_INDEXES or ALL_INDEXES, as appropriate.

Example 5–12 Obtaining the Name of an XMLIndex Index on a Particular Table

```
SELECT INDEX_NAME FROM USER_INDEXES
  WHERE TABLE_NAME = 'PO_CLOB' AND ITYP_NAME = 'XMLINDEX';

INDEX_NAME
---------------
PO_XMLINDEX_IX

1 row selected.
```

You rename or drop an XMLIndex index just as you would any other index, as illustrated in Example 5–13. This renaming changes the name of the XMLIndex index only. It does not change the name of the path table—you can rename the path table separately.

Example 5–13 Renaming and Dropping an XMLIndex Index

```
ALTER INDEX po_xmlindex_ix RENAME TO new_name_ix;

Index altered.

DROP INDEX new_name_ix;

Index dropped.
```

Similarly, you can change other index properties using other ALTER INDEX options, such as REBUILD. XMLIndex is no different from other index types in this respect.

You can use the PARAMETERS clause of a CREATE INDEX statement to name the path table. Example 5–14 names the path table "my_path_table".

Example 5–14 Naming the Path Table of an XMLIndex Index

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PATH TABLE my_path_table');
```

If you do not name the path table this way, then its name is generated by the system, using the index name you provide to CREATE INDEX as a base. Example 5–15 shows this for the index created in Example 5–9.

Example 5–15 Determining the System-Generated Name of an XMLIndex Path Table

```
SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
  WHERE TABLE_NAME = 'PO_CLOB' AND INDEX_NAME = 'PO_XMLINDEX_IX';

PATH_TABLE_NAME
------------------------------
SYS72060_PO_XMLINDE_PATH_TABLE

1 row selected.
```

By default, the storage options of the XMLIndex path table and its secondary indexes are derived from the storage properties of the base table on which the XMLIndex index is created. You can specify different storage options by using a PARAMETERS

clause when you create the index, as shown in Example 5–16. The PARAMETERS clause of CREATE INDEX (and ALTER INDEX) must be between single quotation marks (').

> **See Also:** "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 5-33 for the syntax of the PARAMETERS clause

Example 5–16 Specifying Storage Options When Creating an XMLIndex Index

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS
    ('PATH TABLE po_path_table
      (PCTFREE 5 PCTUSED 90 INITRANS 5
       STORAGE (INITIAL 1k NEXT 2k MINEXTENTS 3 BUFFER_POOL KEEP)
       NOLOGGING ENABLE ROW MOVEMENT PARALLEL 3)
      PATH ID INDEX   po_path_id_ix (LOGGING PCTFREE 1 INITRANS 3)
      ORDER KEY INDEX po_order_key_ix (LOGGING PCTFREE 1 INITRANS 3)
      VALUE INDEX     po_value_ix (LOGGING PCTFREE 1 INITRANS 3)');

Index created.
```

Because XMLIndex is a logical domain index, not a physical index, all physical attributes are either zero (0) or NULL.

In addition to specifying storage options for the path table, Example 5–16 names the secondary indexes. An index is created on column VALUE because it is specified; otherwise, no such index would be created.

Like the name of the path table, the names of the secondary indexes on the path-table columns are generated automatically using the index name as a base, unless you specify them in the PARAMETERS clause. Example 5–17 illustrates this, and shows how you can determine these names using public view USER_IND_COLUMNS. It also shows that the path index and the order index each use two columns, including column RID. Note, too, that no VALUE index was created, by default.

Example 5–17 Determining the Names of the Secondary Indexes of an XMLIndex Index

```
SELECT INDEX_NAME, COLUMN_NAME, COLUMN_POSITION FROM USER_IND_COLUMNS
  WHERE TABLE_NAME IN (SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
                         WHERE INDEX_NAME = 'PO_XMLINDEX_IX')
  ORDER BY INDEX_NAME, COLUMN_NAME;

INDEX_NAME                     COLUMN_NAME  COLUMN_POSITION
------------------------------ ------------ ---------------
SYS73321_PO_XMLINDE_ORDKEY_IX  ORDER_KEY                  2
SYS73321_PO_XMLINDE_ORDKEY_IX  RID                        1
SYS73321_PO_XMLINDE_PATHID_IX  PATHID                     1
SYS73321_PO_XMLINDE_PATHID_IX  RID                        2

4 rows selected.
```

> **See Also:** Example 5–23 on page 5-20 for a similar, but more complex example

The RENAME clause of an ALTER INDEX statement for XMLIndex applies only to the XMLIndex index itself. To rename the path table and secondary indexes, you must determine the names of these objects and use appropriate ALTER INDEX statements on them directly. Similarly, to retrieve the physical properties of the secondary indexes or alter them in any other way, you will need to obtain their names, as in Example 5–17.

You can use ALTER INDEX to modify any of the index parameters of the primary or secondary indexes. As a convenience, an alternative way to change properties of a path-id, order-key, or value index is to use ALTER INDEX on the parent XMLIndex index, providing a PARAMETERS clause with the new properties.

> **See Also:** "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 5-33 for the syntax of the PARAMETERS clause

Creating Additional Secondary Indexes on an XMLIndex Path Table

This section adds extra secondary indexes to the XMLIndex index created in Example 5–16.

You can create any number of additional secondary indexes on the VALUE column of the path table of an XMLIndex index. These can be of different types, including function-based indexes and Oracle Text indexes.

Whether or not a given index is used for a given element occurrence when processing a query is determined by whether it is of the appropriate type for that value and whether it is cost-effective to use it.

Example 5–18 creates a function-based index on column VALUE of the path table using SQL function substr. This might be useful if your queries often use substr applied to the text nodes of XML elements.

Example 5–18 Creating a Function-Based Index on Path-Table Column VALUE

```
CREATE INDEX fn_based_ix ON po_path_table (substr(VALUE, 1, 100));

Index created.
```

If you have many elements whose text nodes represent numeric values, then it can make sense to create a numeric index on the column VALUE. However, doing so directly, in a manner analogous to Example 5–18, raises an ORA-01722 error (invalid number) if some of the element values are *not* numbers. This is illustrated in Example 5–19.

Example 5–19 Trying to Create a Numeric Index on Path-Table Column VALUE Directly

```
CREATE INDEX direct_num_ix ON po_path_table (to_number(VALUE));
CREATE INDEX direct_num_ix ON po_path_table (to_number(VALUE))
                                            *
ERROR at line 1:
ORA-01722: invalid number
```

What is needed is an index that will be used for numeric-valued elements but will be ignored for element occurrences that do not have numeric values. Procedure createNumberIndex of package DBMS_XMLINDEX exists specifically for this purpose. You pass it the names of the database schema, the XMLIndex index, and the numeric index to be created. Creation of a numeric index is illustrated in Example 5–20.

Example 5–20 Creating a Numeric Index on Column VALUE with Procedure createNumberIndex

```
CALL DBMS_XMLINDEX.createNumberIndex('OE', 'PO_XMLINDEX_IX', 'API_NUM_IX');
```

Note that because such an index is specifically designed to ignore elements that do not have numeric values, its use will not detect their presence. If there are non-numeric

elements and, for whatever reason, the XMLIndex index is not used in some query, then an ORA-01722 error will be raised. However, if the index is used, no such error will be raised, because the index ignores non-numeric data. As always, the use of an index will never change the result set—it will never give you different results, but use of an index can prevent you from detecting erroneous data.

Creating a date-valued index is similar to creating a numeric index; you use procedure DBMS_XMLINDEX.createDateIndex. Example 5–21 shows this.

Example 5–21 Creating a Date Index on Column VALUE with Procedure createDateIndex

```
CALL DBMS_XMLINDEX.createDateIndex('OE', 'PO_XMLINDEX_IX', 'API_DATE_IX',
                                   'dateTime');
```

Example 5–22 creates an Oracle Text CONTEXT index on column VALUE. This is useful for full-text queries on text values of XML elements. XPath predicates that use XPath function ora:contains are rewritten to applications of SQL function contains on column VALUE. If a CONTEXT index is defined on column VALUE, then it will be used during predicate evaluation. An Oracle Text index is independent of all other VALUE-column indexes.

Example 5–22 Creating an Oracle Text CONTEXT Index on Path-Table Column VALUE

```
CREATE INDEX po_otext_ix ON po_path_table (VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT
    PARAMETERS('TRANSACTIONAL');

Index created.
```

> **See Also:** "From ora:contains to contains" on page 11-25 for information about parameter TRANSACTIONAL

The query in Example 5–23 shows all of the secondary indexes created on the path table of an XMLIndex index. The indexes created explicitly are in bold. Note, in particular, that some indexes, such as the function-based index created on column VALUE, do not appear as such; the column name listed for it them a system-generated name, such as SYS_NC00006$. This means that you *cannot* see these columns by executing a query with COLUMN_NAME = 'VALUE' in the WHERE clause.

Example 5–23 Showing All Secondary Indexes on an XMLIndex Path Table

```
SELECT c.INDEX_NAME, c.COLUMN_NAME, c.COLUMN_POSITION, e.COLUMN_EXPRESSION
  FROM USER_IND_COLUMNS c LEFT OUTER JOIN USER_IND_EXPRESSIONS e
    ON (c.INDEX_NAME = e.INDEX_NAME)
  WHERE c.TABLE_NAME IN (SELECT PATH_TABLE_NAME FROM USER_XML_INDEXES
                         WHERE INDEX_NAME = 'PO_XMLINDEX_IX')
  ORDER BY c.INDEX_NAME, c.COLUMN_NAME;

INDEX_NAME           COLUMN_NAME  COLUMN_POSITION COLUMN_EXPRESSION
-------------------- ------------ --------------- ----------------------
API_DATE_IX          SYS_NC00008$               1 SYS_EXTRACT_UTC(SYS_XMLCONV("V
                                                  ALUE",3,8,0,0,181))
API_NUM_IX           SYS_NC00007$               1 TO_BINARY_DOUBLE("VALUE")
FN_BASED_IX          SYS_NC00006$               1 SUBSTR("VALUE",1,100)
PO_ORDER_KEY_IX      ORDER_KEY                  2
PO_ORDER_KEY_IX      RID                        1
PO_OTEXT_IX          VALUE                      1
PO_PATH_ID_IX        PATHID                     1
```

```
PO_PATH_ID_IX        RID                       2
PO_VALUE_IX          VALUE                     1

9 rows selected.
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedures `createNumberIndex` and `createDateIndex` in package `DBMS_XMLINDEX`
- "Oracle Text Indexes Are Used Independently of Other Indexes" on page 5-37 for information on using Oracle Text indexes

How to Tell If XMLIndex is Used

It is at query compile time that it is determined whether or not a given `XMLIndex` index can be used, that is, whether the query can be rewritten into a query against the index. If it cannot be determined at compile time that an XPath expression in the query is a subset of the paths you specified to be used for indexing, then an `XMLIndex` index is not used. For example, if the path `/PurchaseOrder/LineItems//*` is included for indexing, then a query with `/PurchaseOrder/LineItems/LineItem/Description` can use the index, but a query with `//Description` cannot. The latter also matches potential `Description` elements that are not children of `/PurchaseOrder/LineItems`, and it is not possible at compile time to know if such additional `Description` elements will be present in the data.

To know whether a particular `XMLIndex` index has been used in resolving a query, you can examine an explain plan of the query. If the index is used, then its path table, order key, or path id will be referenced in the explain plan. The explain plan will *not* directly indicate that a domain index was used; it will *not* refer to the `XMLIndex` index by name.

See Also:

- *Oracle Database SQL Language Reference*
- *Oracle Database Performance Tuning Guide*

Example 5–24 shows that the `XMLIndex` index created in Example 5–14 is used in a particular query.

Example 5–24 Examining an Explain Plan to See If XMLIndex Is Used

The reference to `MY_PATH_TABLE` in the explain plan here indicates that the `XMLIndex` index (created in Example 5–14) was used in this query. Similarly, reference to columns `LOCATOR`, `ORDER_KEY`, and `PATHID` indicates the same thing.

```
SET AUTOTRACE ON EXPLAIN

SELECT XMLQuery('/PurchaseOrder/Requestor' PASSING OBJECT_VALUE RETURNING CONTENT) FROM po_clob
  WHERE XMLExists('/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]' PASSING OBJECT_VALUE);

XMLQUERY('/PURCHASEORDER/REQUESTOR'PASSINGOBJECT_VALUERETURNINGCONTENT)
--------------------------------------------------------------------------
<Requestor>Sarah J. Bell</Requestor>

1 row selected.
```

```
Execution Plan
. . .
-----------------------------------------------------------------------------------------------------------------
| Id  | Operation                      | Name                          | Rows  | Bytes |Cost(%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT               |                               |     1 |    24 |   15  (7)| 00:00:01 |
|   1 |  SORT GROUP BY                 |                               |     1 |  3524 |          |          |
|*  2 |   TABLE ACCESS BY INDEX ROWID  | MY_PATH_TABLE                 |     2 |  7048 |    2  (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN            | SYS55148_PO_XMLINDE_PATHID_IX |     6 |       |    1  (0)| 00:00:01 |
|   4 |  NESTED LOOPS                  |                               |     1 |    24 |   15  (7)| 00:00:01 |
|   5 |   VIEW                         | VW_SQ_1                       |     1 |    12 |   13  (0)| 00:00:01 |
|   6 |    HASH UNIQUE                 |                               |     1 |  5046 |          |          |
|   7 |     NESTED LOOPS               |                               |       |       |          |          |
|   8 |      NESTED LOOPS              |                               |     1 |  5046 |   13  (0)| 00:00:01 |
|*  9 |       TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE                 |     1 |  3524 |   11  (0)| 00:00:01 |
|* 10 |        INDEX RANGE SCAN        | SYS55148_PO_XMLINDE_PATHID_IX |     1 |       |    2  (0)| 00:00:01 |
|* 11 |       INDEX RANGE SCAN         | SYS55148_PO_XMLINDE_PATHID_IX |     6 |       |    1  (0)| 00:00:01 |
|* 12 |      TABLE ACCESS BY INDEX ROWID | MY_PATH_TABLE                 |     1 |  1522 |    2  (0)| 00:00:01 |
|  13 |   TABLE ACCESS BY USER ROWID   | PO_CLOB                       |     1 |    12 |    1  (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SYS_XMLI_LOC_ISNODE("SYS_P0"."LOCATOR")=1)
   3 - access("SYS_P0"."PATHID"=HEXTORAW('74C39DFE')  AND "SYS_P0"."RID"=:B1)
   9 - filter("SYS_P5"."PATHID"=HEXTORAW('6F7C')  AND SYS_XMLI_LOC_ISNODE("SYS_P5"."LOCATOR")=1)
  10 - access("SYS_P5"."VALUE"='SBELL-20021009123336O1PDT')
  11 - access("SYS_P2"."PATHID"=HEXTORAW('093CA37E')  AND "SYS_P5"."RID"="SYS_P2"."RID")
  12 - filter(SYS_XMLI_LOC_ISNODE("SYS_P2"."LOCATOR")=1 AND "SYS_P2"."ORDER_KEY"<"SYS_P5"."ORDER_KEY" AND
              "SYS_P5"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD("SYS_P2"."ORDER_KEY") AND
              SYS_ORDERKEY_DEPTH("SYS_P2"."ORDER_KEY")+1=SYS_ORDERKEY_DEPTH("SYS_P5"."ORDER_KEY"))
. . .
```

Given the name of a path table from an explain plan such as this, you can obtain the name of its `XMLIndex` index as shown in Example 5–25. (This is more or less opposite to the query in Example 5–15.)

Example 5–25 Obtaining the Name of an XMLIndex Index from Its Path-Table Name

```
SELECT INDEX_NAME FROM USER_XML_INDEXES WHERE PATH_TABLE_NAME = 'MY_PATH_TABLE';

INDEX_NAME
------------------------------
PO_XMLINDEX_IX

1 row selected.
```

`XMLIndex` can be used for XPath expressions in the `SELECT` list, the `FROM` list, and the `WHERE` clause of a query, and it is useful for SQL functions `XMLQuery`, `XMLTable`, `XMLExists`, `XMLCast`, `extractValue`, `existsNode`, and `extract`. Unlike function-based indexes (and `CTXXPath` indexes, which are deprecated), `XMLIndex` indexes can be used when you extract an XML fragment from a document. Example 5–26 illustrates this.

Example 5–26 Using XMLIndex to Extract an XML Fragment

```
SET AUTOTRACE ON EXPLAIN

SELECT li.description, li.itemno
  FROM po_clob, XMLTable('/PurchaseOrder/LineItems/LineItem'
                         PASSING OBJECT_VALUE
                         COLUMNS "DESCRIPTION" VARCHAR(40) PATH '/LineItem/Description',
```

```
                                "ITEMNO"      INTEGER     PATH '/LineItem/@ItemNumber') li
  WHERE XMLExists('/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]'
                  PASSING OBJECT_VALUE);

DESCRIPTION                                ITEMNO
------------------------------------------ ----------
A Night to Remember                             1
The Unbearable Lightness Of Being               2
Sisters                                         3

3 rows selected.
```

The explain plan for this query shows, by referring to the path table, that `XMLIndex` is used. It also shows the use of internal SQL function `sys_orderkey_depth`—see "Guidelines for Using XMLIndex" on page 5-32.

```
Execution Plan
. . .
-----------------------------------------------------------------------------------------------------------------------
| Id  | Operation                          | Name                          | Rows  | Bytes |Cost(%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                   |                               |     1 |  1546 | 8  (13)| 00:00:01 |
|*  1 |  FILTER                            |                               |       |       |        |          |
|*  2 |   TABLE ACCESS BY INDEX ROWID      | MY_PATH_TABLE                 |     1 |  3524 | 2   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN                | SYS63727_PO_XMLINDE_PATHID_IX |     6 |       | 1   (0)| 00:00:01 |
|*  4 |  FILTER                            |                               |       |       |        |          |
|*  5 |   TABLE ACCESS BY INDEX ROWID      | MY_PATH_TABLE                 |     1 |  3524 | 2   (0)| 00:00:01 |
|*  6 |    INDEX RANGE SCAN                | SYS63727_PO_XMLINDE_PATHID_IX |     1 |       | 1   (0)| 00:00:01 |
. . .
|* 14 |         TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE                 |     1 |  3524 | 2   (0)| 00:00:01 |
|* 15 |          INDEX RANGE SCAN          | SYS63727_PO_XMLINDE_VALUE_IX  |     1 |       | 1   (0)| 00:00:01 |
|* 16 |         INDEX RANGE SCAN           | SYS63727_PO_XMLINDE_ORDKEY_IX |     1 |       | 1   (0)| 00:00:01 |
|* 17 |        TABLE ACCESS BY INDEX ROWID | MY_PATH_TABLE                 |     1 |  1522 | 2   (0)| 00:00:01 |
|  18 |     TABLE ACCESS BY USER ROWID     | PO_CLOB                       |     1 |    12 | 1   (0)| 00:00:01 |
|* 19 |    INDEX RANGE SCAN                | SYS63727_PO_XMLINDE_PATHID_IX |     6 |       | 1   (0)| 00:00:01 |
|* 20 |   TABLE ACCESS BY INDEX ROWID      | MY_PATH_TABLE                 |     1 |  1522 | 2   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter(:B1<SYS_ORDERKEY_MAXCHILD(:B2))
   2 - filter("SYS_P3"."ORDER_KEY">:B1 AND SYS_XMLI_LOC_ISNODE("SYS_P3"."LOCATOR")=1 AND
              "SYS_P3"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD(:B2) AND SYS_ORDERKEY_DEPTH("SYS_P3"."ORDER_KEY")=
              SYS_ORDERKEY_DEPTH(:B3)+1)
   3 - access("SYS_P3"."PATHID"=HEXTORAW('54393E4C')  AND "SYS_P3"."RID"=:B1)
   4 - filter(:B1<SYS_ORDERKEY_MAXCHILD(:B2))
   5 - filter("SYS_P6"."ORDER_KEY">:B1 AND SYS_XMLI_LOC_ISNODE("SYS_P6"."LOCATOR")=1 AND
              "SYS_P6"."ORDER_KEY"<SYS_ORDERKEY_MAXCHILD(:B2) AND SYS_ORDERKEY_DEPTH("SYS_P6"."ORDER_KEY")=
              SYS_ORDERKEY_DEPTH(:B3)+1)
   6 - access("SYS_P6"."PATHID"=HEXTORAW('7DE452AA')  AND "SYS_P6"."RID"=:B1)
       filter(SYS_PATHID_IS_NMSPC("SYS_P6"."PATHID")=0)
  14 - filter("SYS_P11"."PATHID"=HEXTORAW('6F7C')  AND SYS_XMLI_LOC_ISNODE("SYS_P11"."LOCATOR")=1)
  15 - access("SYS_P11"."VALUE"='SBELL-20021009123336O1PDT')
  16 - access("SYS_P11"."RID"="SYS_P8"."RID" AND "SYS_P8"."ORDER_KEY"<"SYS_P11"."ORDER_KEY")
  17 - filter("SYS_P8"."PATHID"=HEXTORAW('093CA37E')  AND SYS_XMLI_LOC_ISNODE("SYS_P8"."LOCATOR")=1)
  19 - access("SYS_P0"."PATHID"=HEXTORAW('7676FDEA')  AND "SYS_P0"."RID"="PO_CLOB".ROWID)
  20 - filter(SYS_XMLI_LOC_ISNODE("SYS_P0"."LOCATOR")=1)
. . .
```

See Also: "Collecting Statistics on XMLIndex Objects For the Cost-Based Optimizer" on page 5-31

Turning Off Use of XMLIndex

You can turn off the use of XMLIndex in any of these ways:

- Use optimizer hint /*+ NO_XMLINDEX_REWRITE */
- Use optimizer hint /*+ NO_XMLINDEX_REWRITE_IN_SELECT */
- Use optimizer hint /*+ NO_XML_QUERY_REWRITE */

Each of these turns off the use of *all* XMLIndex indexes. In addition to turning off use of XMLIndex, NO_XML_QUERY_REWRITE turns off all XPath rewrite (XMLIndex is part of XPath rewrite).

Hint NO_XMLINDEX_REWRITE_IN_SELECT turns off the use of XMLIndex indexes only for XPath expressions in the SELECT list; XMLIndex indexes can still be used for XPath expressions in other query parts, such as a WHERE clause or a FROM clause. This hint can be especially useful with XML data that is stored as binary XML, in cases where streaming evaluation of XPath expressions in a SELECT list provides better performance than XMLIndex.

Example 5–27 shows the use of these optimizer hints.

Example 5–27 Using Optimizer Hints to Turn Off XMLIndex

```
SELECT /*+ NO_XMLINDEX_REWRITE */
  count(*) FROM po_clob WHERE existsNode(OBJECT_VALUE, '/*') = 1;

SELECT /*+ NO_XMLINDEX_REWRITE_IN_SELECT */
  extractValue(li.OBJECT_VALUE, '/LineItem/Description')
  FROM po_clob p,
       table(XMLSequence(extract(p. OBJECT_VALUE,
                                 '/PurchaseOrder/LineItems/LineItem'))) li;

SELECT /*+ NO_XMLINDEX_REWRITE_IN_SELECT */
  li.description
  FROM po_clob p,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING OBJECT_VALUE
                COLUMNS "DESCRIPTION" VARCHAR(40)
                PATH '/LineItem/Description') li;

SELECT /*+ NO_XML_QUERY_REWRITE */
  count(*) FROM po_clob WHERE existsNode(OBJECT_VALUE, '/*') = 1;
```

In each of the queries that uses hint NO_XMLINDEX_REWRITE_IN_SELECT, the XPath expression in the SELECT list does not use XMLIndex, but the XPath expression in the FROM clause, /PurchaseOrder/LineItems/LineItem, might use XMLIndex. Note that in the query that uses function XMLTable, the XPath expression that corresponds to column li.description does not appear in the SELECT list textually, but it is treated as if it does because of XPath rewrite. That is, XPath rewrite treats the XPath expression as if it were present in the SELECT list.

Note: The NO_INDEX optimizer hint does not apply to XMLIndex.

See Also: "Processing XMLType Methods and XML-Specific SQL Functions" on page 3-59 for information about streaming evaluation of binary XML data

XMLIndex Path Subsetting: Specifying the Paths You Want to Index

One of the advantages of XMLIndex is that it is very general: you need not specify which XPath locations to index; you need no prior knowledge of the XPath expressions that will be queried. By default, XMLIndex indexes all possible XPath locations in your XML data.

However, if you are aware of the XPath expressions that you are most likely to query, you can narrow the focus of XMLIndex indexing and thus improve performance. Having fewer unnecessary indexes means that less space is required for indexing, which improves index maintenance during DML operations. Having fewer indexed nodes improves DDL performance, and having a smaller path table improves query performance.

You narrow the focus of indexing by pruning the set of XPath expressions (paths) corresponding to XML fragments to be indexed, specifying a subset of all possible paths. You can do this in two alternative ways:

- Exclusion – Start with the default behavior of including all possible XPath expressions, and exclude some of them from indexing.
- Inclusion – Start with an empty set of XPath expressions to be used in indexing, and add paths to this inclusion set.

You can specify path subsetting either when you create an XMLIndex index using CREATE INDEX or when you modify it using ALTER INDEX. In both cases, you provide the subsetting information in the PATHS parameter of the statement's PARAMETERS clause. For exclusion, you use keyword EXCLUDE. For inclusion, you use keyword INCLUDE for ALTER INDEX and no keyword for CREATE INDEX (list the paths to include). You can also specify namespace mappings for the nodes targeted by the PATHS parameter.

For ALTER INDEX, keyword INCLUDE or EXCLUDE is followed by keyword ADD or REMOVE, to indicate whether the list of paths that follows the keyword is to be added or removed from the inclusion or exclusion list. For example, this statement adds path /PurchaseOrder/Reference to the list of paths to be excluded from indexing:

```
ALTER INDEX po_xmlindex_ix REBUILD
  PARAMETERS ('PATHS (EXCLUDE ADD (/PurchaseOrder/Reference))');
```

To alter an XMLIndex index so that it *includes all* possible paths, you can use keyword ALL in place of an explicit list of paths – use either EXCLUDE REMOVE (ALL) or INCLUDE ADD (ALL); they are equivalent. (You cannot exclude all paths.)

> **See Also:** "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 5-33 for the syntax of the PARAMETERS clause

Examples of XMLIndex Path Subsetting

This section presents some examples of defining XMLIndex indexes on subsets of XPath expressions.

Example 5–28 XMLIndex Path Subsetting With CREATE INDEX

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLINDEX
  PARAMETERS ('PATHS (INCLUDE (/PurchaseOrder/LineItems//*
                               /PurchaseOrder/Reference))');
```

This statement creates an index that indexes only top-level element PurchaseOrder and some of its children, as follows:

- All `LineItems` elements and their descendants
- All `Reference` elements

It does that by including the specified paths, starting with an empty set of paths to be used for the index.

Example 5–29 XMLIndex Path Subsetting With ALTER INDEX

```
ALTER INDEX po_xmlindex_ix REBUILD
  PARAMETERS ('PATHS (INCLUDE ADD (/PurchaseOrder/Requestor
                                   /PurchaseOrder/Actions/Action//*))');
```

This statement adds two more paths to those used for indexing. These paths index element `Requestor` and descendants of element `Action` (as well as their ancestors).

Example 5–30 XMLIndex Path Subsetting Using a Namespace Prefix

If an XPath expression to be used for `XMLIndex` indexing uses namespace prefixes, you can use a `NAMESPACE MAPPING` clause to the `PATHS` list, to specify those prefixes. Here is an example:

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PATHS INCLUDE (/PurchaseOrder/LineItems//*   /PurchaseOrder/ipo:Reference)
                    NAMESPACE MAPPING (xmlns="http://xmlns.oracle.com"
                                       xmlns:ipo="http://xmlns.oracle.com/ipo"))');
```

XMLIndex Path-Subsetting Rules

The following rules apply to `XMLIndex` path subsetting:

- The paths must reference only child and descendant axes, and they must test only element and attribute nodes or their names (possibly using wildcards). In particular, the paths must not involve predicates.
- You cannot specify both path exclusion and path inclusion; choose one method or the other.
- If an index was created using path exclusion (inclusion), then you can modify it using only path exclusion (inclusion)—index modification must either further restrict or further extend the path subset. For example, you cannot create an index that includes certain paths and subsequently modify it to exclude certain paths.

Using XMLIndex on Oracle XML DB Repository

A database administrator (DBA) can create an `XMLIndex` index on resources in Oracle XML DB Repository to improve querying of XML data or metadata (system-defined or user-defined).

Creating an XMLIndex Index on Repository Resources

Only a user with database role `XDBADMIN` can create an `XMLIndex` index on Oracle XML DB Repository. After creating such an index, you restrict it to those resources that will actually be queried.

You cannot index resources that contain a `REF` (in their contents or metadata) to a row in a view or to a row in a table that is not hierarchy-enabled. An attempt to do so will raise an error.

Follow this procedure as a database administrator to create an `XMLIndex` index on specific repository resources:

1. Create the XMLIndex index on the repository. This excludes repository paths /Resource/ACL, /Resource/RefCount, and /Resource/RCList from the index created. It creates the path table and all secondary indexes, but it does not index any resources.

   ```
   CALL DBMS_XDB_ADMIN.CreateRepositoryXMLIndex();
   ```

   No resources are indexed at this point. They are indexed after step 2.

2. Specify the repository resources to index, by repository path. You use PL/SQL procedure XMLIndexAddPath in package DBMS_XDB_ADMIN to do this.

   ```
   DBMS_XDB_ADMIN.XMLIndexAddPath(<path to index>, <disable secondary indexes?>);
   ```

   The first parameter to XMLIndexAddPath is a repository path expression that targets a resource (file or folder) to index. (Note: A repository path expression is not an XPath expression.) The second parameter is a Boolean value that, if TRUE, disables loading of the path-table secondary indexes during the execution of XMLIndexAddPath. Set this to TRUE only if there are few existing rows in the path table and you are adding many new rows. Disabling the secondary indexes while a path is being indexed prevents updating of the path table index, specifically, loading (populating) of the secondary indexes each time a row is added to it. This can speed up bulk loading of resources.

To drop an XMLIndex index created on the repository, do this:

```
CALL DBMS_XDB_ADMIN.DropRepositoryXMLIndex();
```

See Also:

- Chapter 21, "Accessing Oracle XML DB Repository Data" for information on repository resources and resource paths
- *Oracle Database PL/SQL Packages and Types Reference* for information on the procedures in PL/SQL package DBMS_XDB_ADMIN

Removing Repository Resources From Indexing With XMLIndex

Follow this procedure as a database administrator to remove a resource from indexing:

1. Repeat this procedure for each ancestor of the resource, to first remove them from indexing. You cannot remove a resource from indexing until you have first removed all of its ancestors from indexing.

2. Specify the repository resource to be removed from indexing, by repository path. You use PL/SQL procedure XMLIndexRemovePath in package DBMS_XDB_ADMIN to do this.

   ```
   DBMS_XDB_ADMIN.XMLIndexRemovePath(<path to index>, <recursively?>);
   ```

   The first parameter to XMLIndexRemovePath is a repository path expression that targets a resource to remove from indexing. The second parameter is a Boolean value that, if TRUE, removes the targeted resource and all of its descendants from indexing; if FALSE, only the targeted resource is removed from indexing.

   See Also: *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedure DBMS_XDB_ADMIN.XMLIndexREmovePath

Querying Repository Data and Metadata Indexed With XMLIndex

For an XMLIndex on repository data or metadata to be used when you query the repository, *all* of the targeted resources must be indexed. Use SQL functions under_path and equals_path to target resources by repository path when you query. If you do not use either of these functions, then under_path('/') is implied.

Example 5–31 presents a query of resource data, PurchaseOrder elements whose Reference element has value TFOX-20021009123335520PDT.

Example 5–31 Using XMLIndex When Querying Resource Data

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE XMLExists('declare namespace r = "http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)
                   /r:Resource/r:Contents/PurchaseOrder[Reference="TFOX-20021009123335520PDT"]'
                  PASSING RES)
    AND under_path (RES, '/home/OE/PurchaseOrders/2002/') = 1;

ANY_PATH
------------------------------------------------------------
/home/OE/PurchaseOrders/2002/Jan/TFOX-20021009123335520PDT.xml

1 row selected.
```

The under_path expression here limits the paths queried so that they include only data indexed using XMLIndex. The existsNode expression targets XML nodes using an XPath expression.

You can query repository metadata similarly. To do that, simply target resource elements that represent metadata, either system-defined or user-defined. Example 5–32 shows a query of the CreationDate element in system metadata.

Example 5–32 Using XMLIndex When Querying Resource Metadata

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE XMLExists('declare namespace r =
"http://xmlns.oracle.com/xdb/XDBResource.xsd"; (: :)

/r:Resource/r:CreationDate/text()=xs:dateTime("2005-02-07T18:31:53.093179")'
                   PASSING RES)
   AND under_path (RES, '/home/OE/PurchaseOrders/2002/') = 1;

ANY_PATH
------------------------------------------------------------------
/home/OE/PurchaseOrders/2002/Apr
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/OE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
/home/OE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336191PDT.xml
/home/OE/PurchaseOrders/2002/Apr/PTUCKER-20021009123336291PDT.xml
. . .

144 rows selected.
```

See Also: "Querying Metadata and the Folder Hierarchy" on page 3-87

Dropping an XMLIndex Index on Created on Repository Resources

Only a user with database role XDBADMIN can drop an XMLIndex index created on Oracle XML DB Repository. To drop an XMLIndex index created on the repository, do this:

```
CALL DBMS_XDB_ADMIN.DropRepositoryXMLIndex();
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedure DBMS_XDB_ADMIN.DropRepositoryXMLIndex

XMLIndex Parallelism

You can use a PARALLEL clause (with optional degree) when creating or altering an XMLIndex index, to ensure that the index creation and maintenance are carried out in parallel. This can improve the performance of index creation and maintenance. It can also consume more storage, because storage parameters apply separately to each query server process. For example, an index created with an INITIAL value of 5M and a parallelism degree of 12 consumes at least 60M of storage during index creation.

The syntax for the parallelism clause for CREATE INDEX and ALTER INDEX is the same as for other domain indexes:

```
{ NOPARALLEL | PARALLEL [ integer ] }
```

Example 5–33 creates an XMLIndex index with a parallelism degree of 10.

Example 5–33 Creating an XMLIndex Index in Parallel

```
CREATE INDEX po_xmlindex_ix ON sale_info (sale_po_clob) INDEXTYPE IS XDB.XMLIndex
  PARALLEL 10;
```

In Example 5–33, the path table and the secondary indexes are created with the same parallelism degree as the XMLIndex index itself, 10, by inheritance. You can specify different parallelism degrees for these by using separate PARALLEL clauses. Example 5–34 demonstrates this.

Example 5–34 Using Different PARALLEL Degrees for XMLIndex Internal Objects

```
CREATE INDEX po_xmlindex_ix ON sale_info (sale_po_clob) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('PATH TABLE po_path_table (PARALLEL 10)
               PATH ID INDEX po_pathid_ix
               ORDER KEY INDEX po_orderkey_ix (PARALLEL 5)') NOPARALLEL;
```

In Example 5–34, the XMLIndex index itself is created serially, because of NOPARALLEL. The secondary index on path-table column PATHID is also populated serially, because no parallelism is specified explicitly for it; it inherits the parallelism of the XMLIndex index. The path table itself will be created with a parallelism degree of 10, and the secondary index on path-table column ORDER_KEY will be populated with a degree of 5, due to their explicit parallelism specifications.

Any parallelism you specify for an XMLIndex index, its path table, or its secondary indexes is exploited during subsequent DML operations and queries.

See Also:

- *Oracle Database SQL Language Reference* for information on the `CREATE INDEX` parallel clause
- "PARAMETERS Clause for CREATE INDEX and ALTER INDEX" on page 5-33 for the syntax of the `PARAMETERS` clause

Asynchronous (Deferred) Maintenance of XMLIndex Indexes

By default, `XMLIndex` indexing is updated (maintained) at each DML operation, so that it remains in sync with the base table. In some situations, you might not require this, and using possibly stale indexes might be acceptable. In that use case, you can decide to defer the cost of index maintenance, performing at commit time only or at some time when database load is reduced. This can improve DML performance. It can also improve index maintenance performance by enabling bulk loading of unsynchronized index rows when an index is synchronized.

Using a stale index has no effect, other than performance, on DML operations. It can have an effect on query results, however: If the index is not up-to-date at query time, then the query results might not be up-to-date either. Even if only one column of a base table is of data type `XMLType`, all queries on that table reflect the database data as of the last synchronization of the `XMLIndex` index on the `XMLType` column.

You can specify index maintenance deferment using the parameters clause of a `CREATE INDEX` or `ALTER INDEX` statement.

Be aware that even if you defer synchronization for an `XMLIndex` index, the following database operations will automatically synchronize the index:

- Any DDL operation on the index – `ALTER INDEX` or creation of secondary indexes
- Any DDL operation on the base table – `ALTER TABLE` or creation of another index

Table 5–4 lists the synchronization options and the `ASYNC` clause syntax you use to specify them. The `ASYNC` clause is used in the `PARAMETERS` clause of a `CREATE INDEX` or `ALTER INDEX` statement for `XMLIndex`.

Table 5–4 Index Synchronization

When to Synchronize	ASYNC Clause Syntax
Always	`ASYNC (ALWAYS)` This is the default behavior. You can specify it explicitly, to cancel a previous `ASYNC` specification.
Upon commit	`ASYNC (ON COMMIT)`
Periodically	`ASYNC (EVERY "repeat_interval")` *`repeat_interval`* is the same as for the calendaring syntax of `DBMS_SCHEDULER` To use `EVERY`, you must have the `CREATE JOB` privilege.
Manually, on demand	`ASYNC (MANUAL)` You can manually synchronize the index using PL/SQL procedure `DBMS_XMLINDEX.SyncIndex`.

Optional `ASYNC` syntax parameter `STALE` is intended for possible future use; you need never specify it explicitly. It has value `FALSE` whenever `ASYNC` is `ALWAYS`; otherwise it

has value TRUE. Specifying an explicit STALE value that contradicts this rule raises an error.

Example 5–35 creates an XMLIndex index that is synchronized every Monday at 3:00 pm, starting tomorrow.

Example 5–35 Specifying Deferred Synchronization for XMLIndex

```
CREATE INDEX po_xmlindex_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS XDB.XMLIndex
  PARAMETERS ('ASYNC (SYNC EVERY "FREQ=HOURLY; INTERVAL = 1")');
```

Example 5–36 manually synchronizes the index created in Example 5–35.

Example 5–36 Manually Synchronizing an XMLIndex Index Using SYNCINDEX

```
EXEC DBMS_XMLINDEX.SyncIndex('OE', 'PO_XMLINDEX_IX');
```

When XMLIndex index synchronization is deferred, all DML changes (inserts, updates, deletions) made to the base table since the last index synchronization are recorded in a table, one row per DML operation. The name of this table is the value of column PEND_TABLE_NAME of static public views USER_XML_INDEXES, ALL_XML_INDEXES, and DBA_XML_INDEXES.

You can examine this table to determine when synchronization might be appropriate for a given XMLIndex index. The more rows, the more the index is likely to be in need of synchronization.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference*, section "Calendaring Syntax", for the syntax of *repeat_interval*
- *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL procedure DBMS_XMLINDEX.SyncIndex

Collecting Statistics on XMLIndex Objects For the Cost-Based Optimizer

The Oracle Database cost-based optimizer determines how to most cost-effectively evaluate a given query, including which indexes, if any, to use. For it to be able to do this accurately, you must collect statistics on various database objects.

For XMLIndex, you normally need to collect statistics on only the base table on which the XMLIndex index is defined (using, for example, procedure DBMS_STATS.gather_table_stats). This automatically collects statistics for the XMLIndex index itself, as well as the path table and its secondary indexes. If you delete statistics on the base table (using procedure DBMS_STATS.delete_table_stats), then statistics on the other objects are also deleted. Similarly, if you collect statistics on the XMLIndex index (using procedure DBMS_STATS.gather_index_stats), then statistics are also collected on the path table and its secondary indexes.

Example 5–37 collects statistics on the base table po_clob. Statistics are automatically collected on the XMLIndex index, its path table, and the secondary path-table indexes.

Example 5–37 Automatic Collection of Statistics on XMLIndex Objects

```
CALL DBMS_STATS.gather_table_stats(USER, 'PO_CLOB');
```

Guidelines for Using XMLIndex

The following are some guidelines for using `XMLIndex`. These guidelines are applicable only when the two alternatives discussed return the same result set.

- Avoid prefixing `//` with ancestor elements. For example, use `//c`, *not* **`/a/b`**`//c`, provided these return the same result set.
- Avoid prefixing `/*` with ancestor elements. For example, use `/*/*/*`, *not* **`/a`**`/*/*`, provided these return the same result set.
- Be aware that if an XPath expression indicates that the full `XMLType` table or column is needed anyway, then an `XMLIndex` will not be used, since it would not improve performance. This is the case, for instance, if you access the document root (`/`), as in this query:

```
SELECT COUNT(*) FROM po_clob WHERE existsNode(OBJECT_VALUE, '/') = 1;
```

- When you expect a single result, use `extractValue` instead of `extract` plus method `getStringVal()`, so that an index on column `VALUE` of the path table can be used. (You must thus provide keyword `VALUE` in the `PARAMETERS` clause when you create the `XMLIndex` index.)
- Use `count(*)`, *not* `count(extractValue(…))` in a `SELECT` clause, when possible. For example, if you know that a `LineItem` element in a purchase-order document has only one `Description` child, use this:

```
SELECT count(*) FROM po_clob, XMLTable('//LineItem' PASSING OBJECT_VALUE);
```

  Do not use this:

```
SELECT count(li.value)
 FROM po_clob p, XMLTable('//LineItem' PASSING p.OBJECT_VALUE
                          COLUMNS value VARCHAR2(30) PATH
'/LineItem/Description') li;
```

- Reduce the number of XPath expressions used in a query `FROM` list as much as possible. For example, use this:

```
SELECT li.description
  FROM po_clob p,
       XMLTable('PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
                COLUMNS description VARCHAR2(256)
                PATH '/LineItem/Description') li;
```

  Do not use this:

```
SELECT li.description
  FROM po_clob p,
       XMLTable('PurchaseOrder/LineItems' PASSING p.OBJECT_VALUE) ls,
       XMLTable('LineItems/LineItem'      PASSING ls.OBJECT_VALUE
                COLUMNS description VARCHAR2(256)
                PATH '/LineItem/Description') li;
```

- If you use an XPath expression in a query to drill down inside a virtual table (created, for example, using SQL function `XMLTable`), then create a secondary index on the order key of the path table using SQL function `sys_orderkey_depth`. Here is an example of such a query; the selection navigates to element `Description` inside virtual line-item table `li`.

```
SELECT li.description
  FROM po_clob p,
       XMLTable('PurchaseOrder/LineItems/LineItem' PASSING p.OBJECT_VALUE
```

```
                COLUMNS description VARCHAR2(256)
                PATH '/LineItem/Description') li;
```

Such queries are evaluated using function `sys_orderkey_depth`, which returns the depth of the order-key value. Because the order index uses two columns, the index needed is a *composite* index over columns `ORDER_KEY` and `RID`, as well as over function `sys_orderkey_depth` applied to the `ORDER_KEY` value. For example:

```
CREATE INDEX depth_ix ON my_path_table
  (RID, sys_orderkey_depth(ORDER_KEY), ORDER_KEY);
```

See Also: Example 5–26 on page 5-22 for an example that shows the use of `sys_orderkey_depth`

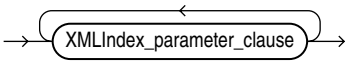
PARAMETERS Clause for CREATE INDEX and ALTER INDEX

This section presents the syntax for the `PARAMETERS` clause of SQL statements `CREATE INDEX` and `ALTER INDEX` for use with `XMLIndex`.

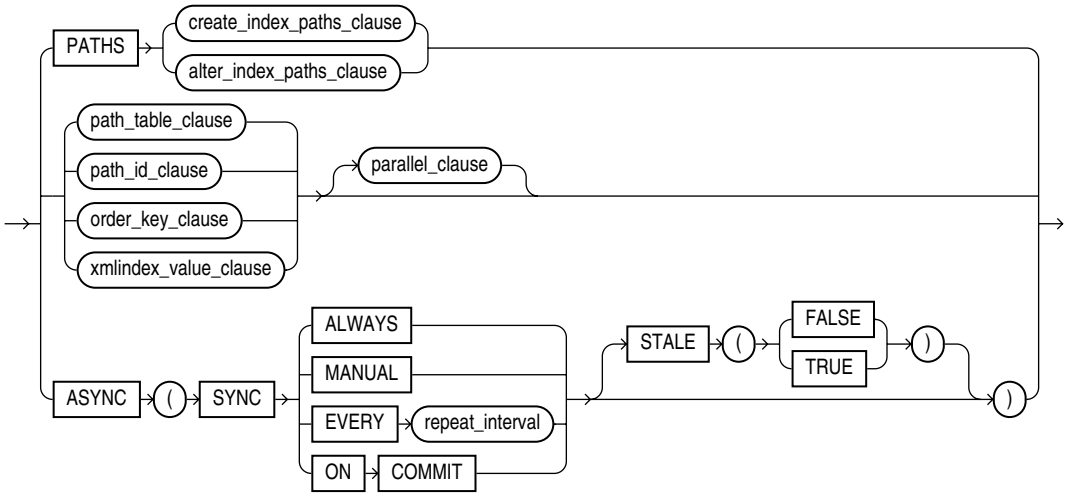
PARAMETERS Clause Syntax for CREATE INDEX and ALTER INDEX

The `PARAMETERS` clause is `PARAMETERS ('`*`XMLIndex_parameters`*`')`, where *`XMLIndex_parameters`* is one or more repetitions of *`XMLIndex_parameter_clause`*:

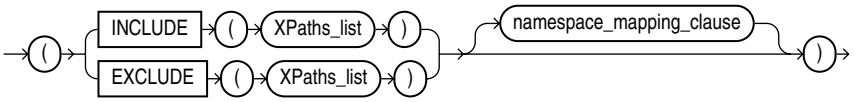
XMLIndex_parameters ::=



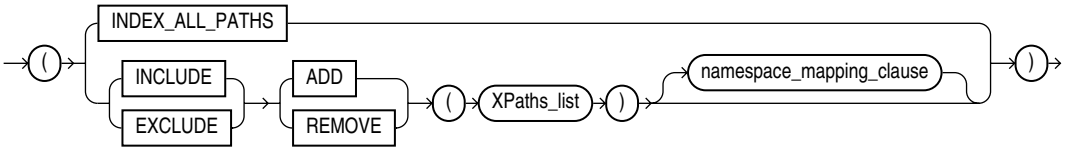
XMLIndex_parameter_clause ::=



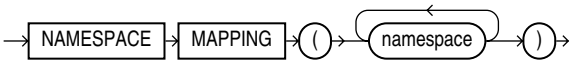
create_index_paths_clause ::=



alter_index_paths_clause ::=

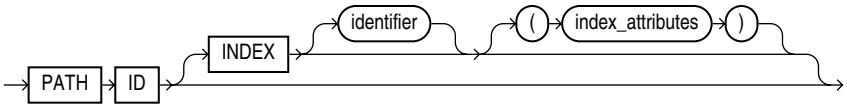


namespace_mapping_clause ::=

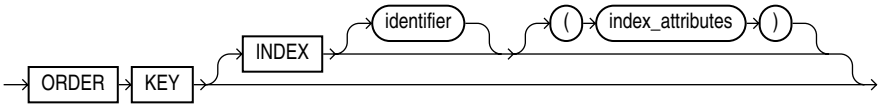


path_table_clause ::=

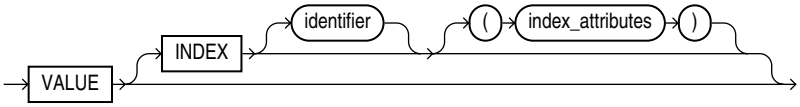
path_id_clause ::=



order_key_clause ::=



xml_index_value_clause ::=



Usage of XMLIndex_parameters

There can be at most one *XMLIndex_parameter_clause* of each type in any *XMLIndex_parameters* clause. For example, there can be at most one PATHS clause, at most one *path_table_clause*, and so on.

Usage of XMLIndex_parameter_clause for ALTER INDEX

Clause *XMLIndex_parameter_clause* can be used with ALTER INDEX only at the table level, and only to add and remove paths.

Usage of PATHS Clause

The following considerations apply to using the PATHS clause.

- There can be at most one PATHS clause in a CREATE INDEX statement. That is, there can be at most one occurrence of PATHS followed by *create_index_paths_clause*.
- Clause *create_index_paths_clause* is used only with CREATE INDEX; *alter_index_paths_clause* is used only with ALTER INDEX.

Usage of create_index_paths_clause and alter_index_paths_clause

The following considerations apply to using *create_index_paths_clause* and *alter_index_paths_clause*.

- The INDEX_ALL_PATHS clause rebuilds the index with all paths included.
- An explicit list of paths to index can include wildcards and //.
- *XPaths_list* is a list of one or more XPath expressions, each of which includes only child axis, descendant axis, name test, and wildcard (*) constructs.
- If *XPaths_list* is omitted, then everything in all documents is indexed.
- For each unique namespace prefix that is used in an XPath expression in *XPaths_list*, a standard XML *namespace* declaration is needed, to provide the corresponding namespace information.
- You can change an index in ways that are not reflected directly in the syntax by dropping it and then creating it again as needed. For example, to change an index that was defined by including paths to one that is defined by excluding paths, drop it and then create it using EXCLUDE.

Usage of xml_index_value_clause

The following considerations apply to using *xml_index_value_clause*.

- Column VALUE is created as VARCHAR2(4000).
- If clause *xml_index_value_clause* consists only of the keyword VALUE, then the value index is created with the usual default attributes.
- If clause *path_id_clause* consists only of the keywords PATH ID, then the path-id index is created with the usual default attributes.
- If clause *order_key_clause* consists only of the keywords ORDER KEY, then the order-key index is created with the usual default attributes.

Usage of ASYNC Clause

The following considerations apply to using the ASYNC clause.

- ALWAYS means automatic synchronization occurs for each DML statement.
- MANUAL means no automatic synchronization occurs. You must manually synchronize the index using DBMS_XMLINDEX.SyncIndex.
- EVERY *repeat_interval* means automatically synchronize the index at interval *repeat_interval*. The syntax of *repeat_interval* is the same as that for PL/SQL package DBMS_SCHEDULER, and it must be enclosed in double-quotes ("). To use EVERY you must have the CREATE JOB privilege.
- ON COMMIT means synchronize the index immediately after a commit operation. The commit does not return until the synchronization is complete. Since the synchronization is performed as a separate transaction, there can be a short period when the data is committed but index changes are not yet committed.
- STALE is optional. A value of TRUE means that query results might be stale; a value of FALSE means that query results are always up-to-date. The default value, and the only permitted explicitly specified value, is as follows.
  - For ALWAYS, STALE is TRUE.
  - For any other ASYNC option besides ALWAYS, STALE is FALSE.

See Also:

- *Oracle Database SQL Language Reference* for the syntax of *index_attributes*
- *Oracle Database SQL Language Reference* for the syntax of *segment_attributes_clause*
- *Oracle Database SQL Language Reference* for the syntax of *table_properties*
- *Oracle Database SQL Language Reference* for the syntax of *parallel_clause*
- *Oracle Database SQL Language Reference* for additional information about the syntax and semantics of CREATE INDEX
- *Oracle Database SQL Language Reference* for additional information about the syntax and semantics of ALTER INDEX
- *Oracle Database PL/SQL Packages and Types Reference*, section "Calendaring Syntax", for the syntax of *repeat_interval*

Oracle Text Indexes on XML Data

You can create an Oracle Text index on an XMLType column. An Oracle Text CONTEXT index enables SQL function contains for full-text search over XML. With structured storage, XPath rewrite can often rewrite XPath function ora:contains to SQL function contains, so in those cases too an Oracle Text index can be employed.

See Also: Chapter 11, "Full-Text Search Over XML Data" for more information about using Oracle Text operations with Oracle XML DB

Creating and Using Oracle Text Indexes

To create an Oracle Text index, use CREATE INDEX, specifying the INDEXTYPE as CTXSYS.CONTEXT, as illustrated in Example 5–38.

Example 5–38 Creating an Oracle Text Index

```
CREATE INDEX po_otext_ix ON po_clob (OBJECT_VALUE) INDEXTYPE IS CTXSYS.CONTEXT;

Index created.
```

You can also perform Oracle Text operations such as contains and score on XMLType columns. Example 5–39 shows an Oracle Text search using SQL function contains.

Example 5–39 Searching XML Data Using SQL Function CONTAINS

```
SELECT DISTINCT extractValue(OBJECT_VALUE,
                             '/PurchaseOrder/ShippingInstructions/address') "Address"
  FROM po_clob
  WHERE contains(OBJECT_VALUE,
                 '$(Fortieth) INPATH (PurchaseOrder/ShippingInstructions/address)') > 0;

Address
------------------------------
1200 East Forty Seventh Avenue
New York
```

```
NY
10024
USA

1 row selected.
```

The explain plan for this query shows, in two ways, that the Oracle Text `CONTEXT` index is used: it references the index explicitly, as a domain index, and it refers to SQL function `contains` in the predicate information.

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 274475732

-------------------------------------------------------------------------------------------
| Id  | Operation                     | Name        | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |             |     7 | 14098 |    10  (10)| 00:00:01 |
|   1 |  HASH UNIQUE                  |             |     7 | 14098 |    10  (10)| 00:00:01 |
|   2 |   TABLE ACCESS BY INDEX ROWID| PO_CLOB     |     7 | 14098 |     9   (0)| 00:00:01 |
|*  3 |    DOMAIN INDEX               | PO_OTEXT_IX |       |       |     4   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   3 - access("CTXSYS"."CONTAINS"(SYS_MAKEXML('2B0A2483AB140B35E040578C8A173FEC',523
              3,"XMLDATA"),'$(Fortieth) INPATH (PurchaseOrder/ShippingInstructions/address)')>0)

20 rows selected.
```

Oracle Text Indexes Are Used Independently of Other Indexes

Oracle Text indexing is completely orthogonal to the other types of indexing described in this chapter. Whenever SQL function `contains` or XPath function `ora:contains` is used, an Oracle Text index can be used for full-text search.

Example 5–40 demonstrates this in the case where both an `XMLIndex` index and an Oracle Text index are defined on the same XML data. The query is the same as in Example 5–39. The Oracle Text index is created on the `VALUE` column of the `XMLIndex` path table of Example 5–14.

Example 5–40 Using an Oracle Text Index and an XMLIndex Index

```
CREATE INDEX po_otext_ix ON my_path_table (VALUE) INDEXTYPE IS CTXSYS.CONTEXT;

Index created.

EXPLAIN PLAN FOR
  SELECT DISTINCT extractValue(OBJECT_VALUE, '/PurchaseOrder/ShippingInstructions/address') "Address"
    FROM po_clob
    WHERE contains(OBJECT_VALUE, '$(Fortieth) INPATH (PurchaseOrder/ShippingInstructions/address)') > 0;

Explained.

--
SET ECHO OFF;

PLAN_TABLE_OUTPUT
-----------------------------------------------------------------------------------------------------------
Plan hash value: 2664483039
```

```
-----------------------------------------------------------------------------------------------------------
| Id  | Operation                    | Name                           | Rows  | Bytes | Cost (%CPU)| Time     |
-----------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                                |     1 |  2014 |     3  (34)| 00:00:01 |
|*  1 |  TABLE ACCESS BY INDEX ROWID| MY_PATH_TABLE                  |     1 |  3524 |     1   (0)| 00:00:01 |
|*  2 |   INDEX RANGE SCAN           | SYS78942_PO_XMLINDE_ORDKEY_IX |     1 |       |     2   (0)| 00:00:01 |
|   3 |  HASH UNIQUE                 |                                |     1 |  2014 |     3  (34)| 00:00:01 |
|*  4 |   TABLE ACCESS FULL          | PO_CLOB                        |     1 |  2014 |     2   (0)| 00:00:01 |
-----------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   1 - filter("SYS_P0"."PATHID"=HEXTORAW('35EF580A')  AND SYS_XMLI_LOC_ISNODE("SYS_P0"."LOCATOR")=1)
   2 - access("SYS_P0"."RID"=:B1)
       filter("SYS_P0"."RID"=:B1)
   4 - filter("CTXSYS"."CONTAINS"(SYS_MAKEXML("PO_CLOB"."XMLDATA"),'$(Fortieth) INPATH
              (PurchaseOrder/ShippingInstructions/address)')>0)

Note
-----
   - dynamic sampling used for this statement

24 rows selected.
```

The explain plan in Example 5–40 references both the `XMLIndex` index and the Oracle Text index, indicating that both are used.

- The `XMLIndex` index is indicated by its path table, `MY_PATH_TABLE`, and its order-key index, `SYS78942_PO_XMLINDE_ORDKEY_IX`.
- The Oracle Text index is indicated by the reference to SQL function `contains` in the predicate information.

6

XML Schema Storage and Query: Basic

The XML Schema Recommendation was created by the World Wide Web Consortium (W3C) to describe the content and structure of XML documents in XML. It includes the full capabilities of Document Type Definitions (DTDs) so that existing DTDs can be converted to XML Schema. XML schemas have additional capabilities compared to DTDs.

This chapter provides basic information about using XML Schema with Oracle XML DB. It explains how to do the following:

- Register, update, and delete an XML schema
- Create storage structures for XML schema-based data
- Map XML Schema data types to SQL data types and binary XML encoding types

This chapter contains these topics:

See Also:

- Chapter 8, "XML Schema Storage and Query: Advanced" for more advanced information about using XML Schema with Oracle XML DB
- Chapter 7, "XPath Rewrite" for information about the optimization of XPath expressions in Oracle XML DB
- `http://www.w3.org/TR/xmlschema-0/` for an introduction to XML Schema

Overview of XML Schema and Oracle XML DB

XML Schema is a schema definition language written in XML. It can be used to describe the structure and various other semantics of conforming instance documents. For example, the following XML schema definition, `purchaseOrder.xsd`, describes the structure and other properties of purchase-order XML documents.

This manual refers to an XML schema instance definition as an **XML schema**.

Example 6–1 XML Schema Instance purchaseOrder.xsd

The following is an XML schema that declares a `complexType` called `purchaseOrderType` and a global element `PurchaseOrder` of this type. This is the same schema as Example 3–7, "Purchase-Order XML Schema, purchaseOrder.xsd", with the exception of the lines in **`bold`** here, which are additional. For brevity, part of the schema is omitted here (marked **`...`**).

```
<xs:schema
  targetNamespace="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  xmlns:po="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  xmlns:xs="http://www.w3.org/2001/XMLSchema" version="1.0">
  <xs:element name="PurchaseOrder" type="po:PurchaseOrderType"/>
   <xs:complexType name="PurchaseOrderType">
    <xs:sequence>
        <xs:element name="Reference" type="po:ReferenceType"/>
        <xs:element name="Actions" type="po:ActionsType"/>
        <xs:element name="Reject" type="po:RejectionType" minOccurs="0"/>
        <xs:element name="Requestor" type="po:RequestorType"/>
        <xs:element name="User" type="po:UserType"/>
        <xs:element name="CostCenter" type="po:CostCenterType"/>
        <xs:element name="ShippingInstructions"
                    type="po:ShippingInstructionsType"/>
        <xs:element name="SpecialInstructions"
                    type="po:SpecialInstructionsType"/>
        <xs:element name="LineItems" type="po:LineItemsType"/>
        <xs:element name="Notes" type="po:NotesType"/>
      </xs:sequence>
    </xs:complexType>
    <xs:complexType name="LineItemsType">
      <xs:sequence>
        <xs:element name="LineItem" type="po:LineItemType"
                    maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>

    ...

    <xs:simpleType name="DescriptionType">
```

```
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

Example 6–2 purchaseOrder.xml: Document That Conforms to purchaseOrder.xsd

The following is an example of an XML document that conforms to XML schema `purchaseOrder.xsd`:

```
<po:PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:po="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  xsi:schemaLocation=
    "http://xmlns.oracle.com/xdb/documentation/purchaseOrder
     http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd">
  <Reference>SBELL-20021009123336O1PDT</Reference>
  <Actions>
    <Action>
      <User>SVOLLMAN</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Sarah J. Bell</Requestor>
  <User>SBELL</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Sarah J. Bell</name>
    <address>400 Oracle Parkway
             Redwood Shores
             CA
             94065
             USA
    </address>
    <telephone>650 506 7400</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Air Mail</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>A Night to Remember</Description>
      <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="2">
      <Description>The Unbearable Lightness Of Being</Description>
      <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
    </LineItem>
    <LineItem ItemNumber="3">
      <Description>Sisters</Description>
      <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
    </LineItem>
  </LineItems>
  <Notes>Section 1.10.32 of &quot;de Finibus Bonorum et Malorum&quot;,
         written by Cicero in 45 BC
```

```
&quot;Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium
 doloremque laudantium, totam rem aperiam, eaque ips
...
tiae consequatur, vel illum qui dolorem eum fugiat quo voluptas nulla
 pariatur?&quot;

1914 translation by H. Rackham

&quot;But I must explain to you how all this mistaken idea of denouncing
 pleasure and praising pain was born and I will give you a c
...
o avoids a pain that produces no resultant pleasure?&quot;

Section 1.10.33 of &quot;de Finibus Bonorum et Malorum&quot;, written by Cicero
in 45 BC

&quot;At vero eos et accusamus et iusto odio dignissimos ducimus qui blanditiis
 praesentium voluptatum deleniti atque corrupti quos
...
 delectus, ut aut reiciendis voluptatibus maiores alias
consequatur aut perferendis doloribus asperiores repellat.&quot;

1914 translation by H. Rackham

&quot;On the other hand, we denounce with righteous indignation and dislike men
 who are so beguiled and demoralized by the charms of
...
secure other greater pleasures, or else he endures pains to avoid worse
 pains.&quot;
  </Notes>
</po:PurchaseOrder>
```

Note: The URL used is a name that uniquely identifies the registered XML schema within the database: `http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd`. This need not point to a location where the XML schema document is located. The target namespace of the XML schema is another URL, different from the XML schema location URL, which specifies an abstract namespace within which elements and types get declared.

An XML schema can optionally specify the target namespace URL. If this attribute is omitted, the XML schema has no target namespace. The target namespace is commonly the same as the URL of the XML schema.

An XML instance document must specify the namespace of the root element (same as the target namespace of the XML schema) and the location (URL) of the XML schema that defines this root element. The location is specified with attribute `xsi:schemaLocation`. When the XML schema has no target namespace, use attribute `xsi:noNamespaceSchemaLocation` to specify the schema URL.

Using Oracle XML DB With XML Schema

Oracle XML DB exploits the strong typing and other powerful properties of XML Schema to process XML database data safely and efficiently.

> **Note:** With XML data that is stored using binary XML storage, you can use a DTD to obtain the XML entities defined there. However, the structural and type information in the DTD is not used by Oracle XML DB; the entities are the only information used.

Oracle XML DB uses annotated XML schemas as metadata. The standard XML Schema definitions are used, along with several Oracle XML DB-defined attributes. These attributes determine how XML instance documents get mapped to the database. Because these attributes are in a different namespace from the XML Schema namespace, such annotated XML schemas are still legal XML Schema documents.

> **See Also:** `http://www.w3.org/2001/XMLSchema`

When using Oracle XML DB with XML Schema, you must first *register* the XML schema. You can then use the XML schema URLs while creating `XMLType` tables, columns, and views. The XML schema URL identifies the XML schema in the database. It is associated with parameter `schemaurl` of PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema`.

Oracle XML DB provides XML Schema support for the following tasks:

- Registering a W3C-compliant XML schemas, both local and global.
- Validating your XML documents against registered XML schema definitions.
- Generating XML schemas from SQL object types.
- Referencing an XML schema owned by another user.
- Explicitly referencing a global XML schema when a local XML schema exists with the same name.
- Generating a database mapping from your XML schemas during XML schema registration. This includes generating SQL object types, collection types, and default tables, and capturing the mapping information using XML schema attributes.
- Specifying a particular SQL data type mapping when there are multiple allowed mappings.
- Creating `XMLType` tables, views, and columns based on registered XML schemas.
- Manipulating and querying XML schema-based `XMLType` tables.
- Automatically inserting data into default tables when XML schema-based documents are inserted into Oracle XML DB Repository using protocols (FTP, HTTP(S)/WebDAV) and languages besides SQL.

> **See Also:** Chapter 3, "Using Oracle XML DB"

Why XML Schema?

`XMLType` is an abstract data type that facilitates storing XML data in database columns and tables. XML Schema offers you additional storage and access options for XML data. You can use XML schemas to define which XML elements and attributes, which kinds of element nesting, and which data types can be used.

XML Schema lets you verify that your XML data conforms to its intended definition: the data is validated against the XML schemas that define its proper structure. This definition includes data types, numbers of allowed item occurrences, and allowed

lengths of items. When storing XML Schema-based documents in Oracle XML DB using protocols such as FTP or HTTP(S), the XML schema information can improve the efficiency of document insertion. When XML instances must be handled without any prior information about them, XML schemas can be useful in predicting optimum storage, fidelity, and access.

If your XML data is highly structured, then you might want to store it object-relationally. In that case, XML Schema is used to efficiently map XML (Schema) data types to SQL data types and object-relational tables and columns. You can take advantage of the strong typing and other advantages of XML Schema for unstructured or semi-structured XML data, as well as for structured data, by storing the data as binary XML.

DTD Support in Oracle XML DB

A **DTD** is a set of rules that define the allowable structure of an XML document. DTDs are text files that derive their format from SGML and can be associated with an XML document either by using the `DOCTYPE` element or by using an external file through a `DOCTYPE` reference. In addition to supporting XML Schema, which provides a structured mapping to object-relational storage or binary XML storage, Oracle XML DB also supports DTD specifications in XML instance documents. Though DTDs are not used to derive the mapping, XML processors can still access and interpret the DTDs.

Inline DTD Definitions

When an XML instance document has an inline DTD definition, it is used during document parsing. Any DTD validations and entity declaration handling is done at this point. However, once parsed, the entity references are replaced with actual values and the original entity reference is lost.

External DTD Definitions

Oracle XML DB also supports external DTD definitions if they are stored in Oracle XML DB Repository. Applications needing to process an XML document containing an external DTD definition such as `/public/flights.dtd`, must first ensure that the DTD document is stored in Oracle XML DB at path `/public/flights.xsd`.

> **See Also:** Chapter 21, "Accessing Oracle XML DB Repository Data"

Managing XML Schemas with DBMS_XMLSCHEMA

Before an XML schema can be used by Oracle XML DB, it must be registered with Oracle Database. You register an XML schema using the PL/SQL package `DBMS_XMLSCHEMA`.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference*

Some of the main `DBMS_XMLSCHEMA` procedures are these:

- `registerSchema` – register an XML schema with Oracle Database
- `deleteSchema` – delete a previously registered XML schema.
- `copyEvolve` – update a registered XML schema; see Chapter 9, "XML Schema Evolution".

Registering an XML Schema

The main arguments to procedure DBMS_XMLSCHEMA.registerSchema are these:

- SCHEMAURL – the XML schema URL. This is a unique identifier for the XML schema within Oracle XML DB. It is conventionally in the form of a URL; however, this is not a requirement. The XML schema URL is used with Oracle XML DB to identify instance documents, by making the schema location hint identical to the XML schema URL. Oracle XML DB will never attempt to access the Web server identified by the specified URL.
- SCHEMADOC – the XML schema source document. This is a VARCHAR, CLOB, BLOB, BFILE, XMLType, or URIType value.
- CSID – the character-set ID of the source-document encoding, when schemaDoc is a BFILE or BLOB value.
- OPTIONS – options to specify how the schema should be registered. The most important option is REGISTER_BINARYXML, which indicates that the XML schema will be used for binary XML storage. Other options include REGISTER_AUTO_OOL and REGISTER_NT_AS_IOT.

> **Note:** If you specify option REGISTER_BINARYXML, then you must also set parameter GENTYPES to FALSE.

Example 6–3 Registering an XML Schema with DBMS_XMLSCHEMA.REGISTERSCHEMA

The following code registers the XML schema at URL http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd. This example shows how to register an XML schema using the BFILE mechanism to read the source document from a file on the local file system of the database server.

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR','purchaseOrder.xsd'),
    CSID => nls_charset_id('AL32UTF8'));
END;
/
```

Delete and Reload Documents, Before Registering an XML Schema They Reference

When you register an XML schema, keep in mind that the act of registering a schema has *no effect* on the status of any instance documents already loaded into Oracle XML DB Repository that reference the XML schema. Because the XML schema was not yet registered, such instance documents were non-schema-based when they were loaded. *They remain non-schema-based after the schema is registered*.

You must *delete* such instance documents, and *reload* them after registering the schema, in order to obtain schema-based documents.

Storage and Access Infrastructure

As part of registering an XML schema, Oracle XML DB also performs several tasks that facilitate storing, accessing, and manipulating XML instances that conform to the XML schema. These steps include:

- Mapping XML Schema data types to Oracle XML DB storage. When XML schema-based data is stored, its storage data types are derived from the XML

Schema data types using a default mapping and, optionally, using mapping information that you specify using XML schema annotations. For binary XML storage, XML Schema types are mapped to binary XML encoding types. For object-relational storage, XML schema registration creates the appropriate SQL object types for the structured storage of conforming documents.

- Creating default tables. XML schema registration generates default `XMLType` tables for all global elements. You can use XML-schema annotations to control the names of the tables, and to provide column-level and table-level storage clauses and constraints for use during table creation.

  See Also:

  - "Mapping XML Schema Data Types to Oracle XML DB Storage" on page 6-41
  - "Default Tables Created During XML Schema Registration" on page 6-10
  - "Oracle XML Schema Annotations" on page 6-33

After XML schema registration, documents that reference the XML schema using the XML Schema instance mechanism can be processed automatically by Oracle XML DB. For XML data that is stored object-relationally, `XMLType` tables and columns can be created that are constrained to the global elements defined by the XML schema.

See Also: Chapter 3, "Using Oracle XML DB"

Atomic Nature of XML Schema Registration

Like all DDL operations, XML schema registration is non-transactional. However, registration is *atomic*, in this sense:

- If registration succeeds, then the operation is auto-committed.
- If registration fails, then the database is rolled back to the state before registration began.

Because XML schema registration potentially involves creating object types and tables, error recovery involves dropping any types and tables thus created. The entire XML schema registration process is guaranteed to be atomic: either it succeeds or the database is restored to its state before the start of registration.

Managing and Storing XML Schemas

XML schema documents are themselves stored in Oracle XML DB as `XMLType` instances. XML schema-related `XMLType` types and tables are created as part of the Oracle XML DB installation script, `catxdbs.sql`.

The XML schema for XML schemas is called the **root XML Schema**, `XDBSchema.xsd`. The root XML schema describes any valid XML schema that can be registered with Oracle XML DB. You can access `XDBSchema.xsd` at Oracle XML DB Repository location `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd`.

See Also: Chapter 34, "Administering Oracle XML DB"

Debugging XML Schema Registration for XML Data Stored Object-Relationally

For XML data stored object-relationally, you can monitor the object types and tables created during XML schema registration by setting the following event before calling `DBMS_XMLSCHEMA.registerSchema`:

```
ALTER SESSION SET EVENTS = '31098 trace name context forever'
```

Setting this event causes the generation of a log of all of the `CREATE TYPE` and `CREATE TABLE` statements. This log is written to the user session trace file, typically found in `ORACLE_BASE/diag/rdbms/ORACLE_SID/ORACLE_SID/udump`. This script can be a useful aid in diagnosing problems during XML schema registration.

See Also: "Using XML Schema with Oracle XML DB" on page 3-17

SQL Object Types Created During XML Schema Registration, for Structured Storage

If parameter `GENTYPES` is `TRUE` when an XML schema is registered for use with XML data stored object-relationally, then Oracle XML DB creates the appropriate SQL object types that enable structured storage of conforming XML documents. By default, all SQL object types are created in the database schema of the user who registers the XML schema. If the `defaultSchema` annotation is used, then Oracle XML DB attempts to create the object type using the specified database schema. The current user must have the necessary privileges to create these object types.

Example 6–4 shows the SQL object types that are created automatically when XML schema `purchaseOrder.xsd` is registered with Oracle XML DB.

Example 6–4 Creating SQL Object Types to Store XMLType Tables

```
DESCRIBE "PurchaseOrderType1668_T"

"PurchaseOrderType1668_T" is NOT FINAL
Name                 Null?  Type
-------------------- ------ --------------------------------
SYS_XDBPD$                  XDB.XDB$RAW_LIST_T
Reference                   VARCHAR2(30 CHAR)
Actions                     ActionsType1661_T
Reject                      RejectionType1660_T
Requestor                   VARCHAR2(128 CHAR)
User                        VARCHAR2(10 CHAR)
CostCenter                  VARCHAR2(4 CHAR)
ShippingInstructions        ShippingInstructionsTyp1659_T
SpecialInstructions         VARCHAR2(2048 CHAR)
LineItems                   LineItemsType1666_T
Notes                       VARCHAR2(4000 CHAR)

DESCRIBE "LineItemsType1666_T"

"LineItemsType1666_T" is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
LineItem                   LineItem1667_COLL

DESCRIBE "LineItem1667_COLL"

"LineItem1667_COLL" VARRAY(2147483647) OF LineItemType1665_T
"LineItemType1665_T" is NOT FINAL
```

```
Name                 Null? Type
-------------------- ----- --------------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
ItemNumber                 NUMBER(38)
Description                VARCHAR2(256 CHAR)
Part                       PartType1664_T
```

Note: By default, the names of the SQL object types and attributes are system-generated. This is the case in Example 6–4. If the XML schema does not contain attribute `SQLName`, then the SQL name is derived from the XML name. You can use XML schema annotations to provide user-defined names (see "Oracle XML Schema Annotations" for details).

Default Tables Created During XML Schema Registration

As part of XML schema registration for XML data, you can create default tables. Default tables are most useful when documents conforming to the XML schema are inserted through APIs and protocols such as FTP and HTTP(S) that do not provide any table specification. In such cases, the XML instance is inserted into the default table.

Example 6–5 Default Table for Global Element PurchaseOrder

```
DESCRIBE "purchaseorder1669_tab"

Name                          Null? Type
----------------------------- ----- -----------------------
TABLE of
  SYS.XMLTYPE(
    XMLSchema "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
    Element "PurchaseOrder")
  STORAGE OBJECT-RELATIONAL TYPE "PurchaseOrderType1668_T"
```

If you provide a value for attribute `defaultTable`, then the `XMLType` table is created with that name. Otherwise it is created with an internally generated name.

Any text specified using the `tableProps` and `columnProps` attributes is appended to the generated `CREATE TABLE` statement.

Generated Names are Case Sensitive

The names of any SQL tables, object, and attributes generated by XML schema registration are *case sensitive*. For instance, in Example 6–3 on page 6-7, a table named `PurchaseOrder1669_TAB` is created automatically during registration of the XML schema. Since this table name was derived from the element name, `PurchaseOrder`, the table name is also mixed case. This means that you must refer to this table in SQL code by using a quoted identifier: `"PurchaseOrder1669_TAB"`. Failure to do so results in an object-not-found error, such as `ORA-00942: table or view does not exist`.

Database Objects That Depend on Registered XML Schemas

The following database objects are dependent on registered XML schemas:

- Tables or views that have an `XMLType` column that conforms to an element in an XML schema.

- Other XML schemas that include or import a given XML schema as part of their definition.
- Cursors that reference an XML schema. This includes references within functions of package DBMS_XMLGEN. Such cursors are purely transient objects.

Listing All Registered XML Schemas

Example 6–6 shows how to use DBMS_XMLSCHEMA.registerSchema to obtain a list of all XML schemas registered with Oracle XML DB. You can also examine USER_XML_SCHEMAS, ALL_XML_SCHEMAS, USER_XML_TABLES, and ALL_XML_TABLES.

Example 6–6 Data Dictionary Table for Registered Schemas

```
DESCRIBE DBA_XML_SCHEMAS

Name          Null? Type
------------- ----- -----------------------
OWNER               VARCHAR2(30)
SCHEMA_URL          VARCHAR2(700)
LOCAL               VARCHAR2(3)
SCHEMA              XMLTYPE(XMLSchema "http://xmlns.oracle.com/xdb/XDBSchema.xsd"
                            Element "schema")
INT_OBJNAME         VARCHAR2(4000)
QUAL_SCHEMA_URL     VARCHAR2(767)
HIER_TYPE           VARCHAR2(11)
BINARY              VARCHAR2(3)
SCHEMA_ID           RAW(16)
HIDDEN              VARCHAR2(3)

SELECT OWNER, LOCAL, SCHEMA_URL FROM DBA_XML_SCHEMAS;

OWNER   LOC   SCHEMA_URL
-----   ---   ----------------------
XDB     NO    http://xmlns.oracle.com/xdb/XDBSchema.xsd
XDB     NO    http://xmlns.oracle.com/xdb/XDBResource.xsd
XDB     NO    http://xmlns.oracle.com/xdb/acl.xsd
XDB     NO    http://xmlns.oracle.com/xdb/dav.xsd
XDB     NO    http://xmlns.oracle.com/xdb/XDBStandard.xsd
XDB     NO    http://xmlns.oracle.com/xdb/log/xdblog.xsd
XDB     NO    http://xmlns.oracle.com/xdb/log/ftplog.xsd
XDB     NO    http://xmlns.oracle.com/xdb/log/httplog.xsd
XDB     NO    http://www.w3.org/2001/xml.xsd
XDB     NO    http://xmlns.oracle.com/xdb/XDBFolderListing.xsd
XDB     NO    http://xmlns.oracle.com/xdb/stats.xsd
XDB     NO    http://xmlns.oracle.com/xdb/xdbconfig.xsd
SCOTT   YES   http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd

13 rows selected.

DESCRIBE DBA_XML_TABLES

Name          Null? Type
------------- ----- -----------------------
OWNER               VARCHAR2(30)
TABLE_NAME          VARCHAR2(30)
XMLSCHEMA           VARCHAR2(700)
SCHEMA_OWNER        VARCHAR2(30)
ELEMENT_NAME        VARCHAR2(2000)
STORAGE_TYPE        VARCHAR2(17)
```

```
ANYSCHEMA           VARCHAR2(3)
NONSCHEMA           VARCHAR2(3)

SELECT TABLE_NAME FROM DBA_XML_TABLES
  WHERE XMLSCHEMA = 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd';

TABLE_NAME
----------------------
PurchaseOrder1669_TAB

1 row selected.
```

Deleting an XML Schema

You can delete a registered XML schema by using procedure `DBMS_XMLSCHEMA.deleteSchema`. This does the following, by default:

1. Checks that the current user has the appropriate privileges to delete the resource corresponding to the XML schema within Oracle XML DB Repository. You can control which users can delete which XML schemas, by setting the appropriate ACLs on the XML schema resources.
2. Checks whether there are any tables dependent on the XML schema to be deleted. If so, raises an error and cancels the deletion. This check is not performed if option `delete_invalidate` or `delete_cascade_force` is used; in that case, no error is raised.
3. Removes the XML schema document from the Oracle XML DB Repository (folder `/sys/schemas`).
4. Removes the XML schema document from `DBA_XML_SCHEMAS`, unless it was registered for use with binary XML instances and neither `delete_invalidate` nor `delete_cascade_force` is used.
5. Drops the default table, if either `delete_cascade` or `delete_cascade_force` is used. Raises an error if `delete_cascade_force` is specified and there are instances in other tables that are also dependent on the XML schema.

DBMS_XMLSCHEMA.DELETESCHEMA Options

The following values are available for option `DELETE_OPTION` of procedure `DBMS_XMLSCHEMA.deleteSchema`:

- `DELETE_RESTRICT` – Raise an error and cancel deletion if dependencies are detected. This is the default behavior.
- `DELETE_INVALIDATE` – Do not raise an error if dependencies are detected. Instead, mark each of the dependencies as being invalid. If the XML schema was registered for use with binary XML, do not remove it from `DBA_XMLSCHEMAS`.
- `DELETE_CASCADE` – Drop all types and default tables that were generated during XML schema registration. Raise an error if there are instances that depend upon the XML schema that are stored in tables other than the default table. However, do not raise an error for any such instances that are stored in `XMLType` columns that were created using `ANY_SCHEMA`. If the XML schema was registered for use with binary XML, do not remove it from `DBA_XMLSCHEMAS`.
- `DELETE_CASCADE_FORCE` – Drop all types and default tables that were generated during XML schema registration. Do not raise an error if there are instances that depend upon the XML schema that are stored in tables other than the default

table. Instead, mark each of the dependencies as being invalid. Remove the XML schema from DBA_XMLSCHEMAS.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Example 6–7 illustrates the use of DELETE_CASCADE_FORCE.

Example 6–7 Deleting an XML Schema with DBMS_XMLSCHEMA.DELETESCHEMA

```
BEGIN
  DBMS_XMLSCHEMA.deleteSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    DELETE_OPTION => DBMS_XMLSCHEMA.DELETE_CASCADE_FORCE);
END;
/
```

If an XML schema was registered for use with binary XML, it is not removed from DBA_XMLSCHEMAS when you delete it using option DELETE_RESTRICT (the default value) or DELETE_CASCADE. As a consequence, although you can no longer use the XML schema to encode new XML instance documents, any existing documents in Oracle XML DB that reference the XML schema can still be *decoded* using it.

This remains the case, until you remove the XML schema from DBA_XMLSCHEMAS using DBMS_XMLSCHEMA.**purgeSchema**. Oracle recommends that, in general, you use delete_restrict or delete_cascade. Instead of using DELETE_CASCADE_FORCE, call DBMS_XMLSCHEMA.purgeSchema when you are sure you no longer need the XML schema.

Procedure purgeSchema removes the XML schema completely from Oracle XML DB; in particular, it removes it from DBA_XMLSCHEMAS. Before you use DBMS_XMLSCHEMA.purgeSchema, be sure that you have transformed all existing XML documents that reference the XML schema to be purged, so they reference a different XML schema or no XML schema. Otherwise, it will be impossible to decode them after the purge.

XMLType Methods Related to XML Schema

Table 6–1 lists some XMLType methods that are useful for working with XML schemas.

Table 6–1 XMLType Methods Related to XML Schema

XMLType Method	Description
isSchemaBased()	Returns TRUE if the XMLType instance is based on an XML schema, FALSE otherwise.
getSchemaURL() getRootElement() getNamespace()	The XML schema URL, root-element name, and namespace, respectively, for an XMLType instance. Method getRootElement() can be used with non-schema-based data, as well as with XML schema-based data. Note that, in spite of its name, getRootElement() does not return the root element; it returns the element *name*.
schemaValidate() isSchemaValid() isSchemaValidated() setSchemaValidated()	Validate an XMLType instance against a registered XML schema. See Chapter 10, "Transforming and Validating XMLType Data".

Local and Global XML Schemas

XML schemas can be registered as local or global:

- A local xml schema is, by default, visible only to its owner.
- A global xml schema is, by default, visible and usable by all database users.

When you register an XML schema, PL/SQL package `DBMS_XMLSCHEMA` adds a corresponding resource to Oracle XML DB Repository. The XML schema URL determines the path name of the XML schema resource in the repository (and it is associated with the `SCHEMAURL` parameter of `registerSchema`).

Note: In Oracle Enterprise Manager, local and global registered XML schemas are referred to as **private** and **public**, respectively.

Local XML Schema

By default, an XML schema belongs to you after you register it with Oracle XML DB. A reference to the XML schema document is stored in Oracle XML DB Repository. Such XML schemas are referred to as **local**. By default, they are usable only by you, the owner. In Oracle XML DB, local XML schema resources are created under folder `/sys/schemas/`*`username`*. The rest of the repository path name is derived from the schema URL.

Example 6–8 Registering a Local XML Schema

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR','purchaseOrder.xsd'),
    LOCAL => TRUE,
    GENTYPES => TRUE,
    GENTABLES => FALSE,
    CSID => nls_charset_id('AL32UTF8'));
END;
/
```

If this local XML schema is registered by user `QUINE`, it is given this path name:

```
/sys/schemas/QUINE/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd
```

Database users need appropriate permissions and Access Control Lists (ACLs) to create a resource with this path name, in order to register the XML schema as a local XML schema.

See Also: Chapter 27, "Repository Resource Security"

Note: Typically, only the owner of the XML schema can use it to define `XMLType` tables, columns, or views, validate documents, and so on. However, Oracle XML DB supports fully qualified XML schema URLs. For example: `http://xmlns.oracle.com/xdb/schemas/QUINE/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd`. Privileged users can use such an extended URL to specify XML schemas belonging to other users.

Global XML Schema

In contrast to local schemas, a privileged user can register an XML schema as global by specifying an argument in the DBMS_XMLSCHEMA registration function. **Global XML schemas** are visible to *all* users. They are stored under folder /sys/schemas/PUBLIC/ in Oracle XML DB Repository.

> **Note:** Access to folder /sys/schemas/PUBLIC is controlled by access control lists (ACLs). By default, this folder is writable only by a database administrator. You need write privileges on this folder to register global XML schemas. Role XDBADMIN provides write access to this folder, assuming that it is protected by the default ACLs. See Chapter 27, "Repository Resource Security".

You can register a local schema with the same URL as an existing global schema. A local schema always shadows (hides) any global schema with the same name (URL).

Example 6–9 Registering a Global XML Schema

```
GRANT XDBADMIN TO QUINE;

Grant succeeded.

CONNECT quine/curry

Connected.

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR','purchaseOrder.xsd'),
    LOCAL => FALSE,
    GENTYPES => TRUE,
    GENTABLES => FALSE,
    CSID => nls_charset_id('AL32UTF8'));
END;
/
```

If this global XML schema is registered by user QUINE, it is given this path name:

```
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd
```

Database users need appropriate permissions (ACLs) to create this resource in order to register the XML schema as global.

DOM Fidelity

Document Object Model (DOM) fidelity is the concept of retaining the structure of a retrieved XML document, compared to the original XML document, for DOM traversals. DOM fidelity is needed to ensure the accuracy and integrity of XML documents stored in Oracle XML DB.

See Also:

- "Overriding the SQLType Value in an XML Schema When Declaring Attributes" on page 6-44
- "Overriding the SQLType Value in an XML Schema When Declaring Elements" on page 6-45

What is DOM Fidelity?

DOM fidelity means that all information in an XML document is preserved, except whitespace that is insignificant. With DOM fidelity, XML data retrieved from the database has the same information as before it was inserted into the database, with the single exception of insignificant whitespace. The term "DOM fidelity" is used because this kind of fidelity is particularly important for DOM traversals.

With binary XML storage of XML data, all of the significant information is encoded in the binary XML format, ensuring DOM fidelity. With structured storage of XML data, the elements and attributes declared in an XML schema are mapped to separate attributes in the corresponding SQL object types. However, the following information in XML instance documents is not stored in these object attributes:

- Namespace declarations
- Comments
- Prefix information

Instead, Oracle XML DB uses a separate mechanism to keep track of this information; it is recorded as instance-level metadata.

SYS_XDBPD$ and DOM Fidelity for Structured Storage

In order to provide DOM fidelity for XML data stored object-relationally, Oracle XML DB maintains instance-level metadata. This metadata is tracked at a type level using the system-defined binary attribute `SYS_XDBPD$`. This object attribute is referred to as the **positional descriptor**, or **PD** for short. Attribute PD is intended for Oracle XML DB *internal use only*. You should never directly access or manipulate this column.

The positional descriptor attribute stores all information that cannot be stored in any of the other attributes. PD information is used to ensure the DOM fidelity of all XML documents stored in Oracle XML DB. Examples of such information include: ordering information, comments, processing instructions, and namespace prefixes.

If DOM fidelity is not required, you can suppress `SYS_XDBPD$` in the XML schema definition by setting the attribute `maintainDOM = "false"` at the type level.

Note: For clarity, the attribute `SYS_XDBPD$` is omitted in many examples in this book. However, it is always present as a positional descriptor (PD) column in all SQL object types generated by the XML schema registration process.

In general, it is not a good idea to suppress the PD attribute, because the extra information, such as comments and processing instructions, could be lost if there is no PD column.

XML Translations

You can store your security objects in Oracle XML DB Repository as `XMLType` instances. You can use any storage model for these instances: structured (object-relational storage), unstructured (`CLOB`), or binary XML. These security objects also contain some strings that need to be translated, which you can search for or display in various languages. The translations for these strings are also stored in the Oracle XML DB Repository, along with the original strings, because they must be associated with the original document. You can retrieve and operate on these strings, depending on your language settings.

Note: XML schemas stored object-relationally are not translatable.

Changing an XML Schema and XML Instance Documents for Translation

This section describes the changes that are required to be made to the XML schema and the XML instance document to make it translatable.

Indicating Translatable Elements in an XML Schema

Attribute `xdb:translate` must be specified in the XML schema for each element that needs to be translated. The following restrictions apply to attribute `xdb:translate`.

1. Attribute `xdb:translate` can be specified only on `complexType` elements that have `simpleContent`. Here, `simpleContent` must be an extension or a restriction of type `string`. However, if a `complexType` element has the `xdb:translate` flag set, then none of its descendants can have this flag set.
2. Attribute `xdb:translate` can be set only on a single-valued element; that is, elements that have exactly one translation. For these elements, the value of `maxoccurs` must be `0` or `1`. If you want to set this attribute on a multiple-valued element, the element must have an `ID` attribute, which uniquely identifies the element.

During XML schema registration, procedure `registerSchema` checks whether the XML schema satisfies these restrictions.

Indicating Translation Language Attributes in an XML Instance Document

The following translation language attributes are supported:

- `xml:lang`: For an instance document associated with an XML schema that supports translations, you must specify the translation language. You can do this by annotating each translation with attribute `xml:lang`. The allowed values of the `xml:lang` attribute are the language identifiers identified by IETF RFC 3066.
- `xdb:srclang`: For multiple-valued elements, that is, elements that can have multiple translations, only one translation can be used as the source language translation. That translation is specified by attribute `xdb:srclang`. This is the default translation, which is returned when the session language is not specified.

Making XML Documents Translatable

In this section, we use the translation-specifying XML schema attributes to make elements in a sample document translatable. Example 6–10 shows an XML schema that defines security class documents.

Example 6–10 XML Schema Defining Security-Class Documents

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
                <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
          </complexType>
        </element>
        <!-- this "any" contains all application specific information
             for a security class in general e.g. reason for creation  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="targetNamespace" type="anyURI" use="required"/>
      <!-- all privileges in this security class are under this target namespace -->
    </complexType>
  </element>
  <element name="aggregatePrivilege">
    <complexType>
      <sequence>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence maxOccurs="unbounded">
          <element name="privilegeRef">
            <complexType>
              <attribute name="name" type="QName" use="required"/>
            </complexType>
          </element>
          <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
        </sequence>
        <!-- this "any" contains all application specific information
             an aggregate privilege e.g. translations  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="name" type="string" use="required"/>
    </complexType>
  </element>
  <element name="privilege">
    <complexType>
      <sequence minOccurs="0">
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence minOccurs="0" maxOccurs="unbounded">
          <element name="columnRef">
            <complexType>
              <attribute name="schema" type="string" use="required"/>
```

```
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
 </element>
</schema>
```

Example 6–11 shows the security class document that is associated with the XML schema of Example 6–10.

Example 6–11 Security Class Document Associated With the XML Schema

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
  <privilege name="privilege1"/>
  <aggregatePrivilege name="iStorePOApprover">
    <title>
iStore Purchase Order Approver
    </title>
    <privilegeRef name="is:privilege1"/>
    <privilegeRef name="oa:submitPO"/>
    <privilegeRef name="oa:privilege3"/>
  </aggregatePrivilege>
  <privilege name="privilege2">
    <title>
secondary privilege
    </title>
    <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
    <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
  </privilege>
  </privlist>
</securityClass>
```

To make the security class or title translatable, set `xdb:translate` to `true`. This is a single-valued element, because as `xdb:maxOccurs` is `1`. Example 6–12 describes the new XML schema, where attribute `xdb:translate` is set to `true`.

Example 6–12 XML Schema With Attribute xdb:translate Set to True for a Single-Valued Element

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
```

```
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
<xs:import namespace="http://www.w3.org/XML/1998/namespace"
        schemaLocation="http://www.w3.org/2001/xml.xsd"/>
<xs:import namespace-"http://xmlns.oracle.com/xdb"
        schemaLocation="http://xmlns.oracle.com/xdb/xmltr.xsd"/>
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element ref="titleref" minOccurs="0" maxOccurs="unbounded"
                 xdb:maxOccurs="1" xdb:translate="true"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
              <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
          </complexType>
        </element>
        <!-- this "any" contains all application specific information
             for a security class in general e.g. reason for creation  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="targetNamespace" type="anyURI" use="required"/>
      <!-- all privileges in this security class are under this target namespace -->
    </complexType>
  </element>
  <element name="aggregatePrivilege">
    <complexType>
      <sequence>
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence maxOccurs="unbounded">
          <element name="privilegeRef">
            <complexType>
              <attribute name="name" type="QName" use="required"/>
            </complexType>
          </element>
          <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
        </sequence>
        <!-- this "any" contains all application specific information
             an aggregate privilege e.g. translations  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="name" type="string" use="required"/>
    </complexType>
  </element>
  <element name="privilege">
    <complexType>
      <sequence minOccurs="0">
        <element name="title" minOccurs="0" maxOccurs="unbounded"/>
        <sequence minOccurs="0" maxOccurs="unbounded">
          <element name="columnRef">
            <complexType>
```

```
            <attribute name="schema" type="string" use="required"/>
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
 </element>
 <element name="titleref">
   <complexType>
     <simpleContent>
       <extension base="xs:string">
         <attribute ref="xml:lang"/>
         <attribute ref="xdb:srclang"/>
       </extension>
     </simpleContent>
   </complexType>
 </element>
</schema>
```

Example 6–13 shows the security class document after the translation.

Example 6–13 Security Class Document After Translation

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps">
  <name>
securityClassExample
  </name>
  <title xml:lang="en" xdb:srclang="true">
Security Class Example
  </title>
  <title xml:lang="es">
Security Class Example - Spanish
  </title>
  <title xml:lang="fr">
Security Class Example - French
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
    <privilege name="privilege1"/>
    <aggregatePrivilege name="iStorePOApprover">
      <title>
iStore Purchase Order Approver
      </title>
      <privilegeRef name="is:privilege1"/>
      <privilegeRef name="oa:submitPO"/>
      <privilegeRef name="oa:privilege3"/>
    </aggregatePrivilege>
    <privilege name="privilege2">
      <title>
secondary privilege
      </title>
```

```
      <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
      <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
    </privilege>
  </privlist>
</securityClass>
```

To make the security class or title translatable in the case of a multi-valued element, set `xdb:maxOccurs` to `unbounded`. However, `xdb:translate` cannot be set to `true` for a multiple-valued element, unless there is an identifier attribute that uniquely identifies each element. Example 6–14 describes the new XML schema, where an identifier attribute, `id`, is set for the `title` element.

Example 6–14 XML Schema With Attribute xdb:translate Set to True for a Multi-Valued Element

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbsc="http://xmlns.oracle.com/xdb/security.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/security.xsd"
        elementFormDefault="qualified" version="1.0">
<xs:import namespace="http://www.w3.org/XML/1998/namespace"
        schemaLocation="http://www.w3.org/2001/xml.xsd"/>
<xs:import namespace-"http://xmlns.oracle.com/xdb"
        schemaLocation="http://xmlns.oracle.com/xdb/xmltr.xsd"/>
  <annotation>
    <documentation>
This XML schema describes the structure of Security Class documents.
    </documentation>
  </annotation>
  <element name="securityClass" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="name" type="string"/>
        <element name="title" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1"/>
        <element name="inherits-from" type="QName" minOccurs="0" maxOccurs="unbounded"/>
        <element name="privlist" minOccurs="0" maxOccurs="unbounded" xdb:maxOccurs="1">
          <complexType>
            <choice minOccurs="0" maxOccurs="unbounded">
              <element ref="xdbsc:privilege"/>
              <element ref="xdbsc:aggregatePrivilege"/>
            </choice>
          </complexType>
        </element>
        <!-- this "any" contains all application specific information
             for a security class in general e.g. reason for creation  -->
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <attribute name="targetNamespace" type="anyURI" use="required"/>
      <!-- all privileges in this security class are under this target namespace -->
    </complexType>
  </element>
  <element name="aggregatePrivilege">
    <complexType>
      <sequence>
        <element name="titleref" minOccurs="0" maxOccurs="unbounded"
                 xdb:maxoccurs="unbounded" xdb:translate="true"/>
        <sequence maxOccurs="unbounded">
          <element name="privilegeRef">
            <complexType>
              <attribute name="name" type="QName" use="required"/>
            </complexType>
```

```
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           an aggregate privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="privilege">
  <complexType>
    <sequence minOccurs="0">
      <element name="titleref" minOccurs="0" maxOccurs="unbounded"
               xdb:maxoccurs="unbounded" xdb:translate="true"/>
      <sequence minOccurs="0" maxOccurs="unbounded">
        <element name="columnRef">
          <complexType>
            <attribute name="schema" type="string" use="required"/>
            <attribute name="table" type="string" use="required"/>
            <attribute name="column" type="string" use="required"/>
          </complexType>
        </element>
        <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
      <!-- this "any" contains all application specific information
           for a privilege e.g. translations  -->
      <any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
    <attribute name="name" type="string" use="required"/>
  </complexType>
</element>
<element name="titleref">
  <complexType>
    <simpleContent>
      <extension base="xs:string">
        <attribute ref="xml:lang"/>
        <attribute ref="xdb:srclang"/>
        <attribute name="id" type="integer"/>
      </extension>
    </simpleContent>
  </complexType>
</element>
</schema>
```

Example 6–15 shows the security class document associated with the XML schema in Example 6–14.

Example 6–15 Security Class Document for an XML Schema With Multiple-Valued Elements

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
```

```
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
  <privlist>
    <privilege name="privilege1"/>
    <aggregatePrivilege name="iStorePOApprover">
      <title>
iStore Purchase Order Approver
      </title>
      <privilegeRef name="is:privilege1"/>
      <privilegeRef name="oa:submitPO"/>
      <privilegeRef name="oa:privilege3"/>
    </aggregatePrivilege>
    <privilege name="privilege2">
      <title id="2" xml:lang="en" xdb:srclang="true">
secondary privilege - english
      </title>
      <title id="1" xml:lang="fr">
primary privilege - french
      </title>
      <title id="1" xml:lang="en" xdb:srclang="true">
primary privilege - english
      </title>
      <columnRef schema="APPS" table="PurchaseOrder" column="POId"/>
      <columnRef schema="APPS" table="PurchaseOrder" column="Amount"/>
    </privilege>
  </privlist>
</securityClass>
```

Operations on Translated Documents

You can perform the following operations on translated documents:

- Insert: You can insert a document into Oracle XML DB, if it conforms to an XML schema that supports translations. For the document that contains translations, you can either provide the language information or use the session language translation.
  - When the document does not contain the language information and the `xml:lang` attribute is not set, the session language is used for translation. Example 6–16 describes a security class document with a session language in Japanese. Attribute `xml:lang` is set to `session language`, and attribute `xdb:srclang` is set to `true`.

Example 6–16 Inserting a Document With No Language Information

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title>
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

Example 6–17 shows the security class document after it is inserted in Oracle XML DB.

Example 6–17 Security Class Document After Insertion

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="jp" xdb:srclang="true">
Security Class Example
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

– When you provide the language information, you set attribute `xml:lang` by either explicitly marking a translation as `xdb:srclang=true` or using the session language translation in attribute `xdb:srclang`. If you do neither, then an arbitrary translation is picked, for which `xdb:srclang` is set to `true`.

  Example 6–18 describes a security class document with a session language of Japanese.

Example 6–18 Inserting a Document With Language Information

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="en">
Security Class Example
  </title>
  <title xml:lang="fr">
Security Class Example - FR
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

Example 6–19 shows the security class document after it is inserted in Oracle XML DB.

Example 6–19 Security Class Document After Insertion

```
<securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
               xmlns:is="xmlns.oracle.com/iStore"
               xmlns:oa="xmlns.oracle.com/OracleApps"
               targetNamespace="xmlns.oracle.com/example">
  <name>
securityClassExample
  </name>
  <title xml:lang="en" xdb:srclang="true">
Security Class Example
  </title>
  <title xml:lang="fr">
Security Class Example - FR
  </title>
  <inherits-from>is:iStorePurchaseOrder</inherits-from>
```

```
</securityClass>
```

- Query: If you query nodes that involve translated elements, the query displays the translation's default behavior. In order to specify that the translation's default behavior should be applied to the query result, you need to use the Oracle XPath function `ora:translate`. This is the syntax of the function:

  ```
  Nodeset translate(Nodeset parent, String childname, String childnsp)
  ```

  Function `ora:translate` returns a positive integer when the name of the parent node matches the name of the specified child node, and the `xml:lang` value is same as the session language or the language for which `xdb:srclang` is `true`. In this syntax description, `parent` is the parent node under which you want to search for the translated nodes, `childname` is the name of the child node, and `childnsp` is the namespace URL of the child node.

  When SQL functions such as `extract` and `extractValue` are applied to translated documents, they return the session language translation, if present, or the source language translation, otherwise. For example, this query using function `extract` returns the session language translation:

  ```
  SELECT extract(value(x), 'ora:translate(/securityClass, "title"),
                           'xmlns:ora="http://xmlns.oracle.com/xdb"')
    FROM some_table x;
  ```

  This is the output of that query:

  ```
  <title xml:lang="fr">
  Security Class Example - FR
  </title>
  ```

  To obtain the result in a particular language, specify it in the XPath expression.

  ```
  SELECT EXTRACT(value(x), '/securityClass/title[@xml:lang="en"]')
    FROM some_table x;
  ```

  This is the output of that query:

  ```
  <title xml:lang="en" xdb:srclang="true">
  Security Class Example
  </title>
  ```

  Because you can store translated documents only as text (`CLOB`) or binary XML, only functional evaluation and queries with a function-based index, an `XMLIndex` index, or a `CONTEXT` index are possible. For `XMLIndex` index and `CONTEXT` index queries, if the document has a session language translation, then that is returned, otherwise the source language translation is returned. However, for queries with a function-based index, you need to create an index with an explicit `xml:lang` predicate for every language for which you want to use the index.

  When you retrieve the complete document using SQL functions such as `getCLOBVal`, `getStringVal`, and `XDBURIType`, only the translations that match the session language translations are returned. For protocols, you can set your language preferences, and the document is returned in that language only.

  The following PL/SQL procedures and functions support XML translations:

  - `DBMS_XMLTRANSLATIONS.translateXML`: Translate a document to the specified language. If the specified language translation is present, it is returned, otherwise, the source language translation is returned.

For example, if you write `TRANSLATEXML (doc,'fr')` to specify French as the translation language for the Example 6–19, it returns the following code and ignores all other translations:

```
securityClass xmlns="http://xmlns.oracle.com/xdb/security.xsd"
              xmlns:is="xmlns.oracle.com/iStore"
              xmlns:oa="xmlns.oracle.com/OracleApps"
              targetNamespace="xmlns.oracle.com/example">
    <name>
        securityClassExample
    </name>
    <title xml:lang="fr">
        Security Class Example - FR
    </title>
    <inherits-from>is:iStorePurchaseOrder</inherits-from>
</securityClass>
```

- `DBMS_XMLTRANSLATIONS.enableTranslation`, `DBMS_XMLTRANSLATIONS.disableTranslation`: Enable or disable translations at session level. Queries will work on the base document if the translation is disabled and on the translated document if it is enabled.
- `DBMS_XMLTRANSLATIONS.getBaseDocument`: Returns the entire document, with all of the translations.

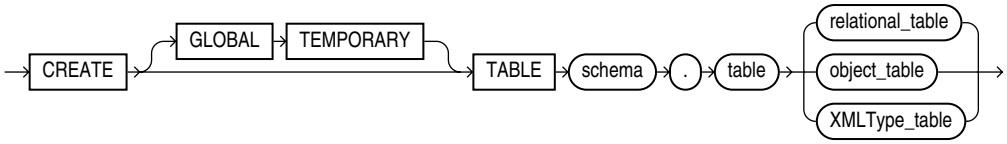
- Update: You can use SQL function `updateXML` to update the translated nodes. However, an error is raised if you try to update a translated node without specifying the translation language. The following PL/SQL procedures support update operations on translated documents:
  - `DBMS_XMLTRANSLATIONS.updateTranslation`: This function updates the translation at a specified `xpath` in a particular language. If the translation in a particular language is not present, then it is inserted.
  - `DBMS_XMLTRANSLATIONS.setSourceLang`: This procedure sets the source language at a specified xpath to the specified language.

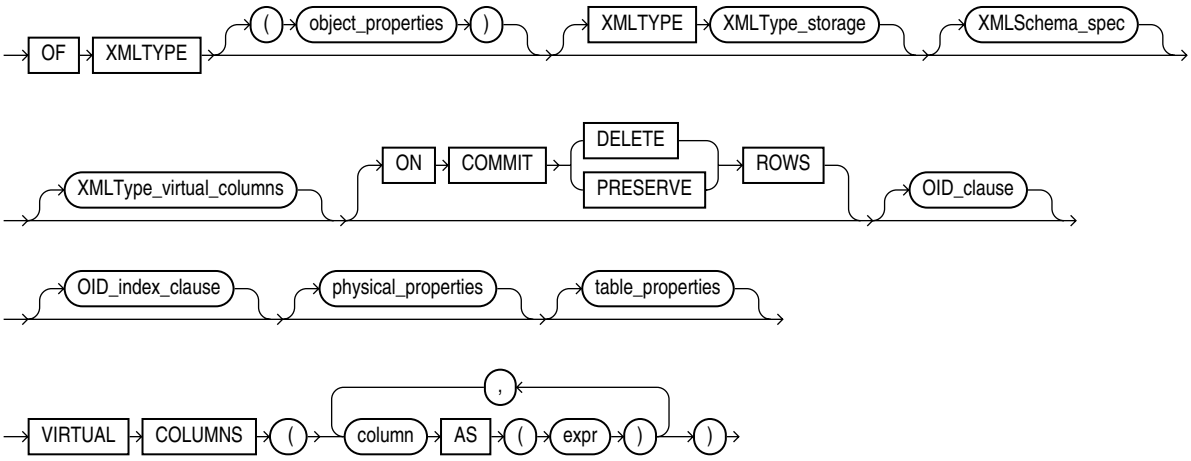
Creating XMLType Tables and Columns Based on XML Schema

Using Oracle XML DB, developers can create `XMLType` tables and columns that are constrained to a global element defined by a registered XML schema. After an `XMLType` column has been constrained to a particular element and a particular XML schema, it can contain only documents that are compliant with the schema definition of that element. You constrain an `XMLType` table column to a particular element and XML schema by adding appropriate `XMLSCHEMA` and `ELEMENT` clauses to the `CREATE TABLE` operation.

Figure 6–1 shows the syntax for creating an `XMLType` table:

Figure 6–1 Creating an XMLType Table





See Also: *Oracle Database SQL Language Reference* for the complete description of `CREATE TABLE`

A subset of the XPointer notation, shown in Example 6–20, can also be used to provide a single URL that contains the XML schema location and element name. See also Chapter 4, "XMLType Operations".

Example 6–20 Creating XML Schema-Based XMLType Tables and Columns

This example shows `CREATE TABLE` statements. The first creates `XMLType` table `purchaseorder_as_table`. The second creates relational table `purchaseorder_as_column`, which has `XMLType` column `xml_document`. In each table, the `XMLType` instance is constrained to the `PurchaseOrder` element that is defined by the XML schema registered with URL `http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd`.

```
CREATE TABLE purchaseorder_as_table OF XMLType
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder";

CREATE TABLE purchaseorder_as_column (id NUMBER, xml_document XMLType)
  XMLTYPE COLUMN xml_document
  ELEMENT
    "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder";
```

There are two ways to specify `XMLSchema` and `Element`:

- as separate clauses, `XMLSchema` and `Element`
- using only the `Element` clause with an XPointer notation

The data associated with an `XMLType` table or column that is constrained to an XML schema can be stored in different ways:

- Decomposed and stored object-relationally (structured storage)
- Stored as text, using a single `CLOB` column (unstructured storage)
- Stored as binary XML, using a single binary-XML column (binary XML storage)

Specifying XMLType Storage Options for XML Schema-Based Data

When you create a table that stores XML instance documents that reference an XML schema, you can specify storage options to use. The default storage model is

structured storage. To use binary XML or unstructured storage instead, you use the `STORE AS` clause in the `CREATE TABLE` statement.

This section describes what you need to know about specifying storage options for XML schema-based data.

Binary XML Storage of XML Schema-Based Data

You use `STORE AS BINARY_XML` during table creation to specify binary XML storage. If you do this, and you specify an XML schema that the XML documents must conform to, then you can use that XML schema to create only `XMLType` tables and columns that are stored as binary XML; you cannot use the same XML schema to create `XMLType` tables and columns that are stored object-relationally or as `CLOB` instances.

The converse is also true: If you use a storage model other than binary XML for the registered XML schema, then you can use that XML schema to create only `XMLType` tables and columns that are *not* stored object-relationally or as `CLOB` instances.

Binary XML storage offers a great deal of flexibility for XML data, especially concerning the use of XML schemas. Binary XML encodes XML data differently, depending upon whether or not an XML schema is used for the encoding, and it can encode the same data differently using different XML schemas.

When an XML schema is taken into account for encoding binary XML data, the XML Schema data types are mapped to encoded types for storage. Alternatively, you can encode XML data, whether or not it references an XML schema, as non-schema-based binary XML. In that case, any referenced XML schema is ignored, and there is no encoding of XML Schema data types.

When you create an `XMLType` table or column and you specify binary XML storage, you can also specify how to encode the column or table to make use of XML schemas. There are three possibilities to choose from:

- Encode the column or table data as *non-schema-based* binary XML. The XML data stored in the column can nevertheless conform to an XML schema, but it need not. Any referenced XML schema is ignored for encoding purposes, and documents are not automatically validated when they are inserted or updated.

  You can nevertheless explicitly validate an XML schema-based document that is encoded as non-schema-based binary XML. This represents an important use case: situations where you do not want to tie documents too closely to a particular XML schema, because you might change it or delete it.

- Encode the column or table data to conform to a *single XML schema*. All rows (documents) must conform to the same XML schema. You can nevertheless specify, as an option, that non-schema-based documents can also be stored in the same column.

- Encode the column or table data to conform to whatever XML schema it references Each row (document) can reference *any XML schema*, and that XML schema is used to encode that particular XML document. In this case also, you can specify, as an option, that non-schema-based documents can also be stored in the same column.

  Note that you can use multiple *versions* of the same XML schema in this way: store documents that conform to different versions; each will be encoding according to the XML schema that it references.

You can specify that any XML schema can be used for encoding by using option `ALLOW ANYSCHEMA` when you create the table.

> **Note:** Oracle recommends that you do *not* use option `ALLOW ANYSCHEMA` if you anticipate using copy-based XML schema evolution (see "Using Copy-Based Schema Evolution" on page 9-2). If you use this option, it is impossible to determine which rows (documents) might conform to the XML schema that is evolved. Conforming rows will not be transformed during copy-based evolution, and they will consequently not be decodable afterward.

You can specify, for tables and columns that use XML schema-based encodings, that they can accept also non-schema-based documents by using option `ALLOW NONSCHEMA`. In the absence of keyword `XMLSCHEMA`, encoding is for non-schema-based documents. In the absence of the keywords `ALLOW NONSCHEMA` but the presence of keyword `XMLSCHEMA`, encoding is for the single XML schema specified. In the absence of the keywords `ALLOW NONSCHEMA` but the presence of the keywords `ALLOW ANYSCHEMA`, encoding is for any XML schema that is referenced.

An error is raised if you try to insert an XML document into an `XMLType` table or column that does not correspond to the document.

The various possibilities are summarized in Table 6–2.

Table 6–2 CREATE TABLE Encoding Options for Binary XML

Storage Options	Encoding Effect
`STORE AS BINARY XML`	Encodes all documents using the non-schema-based encoding.
`STORE AS BINARY XML XMLSCHEMA ...`	Encodes all documents using an encoding based on the referenced XML schema. Trying to insert or update a document that does not conform to the XML schema raises an error.
`STORE AS BINARY XML XMLSCHEMA ... ALLOW NONSCHEMA`	Encodes all XML schema-based documents using an encoding based on the referenced XML schema. Encodes all non-schema-based documents using the non-schema-based encoding. Trying to insert or update an XML schema-based document that does not conform to the referenced XML schema raises an error.
`STORE AS BINARY XML ALLOW ANYSCHEMA`	Encodes all XML schema-based documents using an encoding based on the XML schema referenced by the document. Trying to insert or update a document that does not reference a registered XML schema or that does not conform to the XML schema it references raises an error.
`STORE AS BINARY XML ALLOW ANYSCHEMA ALLOW NONSCHEMA`	Encodes all XML schema-based documents using an encoding based on the XML schema referenced by the document. Encodes all non-schema-based documents using the non-schema-based encoding. Trying to insert or update an XML schema-based document that does not conform to the registered XML schema it references raises an error.

Note: If you use CREATE TABLE with ALLOW NONSCHEMA but not ALLOW ANYSCHEMA, then all documents, even XML schema-based documents, are encoded using the non-schema-based encoding. If you later use ALTER TABLE with ALLOW ANYSCHEMA on the same table, this has no effect on the encoding of documents that were stored prior to the ALTER TABLE operation—all such documents continue to be encoded using the non-schema-based encoding, regardless of whether they reference an XML schema. Only XML schema-based documents that you insert in the table after the ALTER TABLE operation are encoded using XML schema-based encodings.

Unstructured Storage of XML Schema-Based Data

You use STORE AS CLOB during table creation to specify unstructured storage. In this case, an entire XML document is stored in a single CLOB column.

Example 6–21 Specifying CLOB Storage for Schema-Based XMLType Tables and Columns

This example shows how to create an XMLType table and a table with an XMLType column, where the contents of the XMLType are constrained to a global element defined by a registered XML schema, and the contents of the XMLType are stored using a single CLOB column.

```
CREATE TABLE purchaseorder_as_table OF XMLType
  XMLTYPE STORE AS CLOB
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder";

CREATE TABLE purchaseorder_as_column (id NUMBER, xml_document XMLType)
  XMLTYPE COLUMN xml_document
  STORE AS CLOB
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder";
```

You can add LOB storage parameters to the STORE AS CLOB clause.

Structured Storage of XML Schema-Based Data

Structured storage is the default XMLType storage model. With structured storage, collections are mapped into SQL varray values. An XML **collection** is any element that has maxOccurs > 1, allowing it to appear multiple times. By default, the entire contents of such a varray is serialized using a single LOB column. This storage model provides for optimal ingestion and retrieval of the entire document, but it has significant limitations when it is necessary to index, update, or retrieve individual members of the collection.

You can override the way in which such a varray is stored, forcing the members of the collection to be stored as a set of rows in an ordered collection table. You do this by adding an explicit VARRAY STORE AS clause to the CREATE TABLE statement. You can also add STORE AS clauses for any LOB columns that will be generated by the CREATE TABLE statement. The collection and the LOB column must be identified using SQL object-relational notation.

Example 6–22 shows how to create an XMLType table and a table with an XMLType column, where the contents of the XMLType instance are constrained to a global element defined by a registered XML schema, and the contents of the XMLType instance are stored using SQL objects.

Example 6–22 Specifying Structured Storage Options for Schema-Based XMLType Tables and Columns

```
CREATE TABLE purchaseorder_as_table
  OF XMLType (UNIQUE ("XMLDATA"."Reference"),
              FOREIGN KEY ("XMLDATA"."User") REFERENCES hr.employees (email))
ELEMENT
  "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd#PurchaseOrder"
  VARRAY "XMLDATA"."Actions"."Action"
    STORE AS TABLE action_table1
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  VARRAY "XMLDATA"."LineItems"."LineItem"
    STORE AS TABLE lineitem_table1
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  LOB ("XMLDATA"."Notes")
    STORE AS (TABLESPACE USERS ENABLE STORAGE IN ROW
              STORAGE(INITIAL 4K NEXT 32K));

CREATE TABLE purchaseorder_as_column (
  id NUMBER,
  xml_document XMLType,
  UNIQUE (xml_document."XMLDATA"."Reference"),
  FOREIGN KEY (xml_document."XMLDATA"."User") REFERENCES hr.employees (email))

  XMLTYPE COLUMN xml_document
  XMLSCHEMA "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY xml_document."XMLDATA"."Actions"."Action"
    STORE AS TABLE action_table2
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  VARRAY xml_document."XMLDATA"."LineItems"."LineItem"
    STORE AS TABLE lineitem_table2
                  ((PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
  LOB (xml_document."XMLDATA"."Notes")
    STORE AS (TABLESPACE USERS ENABLE STORAGE IN ROW
              STORAGE(INITIAL 4K NEXT 32K));
```

Example 6–22 also shows how to specify that the collection of `Action` elements and the collection of `LineItem` elements are each to be stored as a set of rows in ordered collection tables, and how to specify LOB storage clauses for the LOB that will contain the content of the `Notes` element.

Specifying Relational Constraints on XMLType Tables and Columns

When you store XML data using structured storage, typical relational constraints can be specified for elements and attributes that occur only once in an XML document. Example 6–22 shows how to use object-relational notation to define a unique constraint and a foreign key constraint when creating the table.

It is not possible to define constraints for `XMLType` tables and columns that make use of unstructured storage.

See Also:

- "Using Virtual Columns to Constrain Data Stored as Binary XML" on page 3-4 for how to define constraints on XML data stored as binary XML
- "Adding Unique Constraints to the Parent Element of an Attribute" on page 8-3

Oracle XML Schema Annotations

You can annotate XML schemas to influence the objects and tables that are generated by the XML schema registration process. This means that you add Oracle-specific attributes to `complexType`, `element`, and `attribute` definitions that are declared by the XML schema.

Most XML attributes used by Oracle XML DB belong to the namespace `http://xmlns.oracle.com/xdb`. XML attributes used for encoding XML data as binary XML belong to the namespace `http://xmlns.oracle.com/2004/CSX`. To simplify the process of annotating an XML schema, Oracle recommends that you declare namespace prefixes in the root element of the XML schema.

Common Uses of XML Schema Annotations

Common reasons for wanting to annotate an XML schema include the following:

- To ensures that the names of the tables, objects, and object attributes created by `registerSchema` for structured storage of XML data are well-known names, compliant with any application-naming standards. Set `GENTYPES` or `GENTABLES` to `TRUE` for this.
- To map between the XML schema and existing objects and tables within the database. Set `GENTYPES` or `GENTABLES` to `FALSE` for this.
- To prevent the generation of mixed-case names that require the use of quoted identifiers when working directly with SQL.
- To allow XPath rewrite in the case of (document-correlated recursive) XPath queries, that is, for certain `extract`, `extractValue`, and `existsNode` applications whose XPath expression targets recursive XML data. XPath rewrite is available only for structured storage of XML data.

The most commonly used XML schema annotations are the following:

- `defaultTable` – Name of the default table generated for each global element when parameter `GENTABLES` is `FALSE`. Setting this to the empty string, `""`, prevents a default table from being generated for the element in question.
- `SQLName` – Name of the SQL object attribute that corresponds to each element or attribute defined in the XML schema.
- `SQLType` – For `complexType` definitions, the corresponding object type. For `simpleType` definitions, `SQLType` is used to override the default mapping between XML schema data types and SQL data types. A common use of `SQLType` is to define when unbounded strings should be stored as `CLOB` values, rather than as `VARCHAR(4000) CHAR` values (the default). Note: You cannot use data type `NCHAR`, `NVARCHAR`, or `NCLOB` as the value of a `SQLType` annotation.
- `SQLCollType` – Used to specify the varray type that will manage a collection of elements.
- `maintainDOM` – Used to determine whether or not DOM fidelity should be maintained for a given `complexType` definition
- `storeVarrayAsTable` – Specified in the root element of the XML schema. Used to force all collections to be stored as ordered collection tables (OCTs). An OCT is created for each element that is specified with `maxOccurs > 1`. The OCTs are created with system-generated names. The default value of `storeVarrayAsTable` is `true`.

You need not specify values for any of these attributes. Oracle XML DB provides appropriate values by default during the XML schema registration process. However, if you are using structured storage, then Oracle recommends that you specify the names of at least the top-level SQL types, so that you can reference them later.

XML Schema Annotation Example

Example 6–23 shows a partial listing of the XML schema in Example 6–1, modified to include some of the most important Oracle XML DB annotations.

Example 6–23 Using Common Schema Annotations

```
<xs:schema
  targetNamespace="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:xdb="http://xmlns.oracle.com/xdb"
  xmlns:po="http://xmlns.oracle.com/xdb/documentation/purchaseOrder"
  version="1.0"
  xdb:storeVarrayAsTable="true">
  <xs:element name="PurchaseOrder" type="po:PurchaseOrderType"
              xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="po:ReferenceType" minOccurs="1"
                  xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="po:ActionsType"
                  xdb:SQLName="ACTION_COLLECTION"/>
      <xs:element name="Reject" type="po:RejectionType" minOccurs="0"/>
      <xs:element name="Requestor" type="po:RequestorType"/>
      <xs:element name="User" type="po:UserType" minOccurs="1"
                  xdb:SQLName="EMAIL"/>
      <xs:element name="CostCenter" type="po:CostCenterType"/>
      <xs:element name="ShippingInstructions"
                  type="po:ShippingInstructionsType"/>
      <xs:element name="SpecialInstructions" type="po:SpecialInstructionsType"/>
      <xs:element name="LineItems" type="po:LineItemsType"
                  xdb:SQLName="LINEITEM_COLLECTION"/>
      <xs:element name="Notes" type="po:NotesType" xdb:SQLType="CLOB"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="po:LineItemType" maxOccurs="unbounded"
                  xdb:SQLCollType="LINEITEM_V" xdb:SQLName="LINEITEM_VARRAY"/>
   </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="po:DescriptionType"/>
      <xs:element name="Part" type="po:PartType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T" xdb:maintainDOM="false">
    <xs:attribute name="Id">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
```

```
      </xs:simpleType>
    </xs:attribute>
    <xs:attribute name="Quantity" type="po:moneyType"/>
    <xs:attribute name="UnitPrice" type="po:quantityType"/>
  </xs:complexType>
</xs:schema>
```

The `schema` element includes the declaration of the `xdb` namespace. It also includes the annotation `xdb:storeVarrayAsTable = "true"` (which is the default value). This causes all collections within the XML schema to be managed using ordered collection tables (OCTs).

The definition of the global element `PurchaseOrder` includes a `defaultTable` annotation that specifies that the name of the default table associated with this element is `purchaseorder`.

The global `complexType` `PurchaseOrderType` includes a `SQLType` annotation that specifies that the name of the generated SQL object type will be `purchaseorder_t`. Within the definition of this type, the following annotations are used:

- The element `Reference` includes a `SQLName` annotation that ensures that the name of the SQL attribute corresponding to the `Reference` element will be named `reference`.
- The element `Actions` includes a `SQLName` annotation that ensures that the name of the SQL attribute corresponding to the `Actions` element will be `action_collection`.
- The element `USER` includes a `SQLName` annotation that ensures that the name of the SQL attribute corresponding to the `User` element will be `email`.
- The element `LineItems` includes a `SQLName` annotation that ensures that the name of the SQL attribute corresponding to the `LineItems` element will be `lineitem_collection`.
- The element `Notes` includes a `SQLType` annotation that ensures that the data type of the SQL attribute corresponding to the `Notes` element will be `CLOB`.

The global `complexType` `LineItemsType` includes a `SQLType` annotation that specifies that the names of generated SQL object type will be `lineitems_t`. Within the definition of this type, the following annotations are used:

- The element `LineItem` includes a `SQLName` annotation that ensures that the data type of the SQL attribute corresponding to the `LineItems` element will be `lineitem_varray`, and a `SQLCollName` annotation that ensures that the name of the SQL object type that manages the collection will be `lineitem_v`.

The global `complexType` `LineItemType` includes a `SQLType` annotation that specifies that the names of generated SQL object type will be `lineitem_t`.

The global `complexType` `PartType` includes a `SQLType` annotation that specifies that the names of generated SQL object type will be `part_t`. It also includes the annotation `xdb:maintainDOM = "false"`, specifying that there is no need for Oracle XML DB to maintain DOM fidelity for elements based on this type.

Example 6–24 shows some of the tables and objects that are created when the annotated XML schema is registered.

Example 6–24 Registering an Annotated XML Schema

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
```

```
    SCHEMAURL => 'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd',
    SCHEMADOC => bfilename('XMLDIR', 'purchaseOrder.Annotated.xsd'),
    LOCAL => TRUE,
    GENTYPES => TRUE,
    GENTABLES => TRUE,
    CSID => nls_charset_id('AL32UTF8'));
END;
/

SELECT table_name, xmlschema, element_name FROM USER_XML_TABLES;

TABLE_NAME     XMLSCHEMA                              ELEMENT_NAME
-------------  ---------------------------------   -------------
PURCHASEORDER  http://xmlns.oracle.com/xdb/documen   PurchaseOrder
               tation/purchaseOrder.xsd

1 row selected.

DESCRIBE purchaseorder

Name                           Null? Type
-----------------------------  ----- -----------------
TABLE of SYS.XMLTYPE(XMLSchema
 "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
 ELEMENT "PurchaseOrder") STORAGE Object-relational TYPE "PURCHASEORDER_T"

DESCRIBE purchaseorder_t

PURCHASEORDER_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
REFERENCE                  VARCHAR2(30 CHAR)
ACTION_COLLECTION          ACTIONS_T
REJECT                     REJECTION_T
REQUESTOR                  VARCHAR2(128 CHAR)
EMAIL                      VARCHAR2(10 CHAR)
COSTCENTER                 VARCHAR2(4 CHAR)
SHIPPINGINSTRUCTIONS       SHIPPING_INSTRUCTIONS_T
SPECIALINSTRUCTIONS        VARCHAR2(2048 CHAR)
LINEITEM_COLLECTION        LINEITEMS_T
Notes                      CLOB

DESCRIBE lineitems_t
LINEITEMS_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
LINEITEM_VARRAY            LINEITEM_V

DESCRIBE lineitem_v

LINEITEM_V VARRAY(2147483647) OF LINEITEM_T
LINEITEM_T is NOT FINAL
Name                 Null? Type
-------------------- ----- --------------------------
SYS_XDBPD$                 XDB.XDB$RAW_LIST_T
ITEMNUMBER                 NUMBER(38)
DESCRIPTION                VARCHAR2(256 CHAR)
PART                       PART_T
```

```
DESCRIBE part_t

PART_T is NOT FINAL
Name                 Null? Type
-------------------- ----- -------------------------
ID                         VARCHAR2(14 CHAR)
QUANTITY                   NUMBER(12,2)
UNITPRICE                  NUMBER(8,4)

SELECT table_name, parent_table_column FROM USER_NESTED_TABLES
  WHERE parent_table_name = 'purchaseorder';

TABLE_NAME                     PARENT_TABLE_COLUMN
----------                     ----------------------
SYS_NTNOHV+tfSTRaDTA9FETvBJw==  "XMLDATA"."LINEITEM_COLLECTION"."LINEITEM_VARRAY"
SYS_NTV4bNVqQ1S4WdCIvBK5qjZA==  "XMLDATA"."ACTION_COLLECTION"."ACTION_VARRAY"

2 rows selected.
```

The following are results of this XML schema registration:

- A table called `purchaseorder` was created.
- Types called `purchaseorder_t`, `lineitems_t`, `lineitem_v`, `lineitem_t`, and `part_t` were created. The attributes defined by these types are named according to supplied the `SQLName` annotations.
- The `Notes` attribute defined by `purchaseorder_t` is of data type `CLOB`.
- Type `part_t` does not include a positional descriptor (PD) attribute.
- Ordered collection tables (OCTs) were created to manage the collections of `LineItem` and `Action` elements.

Available Oracle XML DB XML Schema Annotations

Table 6–3, Table 6–4, and Table 6–5 list Oracle XML DB annotations that you can specify in element and attribute declarations. All annotations except those that have the prefix `csx` are applicable to XML schemas registered for structured storage. This includes the portions of hybrid storage that are stored object-relationally.

The following annotations apply to XML schemas registered for unstructured storage:

- `xdb:defaultTable`
- `xdb:defaultTableSchema`

The following annotations apply to XML schemas registered for binary XML storage:

- `xdb:defaultTable`
- `xdb:defaultTableSchema`
- `xdb:tableProps`
- `csx:encodingType`

Table 6–3 Annotations in Elements

Attribute	Values	Default	Description
`xdb:columnProps`	Any column storage clause	`NULL`	Specifies the `COLUMN` storage clause that is inserted into the default `CREATE TABLE` statement. It is useful mainly for elements that get mapped to SQL tables, namely top-level element declarations and out-of-line element declarations.
`xdb:defaultTable`	Any table name	Based on element name	Specifies the name of the SQL table into which XML instances of this XML schema will be stored. This is most useful in cases when the XML data is being inserted from APIs and protocols, such as FTP and HTTP(S), where the table name is not specified. Applicable to structured storage and binary XML storage.
`xdb:defaultTableSchema`	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `xdb:defaultTable`. Applicable to structured storage and binary XML storage.
`csx:encodingType`	Any binary XML encoding type[1]	Based on XML Schema data type	Specifies the encoding type to be used to encode the node value of this element or attribute. This can be used only within elements `xsd:attribute`, `xsd:simpleType`, and `xsd:element` (for elements based on `simpleType` or `simpleContent` only). Applicable only to binary XML storage.
`xdb:maintainDOM`	`true` | `false`	`true`	If `true`, then instances of this element are stored so that they retain DOM fidelity on output. This implies that all comments, processing instructions, namespace declarations, and so on are retained, in addition to the ordering of elements. If `false`, then the output is not guaranteed to have the same DOM action as the input.
`xdb:maintainOrder`	`true` | `false`	`true`	If `true` (recommended), then the collection is mapped to a varray (stored in a LOB or an ordered collection table). If `false`, then the collection is mapped to an unordered table.
`xdb:maxOccurs`	Any positive integer	1	Specifies the maximum number of times an element can appear. If the value is `unbounded`, then there is no limit to the maximum number of occurrences.
`xdb:SQLCollSchema`	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by `xdb:SQLCollType`.
`xdb:SQLCollType`	Any SQL collection type	Name generated from element name	Name of the SQL collection type that corresponds to this XML element. The XML element must be specified with `maxOccurs` > 1.
`xdb:SQLInline`	`true` | `false`	`true`	If `true`, then this element is stored inline as an embedded object attribute (or as a collection, if `maxOccurs` > 1). If `false`, then a `REF` value is stored (or a collection of `REF` values, if `maxOccurs` > 1). This attribute is forced to `false` in certain situations, such as cyclic references, where SQL does not support inlining.
`xdb:SQLName`	Any SQL identifier	Element name	Name of the attribute within the SQL object that maps to this XML element.

Table 6–3 (Cont.) Annotations in Elements

Attribute	Values	Default	Description
xdb:SQLSchema	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by SQLType.
xdb:SQLType	Any SQL data type[2], *except* NCHAR, NVARCHAR, and NCLOB	Name generated from element name	Name of the SQL type corresponding to this XML element declaration.
xdb:srclang	true | false	true	If true, then the given language translation is used as the default translation.
xdb:tableProps	Any table storage clause	NULL	Specifies the TABLE storage clause that is appended to the default CREATE TABLE statement. This is meaningful mainly for global and out-of-line elements. Applicable to structured storage and binary XML storage.
xdb:translate	true | false	true	If true, then instances of this element are translated. The maxOccurs attribute must be <=1 for this element to be set to true.

[1] See "Mapping XML Schema Data Types To Binary XML Encoding Types" on page 6-50.
[2] See "Mapping XML Schema Data Types to SQL Data Types" on page 6-42.

Table 6–4 Annotations in Elements Declaring Global complexType Elements

Attribute	Values	Default	Description
csx:encodingType	Any binary XML encoding type[1]	Based on XML Schema data type	The encoding type to be used to encode the node value of this element or attribute. This can be used only within elements xsd:attribute, xsd:simpleType, and xsd:element (for elements based on simpleType or simpleContent only).
xdb:maintainDOM	true | false	true	If true, then instances of this element are stored so that they retain DOM fidelity on output. This implies that all comments, processing instructions, namespace declarations, and so on are retained, in addition to the ordering of elements. If false, then the output is not guaranteed to have the same DOM action as the input.
xdb:SQLSchema	Any SQL user name	User registering XML schema	Name of the database user (database schema) who owns the type specified by SQLType.
xdb:SQLType	Any SQL data type[2] *except* NCHAR, NVARCHAR, and NCLOB	Name generated from element name	Name of the SQL type that corresponds to this XML element declaration.

[1] See "Mapping XML Schema Data Types To Binary XML Encoding Types" on page 6-50.
[2] See "Mapping XML Schema Data Types to SQL Data Types" on page 6-42.

Table 6–5 Annotations in XML Schema Declarations

Attribute	Values	Default	Description
`xdb:mapUnboundedStringToLob`	`true` | `false`	`false`	If `true`, then unbounded strings are mapped to `CLOB` instances by default. Similarly, unbounded binary data gets mapped to a `BLOB` value, by default. If `false`, then unbounded strings are mapped to `VARCHAR2(4000)` values, and unbounded binary components are mapped to `RAW(2000)` values.
`xdb:storeVarrayAsTable`	`true` | `false`	`true`	If `true`, then the varray is stored as a table (OCT). If `false`, then the varray is stored in a LOB.

See Also: "Changing an XML Schema and XML Instance Documents for Translation" on page 17 for more information on `xdb:maxOccurs`, `xdb:translate`, and `xdb:srclang`.

Querying a Registered XML Schema to Obtain Annotations

The registered version of an XML schema contains a full set of Oracle XML DB annotations. As shown in Example 6–8 and Example 6–9, the location of the registered XML schema depends on whether it is local or global.

A registered XML schema can be queried for the annotations that were supplied by the user or added by the schema registration process. Example 6–25 shows the set of global `complexType` definitions declared by an XML schema for structured storage of XML data, and the corresponding SQL object types and DOM fidelity values.

Example 6–25 Querying Metadata from a Registered XML Schema

```
SELECT ct.xmlschema_type_name, ct.sql_type_name, ct.dom_fidelity
  FROM RESOURCE_VIEW,
       XMLTable(
         XMLNAMESPACES(
           'http://xmlns.oracle.com/xdb/XDBResource.xsd' AS "r",
           'http://xmlns.oracle.com/xdb/documentation/purchaseOrder' AS "po",
           'http://www.w3.org/2001/XMLSchema' AS "xs",
           'http://xmlns.oracle.com/xdb' AS "xdb"),
         '/r:Resource/r:Contents/xs:schema/xs:complexType' PASSING RES
         COLUMNS
           xmlschema_type_name VARCHAR2(30) PATH '@name',
           sql_type_name       VARCHAR2(30) PATH '@xdb:SQLType',
           dom_fidelity        VARCHAR2(6)  PATH '@xdb:maintainDOM') ct
  WHERE
    equals_path(
      RES,
      '/sys/schemas/SCOTT/xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd')
    =1;

XMLSCHEMA_TYPE_NAME        SQL_TYPE_NAME            DOM_FIDELITY
-------------------------  -----------------------  ------------
PurchaseOrderType          PURCHASEORDER_T          true
LineItemsType              LINEITEMS_T              true
LineItemType               LINEITEM_T               true
PartType                   PART_T                   true
ActionsType                ACTIONS_T                true
```

```
RejectionType              REJECTION_T              true
ShippingInstructionsType   SHIPPING_INSTRUCTIONS_T  true

7 rows selected.
```

Mapping XML Schema Data Types to Oracle XML DB Storage

XML data that conforms to an XML schema is typed using XML Schema data types. When this XML data is stored in Oracle XML DB, its storage data types are derived from the XML Schema data types using a default mapping and, optionally, using mapping information that you specify using XML schema annotations.

Whenever you do not specify a data type to use for storage, Oracle XML DB uses the default mapping to annotate the XML schema appropriately, during registration. In this way, the registered XML schema has a complete set of data-type annotations.

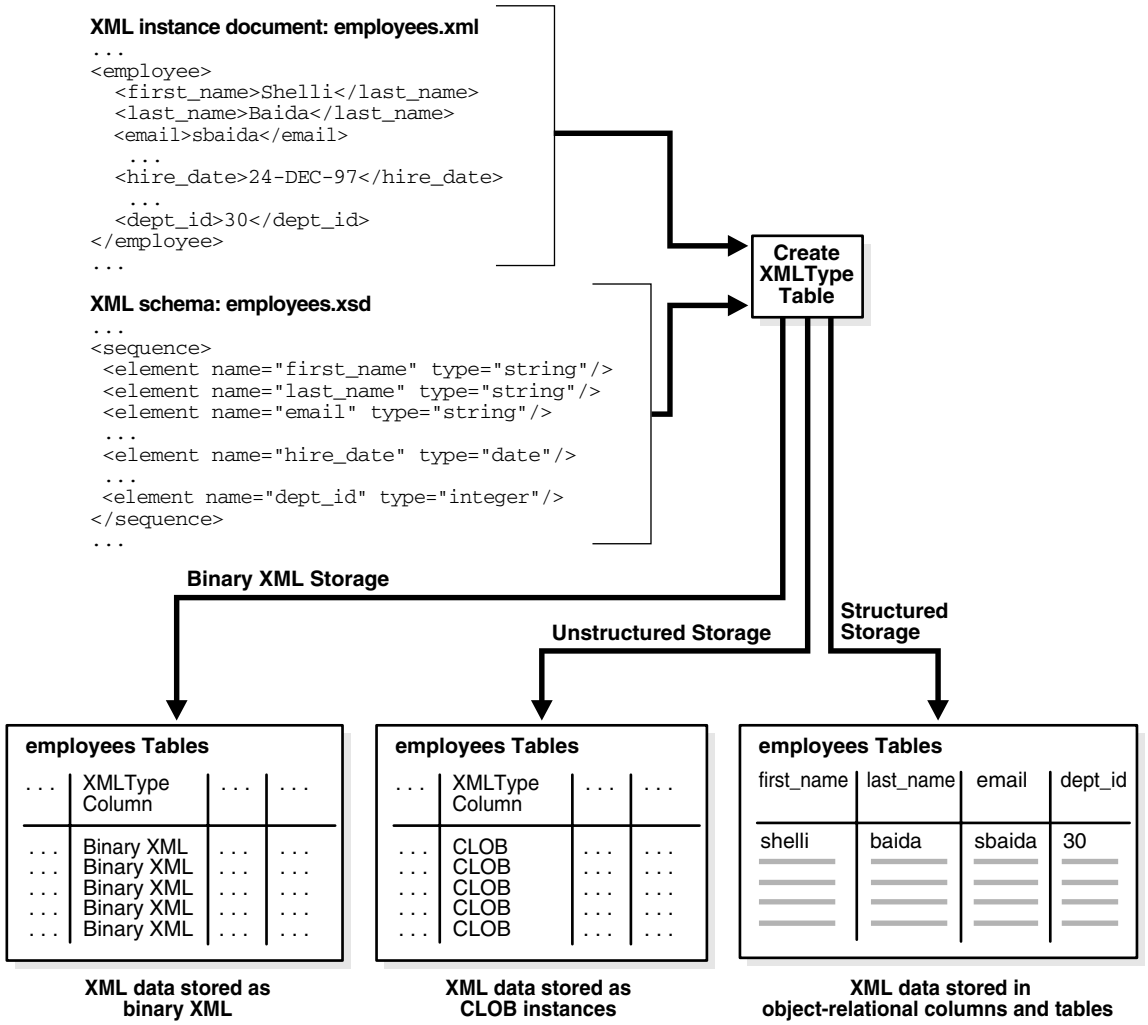
- For unstructured storage, the data-type mapping is trivial: all of the XML data is stored together as a single `CLOB`.
- For structured storage, XML Schema data types are mapped to SQL data types.
- For binary XML storage, XML Schema data types are mapped to Oracle XML DB binary XML encoding types.

See Also:

- "Mapping XML Schema Data Types to SQL Data Types" on page 6-42
- "Mapping XML Schema Data Types To Binary XML Encoding Types" on page 6-50

Figure 6–2 shows how Oracle XML DB creates XML schema-based `XMLType` tables using an XML document and a mapping specified in an XML schema. Depending on the storage method specified in the XML schema, an XML instance document is stored either as a binary XML or `CLOB` value in a single `XMLType` column, or using multiple object-relational columns.

Figure 6–2 How Oracle XML DB Maps XML Schema-Based XMLType Tables



Mapping XML Schema Data Types to SQL Data Types

This section describes how to use PL/SQL package `DBMS_XMLSCHEMA` to map data types for XML Schema attributes and elements to SQL data types.

> **Note:** Do not directly access the SQL data types that are mapped from XML Schema data types during XML schema registration. These SQL types are part of the implementation of Oracle XML DB; they are not exposed for your use. Oracle reserves the right to change the implementation at any time, including in a product patch. Such a change by Oracle will have no effect on applications that abide by the XML abstraction, but it might impact applications that directly access these data types.

Example of Mapping XML Schema Data Types to SQL

Example 6–26 shows a simple example of mapping XML Schema data types to SQL data types. It uses attribute `SQLType` to specify the data-type mapping. It also uses

attribute SQLName to specify the object attributes to use for various XML elements and attributes.

Example 6–26 Mapping XML Schema Data Types to SQL Data Types Using Attribute SQLType

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0"
           xdb:storeVarrayAsTable="true">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType" xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType" minOccurs="1" xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" minOccurs="1" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
      <xs:element name="Notes" type="po:NotesType" xdb:SQLType="CLOB"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                  xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"
                  xdb:SQLName="DESCRIPTION"/>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                  xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
    <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
    <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
  </xs:complexType>

  ...

  <xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
    <xs:sequence>
      <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
        <xs:complexType xdb:SQLType="ACTION_T">
          <xs:sequence>
            <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
            <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
```

```
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
    <xs:all>
      <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
      <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
      <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
    </xs:all>
  </xs:complexType>
  <xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
    <xs:sequence>
      <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
      <xs:element name="address" type="AddressType" minOccurs="0" xdb:SQLName="SHIP_TO_ADDRESS"/>
      <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
    </xs:sequence>
  </xs:complexType>
  ...
</xs:schema>
```

Mapping XML Schema Attribute Data Types to SQL

An attribute declaration can specify its XML Schema data type in terms of one of the following:

- Primitive type
- Global `simpleType`, declared within this XML schema or in an external XML schema
- Reference to global attribute (`ref="..."`), declared within this XML schema or in an external XML schema
- Local `simpleType`

In all cases, the SQL data type and associated information (length and precision) as well as the memory mapping information, are derived from the `simpleType` on which the attribute is based.

Overriding the SQLType Value in an XML Schema When Declaring Attributes

You can explicitly specify a `SQLType` value in the input XML schema document. In this case, the data type you specify is used for schema validation. This allows for the following specific forms of overrides:

- If the default SQL data type is `STRING`, you can override it with `CHAR`, `VARCHAR`, or `CLOB`.
- If the default SQL data type is `RAW`, you can override it with `RAW` or `BLOB`.

Mapping XML Schema Element Data Types to SQL

An element declaration can specify its XML Schema data type in terms of one of the following:

- Any of the ways for specifying type for an attribute declaration. See "Mapping XML Schema Attribute Data Types to SQL" on page 6-44.
- Global `complexType`, specified within this XML schema document or in an external XML schema.
- Reference to a global element (`ref="..."`), which could itself be within this XML schema document or in an external XML schema.
- Local `complexType`.

Overriding the SQLType Value in an XML Schema When Declaring Elements

An element based on a `complexType` is, by default, mapped to a SQL object type that contains object attributes corresponding to each of the sub-elements and attributes. You can override this mapping by explicitly specifying a value for attribute `SQLType` in the input XML schema. The following values for `SQLType` are permitted here:

- `VARCHAR2`
- `RAW`
- `CLOB`
- `BLOB`

These represent storage of the XML data in a text form in the database.

For example, to override the `SQLType` from `VARCHAR2` to `CLOB`, declare the `xdb` namespace using `xmlns:xdb="http://xmlns.oracle.com/xdb"`, and then use `xdb:SQLType = "CLOB"`.

The following special cases are handled:

- If a cycle is detected when processing the `complexType` values that are used to declare elements and the elements declared within the `complexType`, the `SQLInline` attribute is forced to be `false`, and the correct SQL mapping is set to `REF XMLType`.
- If `maxOccurs > 1`, a varray type might be created.
  - If `SQLInline = "true"`, then a varray type is created whose element type is the SQL data type previously determined. Cardinality of the varray is based on the value of attribute `maxOccurs`. Either you specify the name of the varray type using attribute `SQLCollType`, or it is derived from the element name.
  - If `SQLInline = "false"`, then the SQL data type is set to `XDB.XDB$XMLTYPE_REF_LIST_T`. This is a predefined data type that represents an array of `REF` values pointing to `XMLType` instances.
- If the element is a global element, or if `SQLInline = "false"`, then the system creates a default table. Either you specify the name of the default table, or it is derived from the element name.

> **See Also:** Chapter 8, "XML Schema Storage and Query: Advanced" for more information about mapping `simpleType` values and `complexType` values to SQL.

Mapping simpleType to SQL

This section describes how XML schema definitions map XML Schema `simpleType` to SQL object types. Figure 6–3 shows an example of this.

Figure 6–3 Mapping simpleType: XML Strings to SQL VARCHAR2 or CLOB

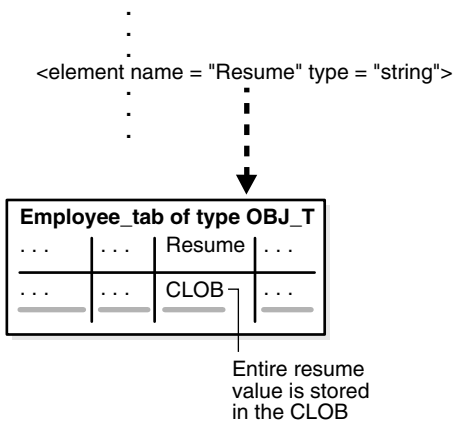


Table 6–6 through Table 6–9 present the default mapping of XML Schema `simpleType` to SQL, as specified in the XML Schema definition. For example:

- A XML Schema *primitive* type is mapped to the closest SQL data type. For example, `DECIMAL`, `POSITIVEINTEGER`, and `FLOAT` are all mapped to SQL `NUMBER`.
- An XML Schema *enumeration* type is mapped to a SQL object type with a single `RAW(`*n*`)` object attribute. The value of *n* is determined by the number of possible values in the enumeration declaration.
- An XML Schema *list* or a *union* type is mapped to a SQL string (`VARCHAR2` or `CLOB`) data type.

Table 6–6 Mapping XML Schema String Data Types to SQL

XML Schema String Type	Length or MaxLength Facet	Default SQL Data Type	Compatible SQL Data Type
`string`	n	`VARCHAR2(n)` if n < 4000, else `VARCHAR2(4000)`	`CHAR`, `CLOB`
`string`	-	`VARCHAR2(4000)` if `mapUnboundedStringToLob = "false"`, `CLOB`	`CHAR`, `CLOB`

Table 6–7 Mapping XML Schema Binary Data Types (hexBinary/base64Binary) to SQL

XML Schema Binary Type	Length or MaxLength Facet	Default SQL Data Type	Compatible SQL Data Type
`hexBinary`, `base64Binary`	n	`RAW(n)` if n < 2000, else `RAW(2000)`	`RAW`, `BLOB`
`hexBinary`, `base64Binary`	-	`RAW(2000)` if `mapUnboundedStringToLob = "false"`, `BLOB`	`RAW`, `BLOB`

Table 6–8 Default Mapping of Numeric XML Schema Primitive Types to SQL

XML Schema Simple Type	Default SQL Data Type	totalDigits (m), fractionDigits(n) Specified	Compatible SQL Data Types
`float`	`NUMBER`	`NUMBER(m+n,n)`	`FLOAT`, `DOUBLE`, `BINARY_FLOAT`
`double`	`NUMBER`	`NUMBER(m+n,n)`	`FLOAT`, `DOUBLE`, `BINARY_DOUBLE`
`decimal`	`NUMBER`	`NUMBER(m+n,n)`	`FLOAT`, `DOUBLE`

Table 6–8 (Cont.) Default Mapping of Numeric XML Schema Primitive Types to SQL

XML Schema Simple Type	Default SQL Data Type	totalDigits (m), fractionDigits(n) Specified	Compatible SQL Data Types
integer	NUMBER	NUMBER(m+n,n)	NUMBER
nonNegativeInteger	NUMBER	NUMBER(m+n,n)	NUMBER
positiveInteger	NUMBER	NUMBER(m+n,n)	NUMBER
nonPositiveInteger	NUMBER	NUMBER(m+n,n)	NUMBER
negativeInteger	NUMBER	NUMBER(m+n,n)	NUMBER
long	NUMBER(20)	NUMBER(m+n,n)	NUMBER
unsignedLong	NUMBER(20)	NUMBER(m+n,n)	NUMBER
int	NUMBER(10)	NUMBER(m+n,n)	NUMBER
unsignedInt	NUMBER(10)	NUMBER(m+n,n)	NUMBER
short	NUMBER(5)	NUMBER(m+n,n)	NUMBER
unsignedShort	NUMBER(5)	NUMBER(m+n,n)	NUMBER
byte	NUMBER(3)	NUMBER(m+n,n)	NUMBER
unsignedByte	NUMBER(3)	NUMBER(m+n,n)	NUMBER

Table 6–9 Mapping XML Schema Date and Time Data Types to SQL

XML Schema Date or Time Type	Default SQL Data Type	Compatible SQL Data Types
dateTime	TIMESTAMP	TIMESTAMP WITH TIME ZONE,DATE
time	TIMESTAMP	TIMESTAMP WITH TIME ZONE,DATE
date	DATE	TIMESTAMP WITH TIME ZONE
gDay	DATE	TIMESTAMP WITH TIME ZONE
gMonth	DATE	TIMESTAMP WITH TIME ZONE
gYear	DATE	TIMESTAMP WITH TIME ZONE
gYearMonth	DATE	TIMESTAMP WITH TIME ZONE
gMonthDay	DATE	TIMESTAMP WITH TIME ZONE
duration	VARCHAR2(4000)	none

Table 6–10 Default Mapping of Other XML Schema Primitive and Derived Data Types to SQL

XML Schema Primitive or Derived Type	Default SQL Data Type	Compatible SQL Data Types
boolean	RAW(1)	VARCHAR2
language(string)	VARCHAR2(4000)	CLOB,CHAR
NMTOKEN(string)	VARCHAR2(4000)	CLOB,CHAR
NMTOKENS(string)	VARCHAR2(4000)	CLOB,CHAR
Name(string)	VARCHAR2(4000)	CLOB,CHAR
NCName(string)	VARCHAR2(4000)	CLOB,CHAR
ID	VARCHAR2(4000)	CLOB,CHAR
IDREF	VARCHAR2(4000)	CLOB,CHAR

Table 6–10 (Cont.) Default Mapping of Other XML Schema Primitive and Derived Data Types to SQL

XML Schema Primitive or Derived Type	Default SQL Data Type	Compatible SQL Data Types
IDREFS	VARCHAR2(4000)	CLOB, CHAR
ENTITY	VARCHAR2(4000)	CLOB, CHAR
ENTITIES	VARCHAR2(4000)	CLOB, CHAR
NOTATION	VARCHAR2(4000)	CLOB, CHAR
anyURI	VARCHAR2(4000)	CLOB, CHAR
anyType	VARCHAR2(4000)	CLOB, CHAR
anySimpleType	VARCHAR2(4000)	CLOB, CHAR
QName	XDB.XDB$QNAME	none
normalizedString	VARCHAR2(4000)	none
token	VARCHAR2(4000)	none

NCHAR, NVARCHAR, and NCLOB SQLType Values are Not Supported

Oracle XML DB does *not* support NCHAR, NVARCHAR, and NCLOB as values for attribute SQLType: you cannot specify that an element is to be of type NCHAR, NVARCHAR, or NCLOB. Also, if you provide your own data type, do not use any of these data types.

simpleType: Mapping XML Strings to SQL VARCHAR2 Versus CLOB

If an XML schema specifies an XML Schema data type to be a string with a maxLength less than 4000, then it is mapped to a VARCHAR2 object attribute of the specified length. However, if maxLength is not specified in the XML schema, then it can only be mapped to a LOB. This is sub-optimal when most of the string values are small and only a small fraction of them are large enough to need a LOB.

> **See Also:** Table 6–6, " Mapping XML Schema String Data Types to SQL"

Working with Time Zones

The following XML Schema data types allow for an optional time-zone indicator as part of their literal values.

- xsd:dateTime
- xsd:time
- xsd:date
- xsd:gYear
- xsd:gMonth
- xsd:gDay
- xsd:gYearMonth
- xsd:gMonthDay

By default, XML schema registration maps xsd:dateTime and xsd:time to SQL data type TIMESTAMP and all the other data types to SQL data type DATE. SQL data types TIMESTAMP and DATE do not permit a time-zone indicator.

If your application needs to work with time-zone indicators, then use attribute SQLType to specify the SQL data type as TIMESTAMP WITH TIME ZONE. This ensures that values containing time-zone indicators can be stored and retrieved correctly. For example:

```
<element name="dob" type="xsd:dateTime"
          xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
<attribute name="endofquarter" type="xsd:gMonthDay"
           xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
```

Using Trailing Z to Indicate UTC Time Zone XML Schema lets the time-zone component be specified as Z, to indicate UTC time zone. When a value with a trailing Z is stored in a SQL TIMESTAMP WITH TIME ZONE column, the time zone is actually stored as +00:00. Thus, the retrieved value contains the trailing +00:00, not the original Z. For example, if the value in the input XML document is 1973-02-12T13:44:32**Z**, the output will look like 1973-02-12T13:44:32**.000000+00:00**.

Mapping complexType to SQL

Using XML Schema, a complexType is mapped to a SQL object type as follows:

- XML attributes declared within the complexType are mapped to SQL object attributes. The simpleType defining an XML attribute determines the SQL data type of the corresponding object attribute.
- XML elements declared within the complexType are also mapped to SQL object attributes. The simpleType or complexType defining an XML element determines the SQL data type of the corresponding object attribute.

If the XML element is declared with attribute maxOccurs > 1, then it is mapped to a SQL collection attribute. The collection could be a varray value (the default, recommended) or an unordered table (if you set attribute maintainOrder to false). The default storage of a varray value is an ordered collections table (OCT). You can choose LOB storage instead, by setting attribute storeAsLob to true.

Specifying Attributes in a complexType XML Schema Declaration

When you have an element based on a global complexType, both the SQLType and SQLSchema attributes must be specified for the complexType declaration. In addition you can optionally include the same SQLType and SQLSchema attributes within the element declaration.

If you do not specify attribute SQLType for the global complexType, Oracle XML DB creates a SQLType attribute with an internally generated name. The elements that reference this global type cannot then have a different value for SQLType. The following code is acceptable:

```
<xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
  <xs:sequence>
    <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
  <xs:sequence>
    <xs:element name="Description" type="DescriptionType"
                xdb:SQLName="DESCRIPTION"/>
    <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
  </xs:sequence>
  <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
```

```
                xdb:SQLType="NUMBER"/>
</xs:complexType>
<xs:complexType name="PartType" xdb:SQLType="PART_T">
  <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:minLength value="10"/>
        <xs:maxLength value="14"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
  <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
</xs:complexType>
```

Mapping XML Schema Data Types To Binary XML Encoding Types

This section describes how to use PL/SQL package `DBMS_XMLSCHEMA` to map the data types used for XML Schema attributes and elements to the encoding types used for binary XML data.

If you register an XML schema using option `REGISTER_BINARYXML`, then XML instance documents that reference that XML schema are stored as binary XML, and their XML Schema data types are encoded in the binary XML data. Each XML Schema data type is mapped to a default binary XML encoding type, but you can override this default mapping by using XML attribute `csx:encodingType`.

Different XML schemas specify possibly different binary XML encodings. If you used option `ALLOW ANYSCHEMA` when you created the `XMLType` table or column, then XML documents that reference different XML schemas, and that therefore might have different binary XML encodings, can be stored in the same `XMLType` column or table.

Note: The binary XML encoding type has no effect on the data types of values used in query results. For example, SQL functions such as `extractValue` return data from a query using a SQL value, and for that they use the default data-type mapping between XML Schema and SQL.

Table 6–11 describes the available binary XML encoding types.Table 6–12 describes how they map to XML Schema data types by default, and which binary XML encoding types you can use to override the default mapping.

Table 6–11 Binary XML Encoding Types

Binary XML Encoding Type	Description
`string`	UTF-8 character data
`binary`	binary data
`boolean`	1 for `true`, 0 for `false` (one byte)
	This is always decoded to XML Schema as `true` or `false`, never as `1` or `0`.
`int`	signed, twos-complement, big-endian integer (1, 2, 4, or 8 bytes)
`unsigned-int`	twos-complement, big-endian integer (1, 2, 4, or 8 bytes)
`float`	IEEE-754 floating-point number (4 or 8 bytes)

Table 6–11 (Cont.) Binary XML Encoding Types

Binary XML Encoding Type	Description
`oranum`	Oracle internal number representation (maximum of 22 bytes)
	Numbers from 1.0×10^{-130} to 1.0×10^{126}. Maximum precision: 38 digits. Maximum scale: -84 to 127.
`oradate`	Oracle internal format for Gregorian dates (7 bytes)
	No fractional seconds. No time-zone information.
`orats`	Oracle internal format for Gregorian dates with time zone information (timestamp)
	1–9 digits for fractional seconds. An XML Schema time-zone component specified originally as `Z` and stored using `orats` is decoded to XML Schema as `+00:00`.
`epoch`	number of seconds since January 1, 1970 (4 or 8 bytes, signed binary)
	No fractional seconds. No time-zone information.
`epochtz`	same as `epoch`, but followed by number of minutes from GMT (4 or 8 bytes, signed binary, followed by 2-byte signed number)
	An XML Schema time-zone component specified originally as `Z` and stored using `epochtz` is decoded to XML Schema as `+00:00`.
`enum`	unsigned integers, starting with zero, one for each possible enumeration value, in the order of definition in the XML schema
`qname`	token ID followed by prefix ID (4 or 8 bytes, followed by 2 bytes)

Table 6–12 Mapping XML Schema Data Types to Binary XML Encoding Types

XML Schema Type	Binary XML Encoding Type	Compatible Encoding Types
`string`	`string`	none
`hexBinary`	`binary`	`string`
`base64binary`	`binary`	`string`
`float`	`float`	`string`
`double`	`float`	`string`
`decimal`	`oranum`	`string`
`integer`	`oranum`	`string`
`nonNegativeInteger`	`oranum`	`string`
`positiveInteger`	`oranum`	`string`
`nonPositiveInteger`	`oranum`	`string`
`negativeInteger`	`oranum`	`string`
`long`	`int`	`oranum`, `string`
`unsignedLong`	`unsigned-int`	`oranum`, `string`
`int`	`int`	`oranum`, `string`
`unsignedInt`	`unsigned-int`	`oranum`, `string`
`short`	`int`	`oranum`, `string`
`unsignedShort`	`unsigned-int`	`oranum`, `string`
`byte`	`int`	`oranum`, `string`

Table 6–12 (Cont.) Mapping XML Schema Data Types to Binary XML Encoding Types

XML Schema Type	Binary XML Encoding Type	Compatible Encoding Types
unsignedByte	unsigned-int	oranum, string
dateTime	orats	oradate, epoch, epochtz, string
time	orats	oradate, epoch, epochtz, string
date	orats	oradate, epoch, epochtz, string
gDay	orats	oradate, epoch, epochtz, string
gMonth	orats	oradate, epoch, epochtz, string
gYear	orats	oradate, epoch, epochtz, string
gYearMonth	orats	oradate, epoch, epochtz, string
gMonthDay	orats	oradate, epoch, epochtz, string
duration	string	none
boolean	boolean	string
language	string	none
NMTOKEN	string	none
NMTOKENS	string	none
Name	string	none
NCName	string	none
ID	string	none
IDREF	string	none
IDREFS	string	none
ENTITY	string	none
ENTITITES	string	none
NOTATION	string	none
anyURI	string	none
anyType	internal encoding[1]	none
anySimpleType	string	none
QName	qname	string
normalizedString	string	none
token	string	none

[1] You cannot specify the encoding type for XML Schema type anyType.

7

XPath Rewrite

This chapter explains the fundamentals of XPath rewrite in Oracle XML DB and how to use it for XML schema-based structured storage. It details the rewriting of XPath-expression arguments to these SQL functions: `existsNode`, `extract`, `extractValue`, `XMLSequence`, `updateXML`, `insertChildXml`, and `deleteXML`.

This chapter contains these topics:

See Also: "XPath Rewrite on XMLType Views" on page 19-19

Overview of XPath Rewrite

For XML schema-based data that is stored object-relationally (structured storage), when you query that data using XQuery expressions your queries can often be rewritten directly to the underlying object-relational columns. This rewrite of queries can also happen when you use queries with XQuery expressions on certain non-schema-based `XMLType` views. The optimization process of rewriting XQuery expressions is called **XPath rewrite**.

This optimization enables the use of B-tree or other indexes, if present on the column, to be used in query evaluation by the Optimizer. This XPath rewrite mechanism is used for XPath-expression arguments to SQL functions such as `XMLQuery`, `XMLTable`, `XMLExists`, `existsNode`, `extract`, `extractValue`, and `updateXML`. This enables the XPath expression to be evaluated against the XML document without constructing the XML document in memory.

The XPath expressions that are rewritten by Oracle XML DB are a proper subset of those that are supported by Oracle XML DB. Whenever you can do so without losing functionality, use XPath expressions that can be rewritten.

Example 7–1 XPath Rewrite

For example, a query such as the following tries to obtain the `Company` element and compare it with the literal string '`Oracle`':

```
SELECT OBJECT_VALUE FROM mypurchaseorders
  WHERE extractValue(OBJECT_VALUE, '/PurchaseOrder/Company') = 'Oracle';
```

Assuming that table `mypurchaseorders` was created with XML schema-based structured storage, the `extractValue` expression is rewritten to the underlying relational column that stores the company information for the purchase order. The query is rewritten to the following:

```
SELECT VALUE(p) FROM mypurchaseorders p WHERE p.XMLDATA."Company" = 'Oracle';
```

> **Note:** `XMLDATA` is a `XMLType` pseudocolumn that enables direct access to the underlying object column. See Chapter 4, "XMLType Operations".

If there is an index such as the following created on the `Company` column, then the preceding query uses that index for its evaluation.

```
CREATE INDEX company_index
  ON mypurchaseorders e (extractValue(OBJECT_VALUE, '/PurchaseOrder/Company'));
```

XPath rewrite happens for XML schema-based tables and both XML schema-based and non-schema-based views. In this chapter, we consider only examples related to XML schema-based tables.

The XPath argument to SQL function `updateXML` in Example 7–2 is rewritten to the equivalent object relational SQL statement of Example 7–3.

Example 7–2 XPath Rewrite with UPDATEXML

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

EXTRACTVAL
----------
SBELL

1 row selected.

UPDATE purchaseorder
  SET OBJECT_VALUE = updateXML(OBJECT_VALUE, '/PurchaseOrder/User/text()', 'SVOLLMAN')
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

EXTRACTVAL
----------
SVOLLMAN

1 row selected.
```

Example 7–3 Rewritten Object Relational Equivalent of XPath Rewrite with UPDATEXML

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

EXTRACTVAL
```

```
----------
SBELL

1 row selected.

UPDATE purchaseorder p
  SET p."XMLDATA"."userid" = 'SVOLLMAN'
  WHERE p."XMLDATA"."reference" = 'SBELL-20021009123336O1PDT';

1 row updated.

SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/User')
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;

EXTRACTVAL
----------
SVOLLMAN

1 row selected.
```

See Also: Chapter 3, "Using Oracle XML DB", "Understanding and Optimizing XPath Rewrite" on page 3-59, for additional examples of XPath rewrite over XML schema-based and non-schema-based views.

Where Does XPath Rewrite Occur?

XPath rewrite occurs for the following SQL functions:

- `deleteXML`
- `existsNode`
- `extract`
- `extractValue`
- `insertChildXML`
- `updateXML`
- `XMLExists`
- `XMLQuery`
- `XMLSequence`
- `XMLTable`

XPath rewrite can happen when these SQL functions are present in any expression in a query, a DML statement, or a DDL statement. For example, you can use SQL function `extractValue` to create indexes on the underlying relational columns.

Example 7–4 SELECT Statement and XPath Rewrite

This example returns the existing purchase orders:

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/Company')
  FROM mypurchaseorders x
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder/Item[1]/Part') = 1;
```

Example 7–5 and Example 7–6 show statements that are rewritten to use underlying columns. Example 7–5 deletes all `PurchaseOrders` where the `Company` is not `Oracle`.

Example 7–5 DML Statement and XPath Rewrite

```
DELETE FROM mypurchaseorders x
  WHERE extractValue(OBJECT_VALUE, '/PurchaseOrder/Company') = 'Oracle Corp';
```

Example 7–6 creates an index on the `Company` column.

Example 7–6 CREATE INDEX Statement and XPath Rewrite

```
CREATE INDEX company_index
  ON mypurchaseorders e (extractValue(OBJECT_VALUE,'/PurchaseOrder/Company'));
```

Because the `Company` column is stored object-relationally and XPath rewrite occurs, an index is created on the underlying relational column. In this case, if the rewrite of the SQL functions results in a simple relational column, then the index is turned into a B-tree or a domain index on the column, rather than a function-based index.

Which XPath Expressions Are Rewritten?

An XPath expression can generally be rewritten if *all* of the following are true:

- The SQL function or `XMLType` method can be rewritten.

  SQL functions `XMLQuery`, `XMLTable`, `XMLExists`, `extract`, `existsNode`, `extractValue`, `updateXML`, `insertChildXML`, `deleteXML`, and `XMLSequence` can be rewritten. Except methods `existsNode()` and `extract()`, *none* of the corresponding `XMLType` *methods* can be rewritten.

- The XPath expression uses only the `descendant` axis.

  Expressions involving axes (such as `parent` and sibling) other than `descendant` *cannot* be rewritten. Expressions that select attributes, elements, or text nodes can be rewritten. XPath predicates can be rewritten to SQL predicates.

- The XML Schema constructs for the XPath expression can be rewritten.

  XML Schema constructs such as complex types, enumerated values, lists, inherited (derived) types, and substitution groups can be rewritten.

- The storage structure chosen during XML schema registration can be rewritten.

  XML data stored object-relationally (structured storage) can be rewritten. Storage of complex types using `CLOB` instances (hybrid storage) *cannot* be rewritten.

Table 7–1 lists some of the kinds of XPath expressions that can be translated into underlying SQL queries.

Table 7–1 Sample List of XPath Expressions for Rewrite to Underlying SQL Constructs

XPath Expression for Translation	Description

Simple XPath expressions:
`/PurchaseOrder/@PurchaseDate`
`/PurchaseOrder/Company`
	Involves traversals over object type attributes only, where the attributes are simple scalar or object types themselves. The only axes supported are the child and the attribute axes.

Collection traversal expressions: `/PurchaseOrder/Item/Part`	Involves traversal of collection expressions. The only axes supported are child and attribute axes. Collection traversal is not supported if the SQL function is used during a `CREATE INDEX` operation.
Predicates: `[Company = "Oracle"]`	Predicates in the XPath are rewritten into SQL predicates.

Table 7–1 (Cont.) Sample List of XPath Expressions for Rewrite to Underlying SQL Constructs

XPath Expression for Translation	Description
List index (positional predicate): `lineitem[1]`	Indexes are rewritten to access the nth item in a collection. These are not rewritten for `updateXML`, `insertChildXML`, and `deleteXML`.
Wildcard traversals: `/PurchaseOrder/*/Part`	If the wildcard can be translated to a unique XPath (for example, `/PurchaseOrder/Item/Part`), then it is rewritten, unless it is the last entry in the path expression.
Descendant axis (XML schema-based data only): `/PurchaseOrder//Part`	Similar to a wildcard expression. The descendant axis is rewritten if it can be mapped to a unique XPath expression and the subsequent element is not involved in a recursive type definition. In some cases, rewriting is possible even if there is a recursive definition.

Oracle-provided extension functions and some XPath functions
`not`, `floor`, `ceiling`, `substring`, `string-length`, `translate`
`ora:contains`
	Any function from the Oracle XML DB namespace (`http://xmlns.oracle.com/xdb`) is rewritten into the underlying SQL function. Some XPath functions are rewritten.

String bind variables inside predicates `'/PurchaseOrder[@Id="'|| :1 || '"]'`	XPath expressions using SQL bind variables are rewritten if they occur between the concatenation (||) operators and are inside the double-quotes.
Un-nest operations using `XMLSequence` `table(XMLSequence(extract(...)))`	When used in a `table` function call, `XMLSequence` combined with `extract` is rewritten to use the underlying ordered collection tables.[1]

[1] A more readable alternative to using `table` with `XMLSequence` is using standard SQL/XML function `XMLTable`.

Common XML Schema Constructs Supported in XPath Rewrite

In addition to standard XML Schema constructs such as `complexType` elements and sequences, the following XML Schema constructs are also supported. This is not an exhaustive list.

- Collections of scalar values, where the scalar values are used in predicates.
- Simple type extensions containing attributes.
- Enumerated simple types.
- Boolean simple type.
- Inheritance of complex types.
- Substitution groups.

Unsupported XML Schema Constructs in XPath Rewrite

The following XML Schema constructs are not supported. This means that if an XPath expression includes nodes with any of the following XML Schema constructs, then the expression is not rewritten:

- XPath expressions accessing children of elements that contain `any` content. When nodes contain `any` content, the expression cannot be rewritten, except when the `any` targets a namespace other than the namespace specified in the XPath. The `any` attributes are handled in a similar way.
- Data-type operations that cannot be coerced, such as the sum of a Boolean value and a number.

Common Storage Constructs Supported in XPath Rewrite

The following storage constructs are supported for XPath rewrite:

- Simple numeric types that are mapped to SQL data type `RAW`.
- Various date and time types that are mapped to SQL data type `TIMESTAMP_WITH_TZ`.
- Collections stored inline, out-of-line, and as OCTs.
- XML functions over XML schema-based and non-schema-based `XMLType` views, and SQL/XML views.

See Also: Chapter 19, "XMLType Views"

Unsupported Storage Constructs in XPath Rewrite

The following XML Schema storage constructs are not supported. This means that if an XPath expression includes nodes with the following storage construct, then the expression is not rewritten:

- If an XML schema maps part of an element definitions to a SQL `CLOB` instance, then XPath expressions that traverse such elements are *cannot* be rewritten

XPath Rewrite Can Change Comparison Semantics

For the most part, there is no difference between rewritten XPath queries and functionally evaluated ones. However, since XPath rewrite uses XML Schema information to turn XPath predicates into SQL predicates, comparison of nonnumeric entities is different.

In XPath 1.0, the comparison operators, >, <, >=, and <=, use only numeric comparison. The two operands are converted to numeric values before comparison. If either of them fails to be converted to a numeric value, then the comparison returns `false`.

For instance, an XPath predicate such as `[ShipDate < '2003-02-01']` will always evaluate to `false` with functional evaluation, for an XML schema element definition such as the following:

```
<element name="ShipDate" type="xs:date" xdb:SQLType="DATE"/>
```

This is because the string value `'2003-02-01'` cannot be converted to a numeric quantity. With XPath rewrite, however, this predicate is translated to a SQL *date* comparison, and this will evaluate to `true` or `false`, depending on the value of `ShipDate`.

Similarly if a collection value is compared with another collection value, the XPath 1.0 semantics dictate that the values must be converted to strings and then compared. With XPath rewrite, however, the comparison uses the rules for comparing SQL values.

To suppress this difference in comparison behavior, you can turn off rewrite either using query hints or session level events.

How Are XPath Expressions Rewritten?

This section uses the same purchase-order XML schema introduced earlier in this chapter.

Example 7–7 Creating XML Schema-Based Purchase-Order Data

```
DECLARE
  doc VARCHAR2(2000) :=
   '<schema
     targetNamespace="http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
     xmlns:po="http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
     xmlns="http://www.w3.org/2001/XMLSchema"
     elementFormDefault="qualified">
      <complexType name="PurchaseOrderType">
        <sequence>
          <element name="PONum" type="decimal"/>
          <element name="Company">
            <simpleType>
              <restriction base="string">
                <maxLength value="100"/>
              </restriction>
            </simpleType>
          </element>
          <element name="Item" maxOccurs="1000">
            <complexType>
              <sequence>
                <element name="Part">
                  <simpleType>
                    <restriction base="string">
                      <maxLength value="20"/>
                    </restriction>
                  </simpleType>
                </element>
                <element name="Price" type="float"/>
              </sequence>
            </complexType>
          </element>
        </sequence>
      </complexType>
      <element name="PurchaseOrder" type="po:PurchaseOrderType"/>
    </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd', doc);
END;
/
```

The XML schema registration creates internal SQL data types. We can now create a table to store the XML values and an ordered collection table to store the items.

```
CREATE TABLE mypurchaseorders OF XMLType
  XMLSchema "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
  ELEMENT "PurchaseOrder"
  VARRAY XMLDATA."Item" STORE AS TABLE item_nested;

Table created
```

Now, we insert a purchase order into this table.

```
INSERT INTO mypurchaseorders
  VALUES(
   XMLType(
     '<PurchaseOrder
          xmlns="http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xsi:schemaLocation
```

```
        = "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd
           http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd">
  <PONum>1001</PONum>
  <Company>Oracle Corp</Company>
  <Item>
    <Part>9i Doc Set</Part>
    <Price>2550</Price>
  </Item>
  <Item>
    <Part>8i Doc Set</Part>
    <Price>350</Price>
  </Item>
</PurchaseOrder>'));
```

Because the XML schema did not specify anything about maintaining the ordering, the default behavior is to maintain the ordering and DOM fidelity. Hence the data types have the `SYS_XDBPD$` (PD) attribute, to store the extra information needed to maintain the ordering of nodes and to capture extra items such as comments and processing instructions.

Object attribute `SYS_XDBPD$` also maintains existential information for the elements, that is, whether or not the element was present in the input document. This is needed for `simpleType` elements, because they map to simple relational columns. Both empty and missing `simpleType` elements map to `NULL` values in the column, and the `SYS_XDBPD$` attribute can be used to distinguish the two cases. The XPath rewrite mechanism takes into account the presence or absence of attribute `SYS_XDBPD$`, and rewrites queries appropriately.

This table has a pseudocolumn `XMLDATA` of type `purchaseorder_t` that stores the actual data.

Rewriting XPath Expressions: Mapping Data Types and Path Expressions

This section describes the mapping of XPath expressions to SQL data types and path expressions.

Mapping for a Simple XPath Expression

A rewrite for a simple XPath expression involves accessing the SQL column corresponding to the expression, as shown in Table 7–2.

Table 7–2 Simple XPath Mapping for purchaseOrder XML Schema

XPath Expression	Maps to
`/PurchaseOrder`	column `XMLDATA`
`/PurchaseOrder/@PurchaseDate`	column `XMLDATA."PurchaseDate"`
`/PurchaseOrder/PONum`	column `XMLDATA."PONum"`
`/PurchaseOrder/Item`	elements of the collection `XMLDATA."Item"`
`/PurchaseOrder/Item/Part`	attribute `"Part"` in the collection `XMLDATA."Item"`

Mapping for simpleType Elements

An XPath expression can contain a `text()` node test, which targets the text node (content) of an element. When rewriting, this maps directly to the underlying relational columns. For example, the XPath expression

"/PurchaseOrder/PONum/text()" maps directly to the SQL column XMLDATA."PONum".

A NULL in the PONum column implies that the text value is not available: either the text() node test is not present in the input document or the element itself is missing. If the column is NULL, there is no need to check for the existence of the element in the SYS_XBDPD$ attribute.

The XPath "/PurchaseOrder/PONum" also maps to the SQL column XMLDATA."PONum". However, in this case, XPath rewrite must check for the existence of the element itself, using attribute SYS_XDBPD$ in column XMLDATA.

Mapping of Predicates

XPath predicates are mapped to SQL predicate expressions. The comparison rules of SQL are used instead of the XPath 1.0 semantics for comparison—see "XPath Rewrite Can Change Comparison Semantics" on page 7-6.

For example, the predicate in the XPath expression /PurchaseOrder[PONum=1001 and Company = "Oracle Corp"] maps to the SQL predicate (XMLDATA."PONum" = 20 AND XMLDATA."Company" = "Oracle Corp").

Example 7–8 Mapping Predicates

This query is rewritten to the structured (object-relational) equivalent:

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Item').getCLOBval()
  FROM mypurchaseorders p
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[PONum=1001 AND Company = "Oracle Corp"]') = 1;
```

Mapping of Collection Predicates XPath expressions can involve relational collection expressions. In Xpath 1.0, these are treated as existential checks: if at least one member of the collection satisfies the expression, then the expression is true.

Example 7–9 Mapping Collection Predicates

The collection predicate in this XPath expression involves the relational greater-than operator (>):

```
/PurchaseOrder[Items/Price > 200]
```

This maps to the following SQL collection expression:

```
exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE x."Price" > 200)
```

In this example, a collection is related to a scalar value. More complicated rewrites occur with a relation between two collections. For example, in the following XPath expression, both LineItems and ShippedItems are collections.

```
/PurchaseOrder[LineItems = ShippedItems]
```

In this case, if *any* combination of nodes from these two collections satisfies the equality, then the predicate is considered satisfied.

Example 7–10 Mapping Collection Predicates, Using EXISTSNODE

Consider an XPath that checks if a Purchaseorder has Items whose Price and Part number happen to be the same: /PurchaseOrder[Items/Price = Items/Part]. This maps to a SQL collection expression such as the following:

```
EXISTS (SELECT NULL
```

```
          FROM table(XMLDATA."Item") x
          WHERE EXISTS (SELECT NULL FROM table(XMLDATA."Item") y
                                    WHERE  y."Part" = x."Price"))
```

The following query is rewritten to a structured equivalent, similar to this:

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Item').getCLOBval()
  FROM  mypurchaseorders p
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Item/Price = Item/Part]') = 1;
```

Document Ordering with Collection Traversals

Most of the rewrite preserves the original document ordering. However, because SQL does not guarantee ordering on the results of subqueries when selecting elements from a collection using SQL function `extract`, the resultant nodes may not be in document order.

Example 7–11 Document Ordering with Collection Traversals

For example:

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder/Item[Price>2100]/Part')
  FROM mypurchaseorders p;
```

This query is rewritten to use a subquery:

```
SELECT (SELECT XMLAgg(XMLForest(x."Part" AS "Part"))
          FROM table(XMLDATA."Item") x WHERE  x."Price" > 2100)
  FROM mypurchaseorders p;
```

In most cases, the result of the aggregation is in the same order as the collection elements, but this is not guaranteed. So, the results may not be in document order.

Schema-Based: Collection Position

An XPath expression can also access an element at a particular position of a collection. For example, `"/PurchaseOrder/Item[1]/Part"` is rewritten to extract out the first `Item` element of the collection, and access the `Part` attribute within that.

If the collection is stored as a varray, then this operation retrieves the nodes in the same order as in the original document. If the collection is stored as an unordered table, then the order is indeterminate.

XPath Expressions That Cannot Be Satisfied

An XPath expression can contain references to nodes that cannot be present in the input document. Such parts of the expression map to SQL `NULL` values during rewrite. For example, the XPath expression `/PurchaseOrder/ShipAddress` cannot be satisfied by any instance document conforming to the `purchaseorder.xsd` XML schema, because the schema does not allow for `ShipAddress` elements under `PurchaseOrder`. Hence this expression would map to a SQL `NULL` literal.

Namespace Handling

Namespaces are handled in the same way as function-based evaluation. For schema-based documents, if the function (such as `existsNode` or `extract`) does not specify any namespace parameter, then the target namespace of the schema is used as the default namespace for the XPath expression.

Example 7–12 Handling Namespaces

For example, the XPath expression `/PurchaseOrder/PONum` is treated as `/a:PurchaseOrder/a:PONum` with `xmlns:a = "http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd"` if the SQL function does not explicitly specify the namespace prefix and mapping. In other words:

```
SELECT * FROM mypurchaseorders p
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder/PONum') = 1;
```

is equivalent to the query:

```
SELECT *
  FROM mypurchaseorders p
  WHERE existsNode(
          OBJECT_VALUE,
          '/PurchaseOrder/PONum',
          'xmlns="http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd')
        = 1;
```

When performing XPath rewrite, the namespace for a particular element is matched with that of the XML schema definition. If the XML schema contains `elementFormDefault = "qualified"` then each node in the XPath expression must target a namespace (this can be done using a default namespace specification or by prefixing each node with a namespace prefix).

If the `elementFormDefault` is unqualified (which is the default), then only the node that defines the namespace should contain a prefix. For instance if the `purchaseorder.xsd` had the element form to be unqualified, then `existsNode` expression should be rewritten as follows:

```
existsNode(
  OBJECT_VALUE,
  '/a:PurchaseOrder/PONum',
  'xmlns:a="http://xmlns.oracle.com/xdb/documentation/purchaseOrder.xsd")
= 1;
```

> **Note:** For the case where `elementFormDefault` is unqualified, omitting the namespace parameter in the `existsNode` expression in the preceding example would cause each node to default to the target namespace. This would not match the XML schema definition and consequently would not return any result. This is true whether or not the function is rewritten.

Date Format Conversions

Date data types such as `date`, `gMonth`, and `gDate` have different format in XML Schema and SQL. If an expression has a string value for columns of such data types, then the rewrite automatically provides the XML format string to convert the string value correctly. Thus, the string value specified for a `date` column must match the XML `date` format, not the SQL `DATE` format.

Example 7–13 Date Format Conversions

For example, the expression `[@PurchaseDate="2002-02-01"]` cannot be simply rewritten as `XMLDATA."PurchaseDate"="2002-02-01"`, because the default date format for SQL is not `YYYY-MM-DD`. Hence during XPath rewrite, the XML format

string is added to convert text values into date data types correctly. Thus the preceding predicate would be rewritten as:

```
XMLDATA."PurchaseDate" = TO_DATE("2002-02-01","SYYYY-MM-DD");
```

Similarly when converting these columns to text values (needed for functions such as `extract`), XML format strings are added to convert them to the same date format as XML.

Existential Checks for Attributes and Elements with Scalar Values

SQL function `existsNode` checks for the existence of a node addressed by an XPath; function `extract` returns a node addressed by an XPath. Oracle XML DB needs to perform special checks for `simpleType` elements and for attributes used in `existsNode` expressions. This is because the SQL column value alone cannot distinguish whether an attribute or a `simpleType` element is missing or is empty; a `NULL` SQL column can represent either. These special checks are not required for intermediate elements, because the value of the user-defined SQL data type indicates the absence or emptiness of the element.

Consider, for example, this expression:

```
existsNode(OBJECT_VALUE, '/PurchaseOrder/PONum/text()') = 1;
```

Because the query is only interested in the text value of the node, this is rewritten to:

```
(p.XMLDATA."PONum" IS NOT NULL)
```

Consider this expression, without the `text()` node test:

```
existsNode(OBJECT_VALUE, '/PurchaseOrder/PONum') = 1;
```

In this case, Oracle XML DB must check the `SYS_XDBPD$` attribute in the parent node to determine whether the element is empty or is missing. This check is done *internally*. It can be represented in *pseudocode* as follows:

```
node_exists(p.XMLDATA."SYS_XDBPD$", "PONum")
```

The pseudofunction ***`node_exists`*** is used for illustration only. It represents an Oracle XML DB implementation that uses its first argument, the positional-descriptor (PD) column (`SYS_XDBPD$`), to determine whether or not its second argument (element or attribute) node exists. It returns true if so, and false if not.

In the case of `extract` expressions, this check needs to be done for both attributes and elements. An expression of the form `extract(OBJECT_VALUE, '/PurchaseOrder/PONum')` maps to pseudocode such as the following:

```
CASE WHEN node_exists(p.XMLDATA.SYS_XDBPD$", "PONum")
       THEN XMLElement("PONum", p.XMLDATA."PONum")
       ELSE NULL END;
```

> **Note:** Be aware of this overhead when writing `existsNode` and `extract` expressions. You can avoid this overhead by using a `text()` node test in the XPath expression; using `extractValue` to obtain only the node value; or by turning off DOM fidelity for the parent node. DOM fidelity can be turned off by setting the value of the attribute `maintainDOM` in the element definition to be `false`. When turned off, empty elements and attributes are treated as missing.

Diagnosing XPath Rewrite

This section presents techniques to determine if your XPath expressions are in fact being rewritten.

Using EXPLAIN PLAN with XPath Rewrite

This section shows how you can use `EXPLAIN PLAN` to examine query plans after XPath rewrite. See "Understanding and Optimizing XPath Rewrite" on page 3-59 for how to use `EXPLAIN PLAN` to optimize XPath rewrite.

If a query evaluation plan does not pick applicable indexes and shows the presence of the SQL function (such as `existsNode` or `extract`), then you know that the rewrite has not occurred. You can then use events to understand why XPath rewrite did not occur—see "Using Events with XPath Rewrite" on page 7-14.

For example, using table `mypurchaseorders` we can see the use of `EXPLAIN PLAN`. We create an index on the `Company` element of `PurchaseOrder` to show how the plans differ.

```
CREATE INDEX company_index ON mypurchaseorders
       (extractValue(OBJECT_VALUE,'/PurchaseOrder/Company'));

Index created.

EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum')
    FROM mypurchaseorders
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Company="Oracle"]') = 1;

Explained.

SELECT PLAN_TABLE_OUTPUT
  FROM table(DBMS_XPLAN.display('plan_table', NULL, 'serial'))
/

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------
| Id  | Operation                    | Name             | Rows | Bytes | Cost |
-------------------------------------------------------------------------------
|   0 | SELECT STATEMENT             |                  |      |       |      |
|   1 |  TABLE ACCESS BY INDEX ROWID | MYPURCHASEORDERS |      |       |      |
|*  2 |   INDEX RANGE SCAN           | COMPANY_INDEX    |      |       |      |
-------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   2 - access("MYPURCHASEORDERS"."SYS_NC00010$"='Oracle')
```

In this explain plan, you can see that the predicate uses internal columns and picks up the index on the `Company` element. This shows that the query has been rewritten to the underlying relational columns.

In the following query, we are trying to perform an arithmetic operation on the `Company` element which is a string type. This is not rewritten, and the `EXPLAIN PLAN` shows that the predicate contains the original `existsNode` expression. Also, since the predicate is not rewritten, a full table scan is used instead of an index range scan.

```
EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum')
    FROM mypurchaseorders
```

```
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Company+PONum="Oracle"]') = 1;

Explained.

SELECT PLAN_TABLE_OUTPUT
  FROM table(DBMS_XPLAN.display('plan_table', NULL, 'serial'))
/

PLAN_TABLE_OUTPUT
-----------------------------------------------------------
| Id  | Operation          | Name
-----------------------------------------------------------
|   0 | SELECT STATEMENT   |
|*  1 |  FILTER            |
|   2 |   TABLE ACCESS FULL| MYPURCHASEORDERS
|*  3 |   TABLE ACCESS FULL| ITEM_NESTED
-----------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   1 - filter(EXISTSNODE(SYS_MAKEXML('C6DB2B4A1A3B0
              6CDE034080020E5CF39',2300,"MYPURCHASEORDERS"."XMLEXTRA",
              "MYPURCHASEORDERS"."XMLDATA"),
      '/PurchaseOrder[Company+PONum="Oracle"]')=1)
   3 - filter("NESTED_TABLE_ID"=:B1)
```

Using Events with XPath Rewrite

Events can be set in the initialization file or can be set for each session using the `ALTER SESSION` statement. The XML events can be used to turn off functional evaluation, turn off the XPath rewrite mechanism and to print diagnostic traces.

Turning Off Functional Evaluation (Event 19021)

By turning on this event, you can raise an error whenever any of the XML functions is not rewritten and is instead evaluated functionally. The error `ORA-19022 - XML XPath functions are disabled` will be raised when such functions execute. This event can also be used to selectively turn off functional evaluation of functions. Table 7–3 lists the various levels and the corresponding behavior.

Table 7–3 Event Levels and Behaviors

Event	Turn *off* functional evaluation of . . .
Level 0x1	all XML functions
Level 0x2	`extract`
Level 0x4	`existsNode`
Level 0x8	`transform`
Level 0x10	`extractValue`
Level 0x20	`updateXML`
Level 0x40	`insertXMLbefore`
Level 0x80	`appendChildXMl`
Level 0x100	`deleteXML`
Level 0x200	`XMLSequence`

Table 7–3 (Cont.) Event Levels and Behaviors

Event	Turn *off* functional evaluation of . . .
Level 0x4000	`insertChildXML`
Level 0x8000	`XMLQuery`

For example,

```
ALTER SESSION SET EVENTS '19021 trace name context forever, level 1';
```

would turn off the functional evaluation of all the XML operators listed earlier. Hence when you perform the query shown earlier that does not get rewritten, you will get an error during the execution of the query.

```
SELECT OBJECT_VALUE FROM mypurchaseorders
  WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Company+PONum="Oracle"]')=1 ;

ERROR:
ORA-19022: XML XPath functions are disabled
```

Tracing Reasons that Rewrite Does Not Occur

Event `19027` with level `8192` (0x2000) can be used to dump traces that indicate the reason that a particular XML function is not rewritten. For example, to check why the query described earlier, did not rewrite, we can set the event and run an `EXPLAIN PLAN`:

```
ALTER SESSION SET EVENTS '19027 TRACE NAME CONTEXT FOREVER, LEVEL 8192';

Session altered.

EXPLAIN PLAN FOR
  SELECT OBJECT_VALUE FROM mypurchaseorders
    WHERE existsNode(OBJECT_VALUE, '/PurchaseOrder[Company+100="Oracle"]') = 1;

Explained.
```

This writes the following the Oracle trace file explaining that the rewrite for the XPath did not occur since there are inputs to an arithmetic function that are not numeric.

```
NO REWRITE
        XPath ==> /PurchaseOrder[Company+PONum = "Oracle"]
        Reason ==> non numeric inputs to arith{2}{4}
```

XPath Rewrite of Individual SQL Functions

This section details XPath rewrite for SQL functions `existsNode`, `extractValue`, `extract`, `XMLSequence`, `updateXML`, `insertChildXML`, and `deleteXML`. It explains the overhead involved in certain types of operations using `existsNode` or `extract` and how to avoid it.

An *update* using one of these SQL functions normally involves updating a copy of the XML document and then replacing the entire document with the newly modified document.

When `XMLType` data is stored in an object-relational manner using XML-schema mapping, updates are optimized to directly modify pieces of the document in place. For example, an update of the `PONum` element can be rewritten to directly update

column XMLDATA."PONum", instead of materializing the whole document in memory and then performing the update.

Each of the functions updateXML, insertChildXML, and deleteXML must satisfy different conditions for it to use such rewrite optimization during update. If all of the conditions are satisfied, then the functional expression is rewritten into a simple relational update. For example:

```
UPDATE purchaseorder_table
  SET OBJECT_VALUE =
      updateXML(OBJECT_VALUE,
                '/PurchaseOrder/@PurchaseDate', '2002-01-02',
                '/PurchaseOrder/PONum/text()', 2200);
```

This update operation is rewritten as something like the following:

```
UPDATE purchaseorder_table p
  SET p.XMLDATA."PurchaseDate" = TO_DATE('2002-01-02', 'SYYYY-MM-DD'),
      p.XMLDATA."PONum" = 2100;
```

XPath Rewrite for EXISTSNODE

SQL function existsNode returns one (1) if the XPath argument targets a nonempty sequence of nodes (text, element, or attribute); otherwise, it returns zero (0). The value is determined differently, depending on the kind of node targeted by the XPath argument:

- If the XPath argument targets a text node (using node test text()) or a complexType element node, Oracle XML DB simply checks whether the database representation of the element content is NULL.
- Otherwise, the XPath argument targets a simpleType element node or an attribute node. Oracle XML DB checks for the existence of the node using the positional-descriptor attribute SYS_XDBPD$. If SYS_XDBPD$ is absent, then the existence of the node is determined by checking whether or not the column is NULL.

EXISTSNODE Mapping with Document Order Preserved

Table 7–4 shows the mapping of various XPath expressions in the case of SQL function existsNode when document ordering is preserved; that is, when SYS_XDBPD$ exists and maintainDOM = "true" is present in the schema document.

Table 7–4 XPath Mapping for EXISTSNODE with Document Ordering Preserved

XPath Expression	Maps to
/PurchaseOrder	CASE WHEN XMLDATA IS NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder/@PurchaseDate	CASE WHEN *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PurchaseDate') THEN 1 ELSE 0 END
/PurchaseOrder/PONum	CASE WHEN *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PONum') THEN 1 ELSE 0 END
/PurchaseOrder[PONum = 2100]	CASE WHEN XMLDATA."PONum"=2100 THEN 1 ELSE 0
/PurchaseOrder[PONum = 2100]/@PurchaseDate	CASE WHEN XMLDATA."PONum"=2100 AND *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PurchaseDate') THEN 1 ELSE 0 END
/PurchaseOrder/PONum/text()	CASE WHEN XMLDATA."PONum" IS NOT NULL THEN 1 ELSE 0

Table 7–4 (Cont.) XPath Mapping for EXISTSNODE with Document Ordering Preserved

XPath Expression	Maps to
/PurchaseOrder/Item	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE value(x) IS NOT NULL) THEN 1 ELSE 0 END
/PurchaseOrder/Item/Part	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE *node_exists*[1](x.SYS_XDBPD$, 'Part')) THEN 1 ELSE 0 END
/PurchaseOrder/Item/Part/text()	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE x."Part" IS NOT NULL) THEN 1 ELSE 0 END

[1] Pseudofunction *node_exists* is used for illustration only. It represents an Oracle XML DB implementation that uses its first argument, the PD column, to determine whether or not its second argument node exists. It returns true if so, and false if not.

Example 7–14 EXISTSNODE Mapping with Document Order Preserved

Using the preceding mapping, this query checks whether purchase order 1001 contains a part with price greater than 2000:

```
SELECT count(*)
  FROM purchaseorder
  WHERE existsNode(OBJECT_VALUE,
                   '/PurchaseOrder[PONum=1001 and Item/Price > 2000]') = 1;
```

This is rewritten as something like the following:

```
SELECT count(*)
  FROM  purchaseorder p
  WHERE CASE WHEN p.XMLDATA."PONum" = 1001
             AND exists(SELECT NULL FROM table(XMLDATA."Item") p
                        WHERE  p."Price" > 2000 ))
              THEN 1
              ELSE 0
        END = 1;
```

This `CASE` expression is further optimized due to the constant relational equality expressions. The query becomes:

```
SELECT count(*)
  FROM purchaseorder p
  WHERE p.XMLDATA."PONum"=1001
    AND exists(SELECT NULL FROM table(p.XMLDATA."Item") x
                WHERE  x."Price" > 2000);
```

This uses relational indexes for its evaluation, if present on the `Part` and `PONum` columns.

EXISTSNODE Mapping Without Document Order Preserved

If the positional-descriptor attribute `SYS_XDBPD$` does not exist (that is, if the XML schema specifies `maintainDOM = "false"`) then `NULL` scalar columns map to `simpleType` elements that do not exist. In that case, you do not need to check for node existence using attribute `SYS_XDBPD$`. Table 7–5 shows the mapping of `existsNode` in the absence of the `SYS_XDBPD$` attribute.

Table 7–5 XPath Mapping for EXISTSNODE Without Document Ordering

XPath Expression	Maps to
/PurchaseOrder	CASE WHEN XMLDATA IS NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder/@PurchaseDate	CASE WHEN XMLDATA.'PurchaseDate' IS NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder/PONum	CASE WHEN XMLDATA."PONum" IS NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder[PONum = 2100]	CASE WHEN XMLDATA."PONum" = 2100 THEN 1 ELSE 0 END
/PurchaseOrder[PONum = 2100]/@PurchaseOrderDate	CASE WHEN XMLDATA."PONum" = 2100 AND XMLDATA."PurchaseDate" NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder/PONum/text()	CASE WHEN XMLDATA."PONum" IS NOT NULL THEN 1 ELSE 0 END
/PurchaseOrder/Item	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE value(x) IS NOT NULL) THEN 1 ELSE 0 END
/PurchaseOrder/Item/Part	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE x."Part" IS NOT NULL) THEN 1 ELSE 0 END
/PurchaseOrder/Item/Part/text()	CASE WHEN exists(SELECT NULL FROM table(XMLDATA."Item") x WHERE x."Part" IS NOT NULL) THEN 1 ELSE 0 END

XPath Rewrite for EXTRACTVALUE

SQL function `extractValue` is a shortcut for extracting text nodes and attributes using function `extract` and then using method `getStringVal()` or `getNumberVal()` to obtain the scalar content. Function `extractValue` returns the values of attribute nodes or the text nodes of elements with scalar values. Function `extractValue` cannot handle XPath expressions that return multiple values or `complexType` elements.

Table 7–6 shows the mappings of various XPath expressions for function `extractValue`. If an XPath expression targets an element, then `extractValue` retrieves the text node of the element. For example, `/PurchaseOrder/PONum` and `/PurchaseOrder/PONum/text()` are handled identically by `extractValue`: both retrieve the scalar content of `PONum`.

Table 7–6 XPath Mapping for EXTRACTVALUE

XPath Expression	Maps to
/PurchaseOrder	Not supported. Function `extractValue` can only retrieve values for scalar elements and attributes.
/PurchaseOrder/@PurchaseDate	XMLDATA."PurchaseDate"
/PurchaseOrder/PONum	XMLDATA."PONum"
/PurchaseOrder[PONum = 2100]	(SELECT TO_XML(x.XMLDATA) FROM DUAL WHERE x."PONum" = 2100)
/PurchaseOrder[PONum = 2100]/@PurchaseDate	(SELECT x.XMLDATA."PurchaseDate") FROM DUAL WHERE x."PONum" = 2100)
/PurchaseOrder/PONum/text()	XMLDATA."PONum"
/PurchaseOrder/Item	Not supported. Function `extractValue` can only retrieve values for scalar elements and attributes.

Table 7–6 (Cont.) XPath Mapping for EXTRACTVALUE

XPath Expression	Maps to
`/PurchaseOrder/Item/Part`	Not supported. Function `extractValue` cannot retrieve multiple scalar values.
`/PurchaseOrder/Item/Part/text()`	Not supported. Function `extractValue` cannot retrieve multiple scalar values.

Example 7–15 Rewriting EXTRACTVALUE

Consider this SQL query:

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum') FROM purchaseorder
  WHERE extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum') = 1001;
```

This query would be rewritten as something like the following:

```
SELECT p.XMLDATA."PONum" FROM purchaseorder p WHERE p.XMLDATA."PONum" = 1001;
```

Because it gets rewritten to simple scalar columns, any indexes on attribute `PONum` can be used to satisfy the query.

Creating Indexes with EXTRACTVALUE

Function `extractValue` can be used in index expressions. If the expression gets rewritten into scalar columns, then the index is turned into a B-tree index instead of a function-based index.

Example 7–16 Creating Indexes with EXTRACTVALUE

```
CREATE INDEX my_po_index ON purchaseorder
  (extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference);
```

This would get rewritten into something like the following:

```
CREATE INDEX my_po_index ON purchaseorder x (x.XMLDATA."Reference");
```

This produces a regular B-tree index. Unlike a function-based index, the same index can now satisfy queries that target the column, such as the following:

```
existsNode(OBJECT_VALUE, '/PurchaseOrder[Reference="SBELL-20021009123336O1PDT"]') = 1;
```

XPath Rewrite for EXTRACT

SQL function `extract` retrieves XPath results as XML. For Xpath expressions involving text nodes, `extract` is rewritten similarly to `extractValue`.

EXTRACT Mapping with Document Order Maintained

Table 7–7 shows the mapping of various XPath expressions inside `extract` expressions when document order is preserved (that is, when `SYS_XDBPD$` exists and `maintainDOM = "true"` in the XML schema document).

Table 7–7 XPath Mapping for EXTRACT with Document Ordering Preserved

XPath	Maps to
/PurchaseOrder	XMLForest(XMLDATA AS "PurchaseOrder")
/PurchaseOrder/@PurchaseDate	CASE WHEN *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PurchaseDate') THEN XMLElement("", XMLDATA."PurchaseDate") ELSE NULL END;
/PurchaseOrder/PONum	CASE WHEN *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PONum') THEN XMLElement("PONum", XMLDATA."PONum") ELSE NULL END
/PurchaseOrder[PONum = 2100]	SELECT XMLForest(XMLDATA as "PurchaseOrder") FROM DUAL WHERE XMLDATA."PONum" = 2100
/PurchaseOrder [PONum = 2100]/@PurchaseDate	SELECT CASE WHEN *node_exists*[1](XMLDATA.SYS_XDBPD$, 'PurchaseDate') THEN XMLElement("", XMLDATA."PurchaseDate") ELSE NULL END FROM DUAL WHERE XMLDATA."PONum" = 2100
/PurchaseOrder/PONum/text()	XMLElement("", XMLDATA."PONum")
/PurchaseOrder/Item	SELECT XMLAgg(XMLForest(value(it) AS "Item")) FROM table(XMLDATA."Item") it
/PurchaseOrder/Item/Part	SELECT XMLAgg(CASE WHEN *node_exists*[1](p.SYS_XDBPD$, 'Part') THEN XMLForest(p."Part" AS "Part") ELSE NULL END) FROM table(XMLDATA."Item") p
/PurchaseOrder/Item/Part/text()	SELECT XMLAgg(XMLElement("", p."Part")) FROM table(XMLDATA."Item") p

[1] Pseudofunction *node_exists* is used for illustration only. It represents an Oracle XML DB implementation that uses its first argument, the PD column, to determine whether or not its second argument node exists. It returns true if so, and false if not.

Example 7–17 XPath Mapping for EXTRACT with Document Ordering Preserved

Using the mapping in Table 7–7, consider this query that extracts the PONum element, where the purchase order contains a part with price greater than 2000:

```
SELECT extract(OBJECT_VALUE, '/PurchaseOrder[Item/Part > 2000]/PONum')
  FROM purchaseorder_table;
```

This query would become something like the following:

```
SELECT (SELECT CASE WHEN node_exists(p.XMLDATA.SYS_XDBPD$, 'PONum')
                    THEN XMLElement("PONum", p.XMLDATA."PONum")
                    ELSE NULL END
          FROM DUAL
          WHERE exists(SELECT NULL FROM table(XMLDATA."Item") p
                       WHERE  p."Part" > 2000))
  FROM purchaseorder_table p;
```

EXTRACT Mapping Without Maintaining Document Order

If attribute SYS_XDBPD$ does not exist (that is, if the XML schema specifies maintainDOM = "false"), then NULL scalar columns map to simpleType elements that do not exist. Hence you do not need to check for the node existence using attribute SYS_XDBPD$. Table 7–8 shows the mapping for function existsNode in the absence of SYS_XDBPD$.

Table 7–8 XPath Mapping for EXTRACT Without Document Ordering Preserved

XPath	Equivalent to
/PurchaseOrder	XMLForest(XMLDATA AS "PurchaseOrder")
/PurchaseOrder/@PurchaseDate	XMLForest(XMLDATA."PurchaseDate" AS "PurchaseDate")
/PurchaseOrder/PONum	XMLForest(XMLDATA."PONum" AS "PONum")
/PurchaseOrder[PONum = 2100]	SELECT XMLForest(XMLDATA AS "PurchaseOrder") FROM DUAL WHERE XMLDATA."PONum" = 2100
/PurchaseOrder [PONum = 2100]/@PurchaseDate	SELECT XMLForest(XMLDATA."PurchaseDate" AS "PurchaseDate "") FROM DUAL WHERE XMLDATA."PONum" = 2100
/PurchaseOrder/PONum/text()	XMLForest(XMLDATA.PONum AS "")
/PurchaseOrder/Item	SELECT XMLAgg(XMLForest(value(p) AS "Item") FROM table(XMLDATA."Item") p
/PurchaseOrder/Item/Part	SELECT XMLAgg(XMLForest(p."Part" AS "Part") FROM table(XMLDATA."Item") p
/PurchaseOrder/Item/Part/text()	SELECT XMLAgg(XMLForest(p. "Part" AS "Part")) FROM table(XMLDATA."Item") p

XPath Rewrite for XMLSEQUENCE

You can use SQL function `XMLSequence` in conjunction with SQL functions `extract` and `table` to un-nest XML collection values.[1] When used with XML schema-based storage, these functions also get rewritten to access the underlying relational collection storage.

For example, this query obtains the price and part numbers of all items in a relational form:

```
SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum') AS ponum,
       extractValue(value(it), '/Item/Part') AS part,
       extractValue(value(it), '/Item/Price') AS price
  FROM purchaseorder,
       table(XMLSequence(extract(OBJECT_VALUE, '/PurchaseOrder/Item'))) it;

PONUM PART                 PRICE
----- -------------------- ---------
1001  9i Doc Set           2550
1001  8i Doc Set            350
```

In this example, SQL function `extract` returns a fragment containing the list of `Item` elements. Function `XMLSequence` converts the fragment into a collection of `XMLType` values one for each `Item` element. Function `table` converts the elements of the collection into rows of `XMLType`. The XML data returned from `table` is used to extract the `Part` and the `Price` elements.

The applications of SQL functions `extract` and `XMLSequence` are rewritten to a simple `SELECT` operation on the ordered collection table (OCT) `item_nested`.

```
EXPLAIN PLAN
  FOR SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum') AS ponum,
             extractValue(value(it) , '/Item/Part') AS part,
             extractValue(value(it), '/Item/Price') AS price
        FROM purchaseorder,
```

[1] A more readable alternative to using function `table` with `XMLSequence` is using standard SQL/XML function `XMLTable`.

```
            table(XMLSequence(extract(OBJECT_VALUE, '/PurchaseOrder/Item'))) it;

Explained

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------
| Id  | Operation                     | Name            |
-------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |                 |
|   1 |  NESTED LOOPS                 |                 |
|   2 |   TABLE ACCESS FULL           | ITEM_NESTED     |
|   3 |   TABLE ACCESS BY INDEX ROWID | PURCHASEORDER   |
|*  4 |    INDEX UNIQUE SCAN          | SYS_C002973     |
-------------------------------------------------------------------------------

Predicate Information (identified by operation id)
---------------------------------------------------
   4 - access("NESTED_TABLE_ID"="SYS_ALIAS_1"."SYS_NC0001100012$")
```

The `EXPLAIN PLAN` output shows that the optimizer is able to use a simple nested-loops join between OCT `item_nested` and table `purchaseorder`. You can also query the `Item` values further and create appropriate indexes on the OCT, to speed up such queries.

For example, to search on the price to get all the expensive items, we could create an index on the `Price` column of the OCT. The following `EXPLAIN PLAN` uses a price index to obtain the list of items and then joins with table `purchaseorder` to obtain the `PONum` value.

```
CREATE INDEX price_index ON item_nested ("Price");

Index created.

EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/PurchaseOrder/PONum') AS ponum,
         extractValue(value(it), '/Item/Part') AS part,
         extractValue(value(it), '/Item/Price') AS price
    FROM  purchaseorder,
          table(XMLSequence(extract(OBJECT_VALUE, '/PurchaseOrder/Item'))) it
    WHERE extractValue(value(it), '/Item/Price') > 2000;

Explained.

PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------
| Id  | Operation                     | Name            |
-------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |                 |
|   1 |  NESTED LOOPS                 |                 |
|   2 |   TABLE ACCESS BY INDEX ROWID | ITEM_NESTED     |
|*  3 |    INDEX RANGE SCAN           | PRICE_INDEX     |
|   4 |   TABLE ACCESS BY INDEX ROWID | PURCHASEORDER   |
|*  5 |    INDEX UNIQUE SCAN          | SYS_C002973     |
-------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------
   3 - access("ITEM_NESTED"."Price">2000)
   5 - access("NESTED_TABLE_ID"="SYS_ALIAS_1"."SYS_NC0001100012$")
```

XPath Rewrite for UPDATEXML

SQL function `updateXML` must satisfy the following conditions for it to use rewrite optimization:

- The `XMLType` argument must be based on a registered XML schema.
- The `XMLType` argument must also be the target of the `UPDATE` operation. For example:

```
UPDATE purchaseorder_table SET OBJECT_VALUE = updateXML(OBJECT_VALUE,...);
```

- XPath arguments must all be different (no duplicates).
- XPath arguments must otherwise be rewritable, as described in "Which XPath Expressions Are Rewritten?" on page 7-4.
- XPath arguments that target elements mapped by an XML schema with `maxOccurs <= 1` are rewritten only if the schema annotation `maintainDom = false` is present.
- XPath arguments cannot target nodes that have default values (as defined in the XML schema).
- XPath arguments must not have a positional predicate (for example, `foo[2]`).
- If an XPath argument has a predicate, the predicate must not come before a collection.

  For example, `/PurchaseOrder/LineItems[@MyAtt="3"]/LineItem` will not be rewritten, because the predicate occurs before the `LineItem` collection. (This assumes an XML schema where `LineItems` has an attribute `MyAtt`.)
- If an XPath-expression argument references a collection, the collection must be stored as a separate ordered collection table or out of line (`REF` storage); it must not be stored in line.
- If an XPath argument references a collection, the collection must not be scalar (`simpleType` with `maxOccurs > 1`).

> **See Also:** Example 7–2, Example 7–3, Example 3–35, and Example 3–35 for examples of rewriting `updateXML` expressions

XPath Rewrite for INSERTCHILDXML and DELETEXML

SQL function `deleteXML` must satisfy the following conditions for it to use rewrite optimization:

- The `XMLType` argument must be based on a registered XML schema.
- The `XMLType` argument must also be the target of the `UPDATE` operation. For example:

```
UPDATE purchaseorder_table SET OBJECT_VALUE = updateXML(OBJECT_VALUE,...);
```

- XPath arguments must otherwise be rewritable, as described in "Which XPath Expressions Are Rewritten?" on page 7-4.
- The XPath argument must not have a positional predicate (for example, `foo[2]`).
- If the XPath argument has a predicate, the predicate must not come before a collection.

For example, `/PurchaseOrder/LineItems[@MyAtt="3"]/LineItem` will not be rewritten, because the predicate occurs before the `LineItem` collection. (This assumes an XML schema where `LineItems` has an attribute `MyAtt`.)

- The XPath argument must target an unbounded collection (element with `maxOccurs = "unbounded"`).
- The XPath argument must not target a `choice` of collections, as defined in the XML schema.
- The parent of the targeted collection must be defined in the XML schema with annotation `maintainDOM = "false"`.
- If an XPath argument references a collection, the collection must be stored as a separate ordered collection table, not out of line (`REF` storage) or in line.
- If an XPath argument references a collection, the collection must not be scalar (`simpleType` with `maxOccurs > 1`).

8

XML Schema Storage and Query: Advanced

This chapter describes advanced techniques for storing structured XML schema-based `XMLType` objects.

See Also:

- Chapter 6, "XML Schema Storage and Query: Basic" for basic information about using XML Schema with Oracle XML DB
- Chapter 7, "XPath Rewrite" for information about the optimization of XPath expressions in Oracle XML DB
- Chapter 9, "XML Schema Evolution" for information about updating an XML schema after you have registered it with Oracle XML DB
- `http://www.w3.org/TR/xmlschema-0/` for an introduction to XML Schema

This chapter contains these topics:

Generating XML Schemas with DBMS_XMLSCHEMA.GENERATESCHEMA

An XML schema can be generated from an object-relational type automatically using a default mapping. PL/SQL functions `generateSchema` and `generateSchemas` in

package DBMS_XMLSCHEMA take in a string that has the object type name and another that has the Oracle XML DB XML schema.

- Function generateSchema returns an XMLType containing an XML schema. It can optionally generate an XML schema for all types referenced by the given object type or restricted only to the top-level types.
- Function generateSchemas is similar, except that it returns an XMLSequenceType value. This is a varray of XMLType instances, each of which is an XML schema that corresponds to a different namespace. It also takes an additional optional argument that specifies the root URL of the preferred XML schema location:

  http://xmlns.oracle.com/xdb/schemas/<schema>.xsd

  They can also optionally generate annotated XML schemas that can be used to register the XML schema with Oracle XML DB.

  See Also: "Creating XMLType Tables and Columns Based on XML Schema" on page 6-27

Example 8–1 Generating an XML Schema with Function GENERATESCHEMA

For example, given the object type:

```
CREATE TYPE employee_t AS OBJECT(empno NUMBER(10),
                                 ename VARCHAR2(200),
                                 salary NUMBER(10,2)):
```

You can generate the schema for this type as follows:

```
SELECT DBMS_XMLSCHEMA.generateschema('T1', 'EMPLOYEE_T') FROM DUAL;
```

This returns a schema corresponding to the type employee_t. The schema declares an element named EMPLOYEE_T and a complexType called EMPLOYEE_TType. The schema includes other annotations from http://xmlns.oracle.com/xdb.

```
DBMS_XMLSCHEMA.GENERATESCHEMA('T1', 'EMPLOYEE_T')
--------------------------------------------------------------------------
<xsd:schema targetNamespace="http://ns.oracle.com/xdb/T1"
            xmlns="http://ns.oracle.com/xdb/T1"
            xmlns:xsd="http://www.w3.org/2001/XMLSchema"
            xmlns:xdb="http://xmlns.oracle.com/xdb"
            xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
            xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                http://xmlns.oracle.com/xdb/XDBSchema.xsd">
  <xsd:element name="EMPLOYEE_T" type="EMPLOYEE_TType"
               xdb:SQLType="EMPLOYEE_T" xdb:SQLSchema="T1"/>
  <xsd:complexType name="EMPLOYEE_TType">
    <xsd:sequence>
      <xsd:element name="EMPNO" type="xsd:double" xdb:SQLName="empno"
                   xdb:SQLType="NUMBER"/>
      <xsd:element name="ENAME" type="xsd:string" xdb:SQLName="ename"
                   xdb:SQLType="VARCHAR2"/>
      <xsd:element name="SALARY" type="xsd:double" xdb:SQLName="salary"
                   xdb:SQLType="NUMBER"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:schema>
```

Adding Unique Constraints to the Parent Element of an Attribute

After creating an XMLType table based on an XML schema, how can you add a unique constraint to the parent element of an attribute? You might, for example, want to create a unique key based on an attribute of an element that repeats itself (a collection).

To create constraints on elements that can occur more than once, store the varray as an ordered collection table (OCT). You can then create constraints on the OCT.

Example 8–2 shows an XML schema that lets attribute No of element <PhoneNumber> appear more than once. The example shows how you can add a unique constraint to ensure that the same phone number cannot be repeated within a given instance document.

Example 8–2 Adding a Unique Constraint to the Parent Element of an Attribute

```
BEGIN DBMS_XMLSCHEMA.registerschema('emp.xsd',
   '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
               xmlns:xdb="http://xmlns.oracle.com/xdb">
      <xs:element name="Employee" xdb:SQLType="EMP_TYPE">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="EmployeeId" type="xs:positiveInteger"/>
            <xs:element name="PhoneNumber" maxOccurs="10">
              <xs:complexType>
                <xs:attribute name="No" type="xs:integer"/>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:schema>',
   TRUE,
   TRUE,
   FALSE,
   FALSE);
END;
/

PL/SQL procedure successfully completed.

CREATE TABLE emp_tab OF XMLType
  XMLSCHEMA "emp.xsd" ELEMENT "Employee"
  VARRAY XMLDATA."PhoneNumber" STORE AS TABLE phone_tab;

Table created.

ALTER TABLE phone_tab ADD UNIQUE (NESTED_TABLE_ID, "No");

Table altered.

INSERT INTO emp_tab
  VALUES(XMLType('<Employee>
                    <EmployeeId>1234</EmployeeId>
                    <PhoneNumber No="1234"/>
                    <PhoneNumber No="2345"/>
                  </Employee>').createSchemaBasedXML('emp.xsd'));

1 row created.

INSERT INTO emp_tab
```

```
VALUES(XMLType('<Employee>
                  <EmployeeId>3456</EmployeeId>
                  <PhoneNumber No="4444"/>
                  <PhoneNumber No="4444"/>
                </Employee>').createSchemaBasedXML('emp.xsd'));
```

This returns the expected result:

```
*
ERROR at line 1:
ORA-00001: unique constraint (SCOTT.SYS_C002136) violated
```

The constraint in this example applies to each collection, and not across all instances. This is achieved by creating a concatenated index with the collection id column. To apply the constraint across all collections of all instance documents, omit the collection id column.

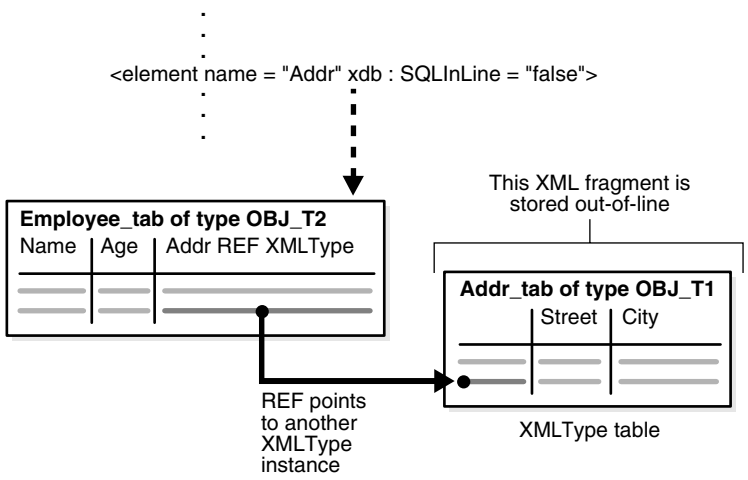
Note: You can create only a *functional* constraint as a unique or foreign key constraint on `XMLType` data stored as binary XML.

Setting Attribute SQLInline to false for Out-Of-Line Storage

By default, a child XML element is mapped to an embedded SQL object attribute, when `XMLType` data is stored object-relationally. However, there are scenarios where out-of-line storage offers better performance. In such cases, set XML schema annotation attribute `SQLInline` to `false`, and Oracle XML DB will generate a SQL object type with an embedded `REF` attribute. The `REF` points to another `XMLType` instance that is stored out of line and that corresponds to the XML fragment. Default `XMLType` tables are also created, to store the out-of-line fragments.

Figure 8–1 illustrates the mapping of `complexType` to SQL for out-of-line storage.

Figure 8–1 Mapping complexType to SQL for Out-Of-Line Storage



Example 8–3 Setting SQLInline to False for Out-Of-Line Storage

In this example, attribute `xdb:SQLInline` of element `Addr` is set to `false`. The resulting SQL object type, `obj_t2`, has a column of type `XMLType` with an embedded `REF` attribute. The `REF` attribute points to another `XMLType` instance of SQL object

type `obj_t1` in table `addr_tab`. Table `addr_tab` is stored out of line. It has columns `street` and `city`.

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="EmpType" xdb:SQLType="EMP_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <element name="Addr"
                    xdb:SQLInline="false"
                    xdb:defaultTable="ADDR_TAB">
             <complexType xdb:SQLType="ADDR_T">
               <sequence>
                 <element name="Street" type="string"/>
                 <element name="City" type="string"/>
               </sequence>
             </complexType>
           </element>
         </sequence>
       </complexType>
       <element name="Employee" type="emp:EmpType"
                xdb:defaultTable="EMP_TAB"/>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL        => 'emp.xsd',
    SCHEMADOC        => doc,
    ENABLE_HIERARCHY => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_NONE);
END;
/
```

When registering this XML schema, Oracle XML DB generates the following `XMLType` tables and types:

```
DESCRIBE emp_tab
 Name                          Null?    Type
 ----------------------------- -------- ------------------------------------------------------------
TABLE of SYS.XMLTYPE(XMLSchema "emp.xsd" Element "Employee") STORAGE Object-relational TYPE "EMP_T"

DESCRIBE addr_tab
 Name                          Null?    Type
 ----------------------------- -------- ------------------------------------------------------------
TABLE of SYS.XMLTYPE(XMLSchema "emp.xsd" Element "Addr") STORAGE Object-relational TYPE "ADDR_T"

DESCRIBE emp_t
 emp_t is NOT FINAL
 Name                          Null?    Type
 ----------------------------- -------- --------------------
 SYS_XDBPD$                             XDB.XDB$RAW_LIST_T
 Name                                   VARCHAR2(4000 CHAR)
 Age                                    NUMBER
 Addr                                   REF OF XMLTYPE

DESCRIBE addr_t
 Name                          Null?    Type
 ----------------------------- -------- --------------------
```

```
 SYS_XDBPD$                              XDB.XDB$RAW_LIST_T
 Street                                  VARCHAR2(4000 CHAR)
 City                                    VARCHAR2(4000 CHAR)
```

Table `emp_tab` holds all of the employee information, and it contains an object reference that points to the address information that is stored out of line, in table `addr_tab`.

The advantage of this model is that it lets you query the out-of-line table (`addr_tab`) directly, to look up address information. Example 8–4 illustrates querying table `addr_tab` directly to obtain the distinct city information for all employees.

Example 8–4 Querying an Out-Of-Line Table

```
INSERT INTO emp_tab
  VALUES
    (XMLType('<x:Employee
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:x="http://www.oracle.com/emp.xsd"
                 xsi:schemaLocation="http://www.oracle.com/emp.xsd emp.xsd">
                <Name>Abe Bee</Name>
                <Age>22</Age>
                <Addr>
                  <Street>A Street</Street>
                  <City>San Francisco</City>
                </Addr>
              </x:Employee>'));

INSERT INTO emp_tab
  VALUES
    (XMLType('<x:Employee
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:x="http://www.oracle.com/emp.xsd"
                 xsi:schemaLocation="http://www.oracle.com/emp.xsd emp.xsd">
                <Name>Cecilia Dee</Name>
                <Age>23</Age>
                <Addr>
                  <Street>C Street</Street>
                  <City>Redwood City</City>
                </Addr>
              </x:Employee>'));
. . .

SELECT DISTINCT extractValue(OBJECT_VALUE, '/Addr/City') AS city FROM addr_tab;

CITY
-------------
Redwood City
San Francisco
```

The disadvantage of this storage model is that, in order to obtain the entire `Employee` element, you must access an additional table for the address.

XPath Rewrite for Out-Of-Line Tables

XPath expressions that involve elements stored out of line can be rewritten. The query involves a join with the out-of-line table. Example 8–5 shows such a query. A fragment of the explain plan for this query is shown, for comparison with Example 8–6.

Example 8–5 XPath Rewrite for an Out-Of-Line Table

```
SELECT XMLCast(XMLQuery('declare namespace x = "http://www.oracle.com/emp.xsd"; (: :)
                         /x:Employee/Name' PASSING OBJECT_VALUE RETURNING CONTENT)
               AS VARCHAR2(20))
  FROM emp_tab
  WHERE XMLExists('declare namespace x = "http://www.oracle.com/emp.xsd"; (: :)
                   /x:Employee/Addr[City="San Francisco"]' PASSING OBJECT_VALUE);

XMLCAST(XMLQUERY(...
--------------------
Abe Bee
Eve Fong
George Hu
Iris Jones
Karl Luomo
Marina Namur
Omar Pinano
Quincy Roberts

8 rows selected.

|*  3 |    INDEX RANGE SCAN          | ADDR_CITY_IDX |     1 |       |     1   (0)| 00:00:01 |
|   2 |   TABLE ACCESS BY INDEX ROWID| ADDR_TAB      |     1 |  2012 |     1   (0)| 00:00:01 |
|   4 |   TABLE ACCESS FULL          | EMP_TAB       |    16 | 32464 |     2   (0)| 00:00:01 |
```

The XQuery expression here is rewritten to a SQL `EXISTS` subquery that queries table `addr_tab`, joining it with table `emp_tab` using the object identifier column in `addr_tab`. The optimizer uses full table scans of tables `emp_tab` and `addr_tab`. If there are many entries in the `addr_tab`, then you can try to make this query more efficient by creating an index on the city, as shown in Example 8–6. The corresponding explain-plan fragment for the same query as in Example 8–5 shows that the city index is picked up.

Example 8–6 Using an Index with an Out-Of-Line Table

```
CREATE INDEX addr_city_idx
  ON addr_tab (extractValue(OBJECT_VALUE, '/Addr/City'));

|   2 |   TABLE ACCESS BY INDEX ROWID| ADDR_TAB      |     1 |  2012 |     1   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN          | ADDR_CITY_IDX |     1 |       |     1   (0)| 00:00:01 |
|   4 |   TABLE ACCESS FULL          | EMP_TAB       |    16 | 32464 |     2   (0)| 00:00:01 |
```

Note: When gathering statistics for the optimizer on an `XMLType` table that is stored object-relationally, Oracle recommends that you gather statistics on *all* of the tables defined by the XML schema, that is, all of the tables in `USER_XML_TABLES`. You can use procedure `DBMS_STATS.gather_schema_stats` to do this, or use `DBMS_STATS.gather_table_stats` on each such table. This informs the optimizer about all of the dependent tables that are used to store the `XMLType` data.

See Also: Chapter 7, "XPath Rewrite"

Storing Collections in Out-Of-Line Tables

You can also map list items to be stored out of line. In this case, instead of a single REF column, the parent element contains a varray of REF values that point to the collection members. For example, suppose that there is a list of addresses for each employee and that list is mapped to out-of-line storage.

Example 8–7 Storing a Collection Out of Line

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="EmpType" xdb:SQLType="EMP_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <element name="Addr" xdb:SQLInline="false"
                    maxOccurs="unbounded" xdb:defaultTable="ADDR_TAB">
             <complexType xdb:SQLType="ADDR_T">
               <sequence>
                 <element name="Street" type="string"/>
                 <element name="City" type="string"/>
               </sequence>
             </complexType>
           </element>
         </sequence>
       </complexType>
       <element name="Employee" type="emp:EmpType"
                xdb:defaultTable="EMP_TAB"/>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    SCHEMAURL        => 'emp.xsd',
    SCHEMADOC        => doc,
    ENABLE_HIERARCHY => DBMS_XMLSCHEMA.ENABLE_HIERARCHY_NONE);
END;
/
```

When you register this XML schema, Oracle XML DB generates tables emp_tab and addr_tab and types emp_t and addr_t, as in Example 8–3. However, this time, type emp_t contains a varray of REF values to addresses, instead of a single REF attribute.

```
DESCRIBE emp_t
 emp_t is NOT FINAL
 Name                                      Null?    Type
 ----------------------------------------- -------- ----------------------------
 SYS_XDBPD$                                         XDB.XDB$RAW_LIST_T
 Name                                               VARCHAR2(4000 CHAR)
 Age                                                NUMBER
 Addr                                               XDB.XDB$XMLTYPE_REF_LIST_T
```

By default, XML schema attribute storeVarrayAsTable has value true, which means that this varray of REF values is stored out of line, in an intermediate table.

This means that, in addition to creating the tables and types just mentioned, XML schema registration also creates the intermediate table that stores the list of REF

values. This table has a system-generated name, but you can rename it, in order to, for example, create an index on it.

Example 8–8 Renaming an Intermediate Table of REF Values

```
DECLARE
  gen_name VARCHAR2 (4000);
BEGIN
  SELECT TABLE_NAME INTO gen_name FROM USER_NESTED_TABLES
    WHERE PARENT_TABLE_NAME = 'EMP_TAB';
  EXECUTE IMMEDIATE 'RENAME "' || gen_name || '"TO emp_tab_reflist';
END;
/

DESCRIBE emp_tab_reflist
 Name                      Null?    Type
 ------------------------- -------- ----------------
 COLUMN_VALUE                       REF OF XMLTYPE
```

Example 8–9 shows a query that selects the names of all San Francisco-based employees and the streets in which they live. The example queries the address table on element `City`, and joins back with the employee table. The explain-plan fragment shown indicates a join between tables `emp_tab_reflist` and `emp_tab`.

Example 8–9 XPath Rewrite for an Out-Of-Line Collection

```
SELECT em.name, ad.street
  FROM emp_tab,
       XMLTable(XMLNAMESPACES ('http://www.oracle.com/emp.xsd' AS "x"),
                '/x:Employee' PASSING OBJECT_VALUE
                COLUMNS name   VARCHAR2(20) PATH 'Name') em,
       XMLTable(XMLNAMESPACES ('http://www.oracle.com/emp.xsd' AS "x"),
                '/x:Employee/Addr' PASSING OBJECT_VALUE
                COLUMNS street VARCHAR2(20) PATH 'Street',
                        city   VARCHAR2(20) PATH 'City') ad
  WHERE ad.city = 'San Francisco';

NAME                 STREET
-------------------- --------------------
Abe Bee              A Street
Eve Fong             E Street
George Hu            G Street
Iris Jones           I Street
Karl Luomo           K Street
Marina Namur         M Street
Omar Pinano          O Street
Quincy Roberts       Q Street

8 rows selected.
```

```
|   4 |    TABLE ACCESS FULL          | EMP_TAB_REFLIST |    32 |   640 |     2   (0)| 00:00:01 |
|   5 |   TABLE ACCESS BY INDEX ROWID| EMP_TAB          |     1 |    29 |     1   (0)| 00:00:01 |
|*  6 |    INDEX UNIQUE SCAN          | SYS_C005567     |     1 |       |     0   (0)| 00:00:01 |
```

We can improve performance by creating an index on the `REF` values in the intermediate table, `emp_tab_reflist`. This lets Oracle XML DB query the address table, obtain an object reference (`REF`) to the relevant row, join it with the intermediate table storing the list of `REF` values, and join that table back with the employee table.

You can create an index on REF values only if the REF is *scoped* or has a referential constraint. A scoped REF column stores pointers only to objects in a particular table. The REF values in table emp_tab_reflist point only to objects in table addr_tab, so we can create a scope constraint and an index on the REF column, as shown in Example 8–10.

Example 8–10 XPath Rewrite for an Out-Of-Line Collection, with Index on REFs

```
ALTER TABLE emp_tab_reflist ADD SCOPE FOR (COLUMN_VALUE) IS addr_tab;
CREATE INDEX reflist_idx ON emp_tab_reflist (COLUMN_VALUE);
```

The explain-plan fragment for the same query as in Example 8–9 shows that index reflist_idx is picked up—compare with Example 8–9.

```
|   4 |    TABLE ACCESS BY INDEX ROWID| EMP_TAB_REFLIST |     1 |    20 |     1   (0)| 00:00:01 |
|*  5 |     INDEX RANGE SCAN          | REFLIST_IDX     |     1 |       |     0   (0)| 00:00:01 |
|   6 |   TABLE ACCESS BY INDEX ROWID | EMP_TAB         |       |       |            |          |
|*  7 |    INDEX UNIQUE SCAN          | SYS_C005567     |     1 |       |     0   (0)| 00:00:01 |
```

In some cases, where the more selective predicates in the query are on the employee table, you might want to set XML schema attribute storeVarrayAsTable to false, in order to store the varray of REF values in line in table emp_tab. Storing the varray in line effectively forces any query involving the two tables emp_tab and addr_tab to always be driven from emp_tab. There is then no way to efficiently join back from the address table. This means that this approach is not appropriate when the number of employees is large, because it involves a full table scan of table emp_tab, which can be expensive.

Fully Qualified XML Schema URLs

By default, XML schema URL names are always referenced within the scope of the current user. In other words, when database users specify XML schema URLs, they are first resolved as the names of *local* XML schemas owned by the current user.

- If there are no such XML schemas, then they are resolved as names of *global* XML schemas.
- If there are no *global* XML schemas either, then Oracle XML DB raises an error.

To permit explicit reference to XML schemas in these cases, Oracle XML DB supports the notion of *fully qualified* XML schema URLs. In this form, the name of the database user owning the XML schema is also specified as part of the XML schema URL, except that such XML schema URLs belong to the Oracle XML DB namespace:

```
http://xmlns.oracle.com/xdb/schemas/<database-user>/<schemaURL-minus-protocol>
```

Example 8–11 Using a Fully Qualified XML Schema URL

For example, consider the global XML schema with the following URL:

```
http://www.example.com/po.xsd
```

Assume that database user QUINE has a local XML schema with the same URL:

```
http://www.example.com/po.xsd
```

Another user can reference the local XML schema owned by QUINE as follows:

```
http://xmlns.oracle.com/xdb/schemas/QUINE/www.example.com/po.xsd
```

Similarly, the fully qualified URL for the global XML schema is:

```
http://xmlns.oracle.com/xdb/schemas/PUBLIC/www.example.com/po.xsd
```

Mapping XML Fragments to Large Objects (LOBs)

You can specify the SQLType for a complex element as a Character Large Object (CLOB) value or a Binary Large Object (BLOB) value, as shown in Figure 8–2. Here the entire XML fragment is stored in a LOB attribute. This is useful when parts of the XML document are seldom queried but are mostly retrieved and stored as single pieces. By storing XML fragments as LOBs, you can save on parsing, decomposition, and recomposition overheads.

Example 8–12 Oracle XML DB XML Schema: Mapping complexType XML Fragments to LOBs

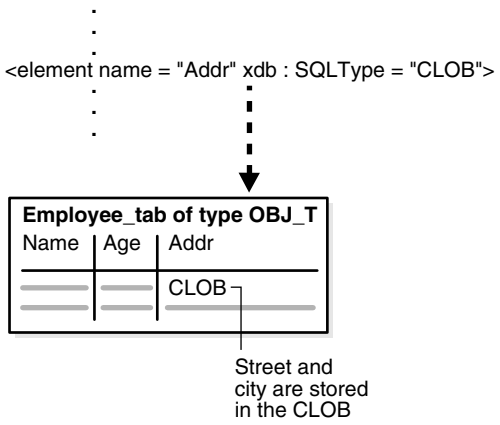
In the following example, the XML schema specifies that the XML fragment element Addr uses the attribute SQLType = "CLOB":

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="Employee" xdb:SQLType="OBJ_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <element name="Addr" xdb:SQLType="CLOB">
             <complexType >
               <sequence>
                 <element name="Street" type="string"/>
                 <element name="City" type="string"/>
               </sequence>
             </complexType>
           </element>
         </sequence>
       </complexType>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/PO.xsd', doc);
END;
```

On registering this XML schema, Oracle XML DB generates the following types and XMLType tables:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            Name VARCHAR2(4000),
                            Age NUMBER,
                            Addr CLOB);
```

Figure 8–2 Mapping complexType XML Fragments to Character Large Objects (CLOB)



complexType Extensions and Restrictions in Oracle XML DB

In XML Schema, `complexType` values are declared based on `complexContent` and `simpleContent`.

- `simpleContent` is declared as an extension of `simpleType`.
- `complexContent` is declared as one of the following:
  - Base type
  - `complexType` extension
  - `complexType` restriction

This section describes the Oracle XML DB extensions and restrictions to `complexType`.

complexType Declarations in XML Schema: Handling Inheritance

For `complexType`, Oracle XML DB handles inheritance in the XML schema as follows:

- For complex types declared to *extend* other complex types, the SQL type corresponding to the base type is specified as the supertype for the current SQL type. Only the additional attributes and elements declared in the sub-complextype are added as attributes to the sub-object-type.
- For complex types declared to *restrict* other complex types, the SQL type for the sub-complex type is set to be the same as the SQL type for its base type. This is because SQL does not support restriction of object types through the inheritance mechanism. Any constraints are imposed by the restriction in XML schema.

Example 8–13 Inheritance in XML Schema: complexContent as an Extension of complexTypes

Consider an XML schema that defines a base `complexType Address` and two extensions `USAddress` and `IntlAddress`.

```
DECLARE
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="Address" xdb:SQLType="ADDR_T">
```

```
        <xs:sequence>
          <xs:element name="street" type="xs:string"/>
          <xs:element name="city" type="xs:string"/>
        </xs:sequence>
      </xs:complexType>
      <xs:complexType name="USAddress" xdb:SQLType="USADDR_T">
        <xs:complexContent>
          <xs:extension base="Address">
            <xs:sequence>
              <xs:element name="zip" type="xs:string"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
      <xs:complexType name="IntlAddress" final="#all" xdb:SQLType="INTLADDR_T">
        <xs:complexContent>
          <xs:extension base="Address">
            <xs:sequence>
              <xs:element name="country" type="xs:string"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/PO.xsd', doc);
END;
```

Note: Type `intladdr_t` is created as a *final* type because the corresponding `complexType` specifies the "`final`" attribute. By default, all `complexTypes` can be extended and restricted by other types, so all SQL object types are created as types that are *not* final.

```
CREATE TYPE addr_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                             "street" VARCHAR2(4000),
                             "city" VARCHAR2(4000)) NOT FINAL;
CREATE TYPE usaddr_t UNDER addr_t ("zip" VARCHAR2(4000)) NOT FINAL;
CREATE TYPE intladdr_t UNDER addr_t ("country" VARCHAR2(4000)) FINAL;
```

Example 8–14 Inheritance in XML Schema: Restrictions in complexTypes

Consider an XML schema that defines a base `complexType` `Address` and a restricted type `LocalAddress` that prohibits the specification of `country` attribute.

```
DECLARE
  doc varchar2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="Address" xdb:SQLType="ADDR_T">
         <xs:sequence>
           <xs:element name="street" type="xs:string"/>
           <xs:element name="city" type="xs:string"/>
           <xs:element name="zip" type="xs:string"/>
           <xs:element name="country" type="xs:string" minOccurs="0"
                       maxOccurs="1"/>
         </xs:sequence>
       </xs:complexType>
       <xs:complexType name="LocalAddress" xdb:SQLType="USADDR_T">
         <xs:complexContent>
```

```
          <xs:restriction base="Address">
            <xs:sequence>
              <xs:element name="street" type="xs:string"/>
              <xs:element name="city" type="xs:string"/>
              <xs:element name="zip" type="xs:string"/>
              <xs:element name="country" type="xs:string"
                          minOccurs="0" maxOccurs="0"/>
            </xs:sequence>
          </xs:restriction>
        </xs:complexContent>
      </xs:complexType>
    </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/PO.xsd', doc);
END;
```

Because inheritance support in SQL does not support a notion of restriction, the SQL type corresponding to the restricted `complexType` is a empty subtype of the parent object type. For the preceding XML schema, the following SQL types are generated:

```
CREATE TYPE addr_t AS OBJECT (SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                              "street"   VARCHAR2(4000),
                              "city"     VARCHAR2(4000),
                              "zip"      VARCHAR2(4000),
                              "country"  VARCHAR2(4000)) NOT FINAL;
CREATE TYPE usaddr_t UNDER addr_t;
```

Mapping complexType: simpleContent to Object Types

A `complexType` based on a `simpleContent` declaration is mapped to an object type with attributes corresponding to the XML attributes and an extra `SYS_XDBBODY$` attribute corresponding to the body value. The data type of the body attribute is based on `simpleType` which defines the body type.

Example 8–15 XML Schema complexType: Mapping complexType to simpleContent

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp.xsd"
             xmlns:emp="http://www.oracle.com/emp.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="name" xdb:SQLType="OBJ_T">
         <simpleContent>
           <restriction base="string">
           </restriction>
         </simpleContent>
       </complexType>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerschema('http://www.oracle.com/emp.xsd', doc);
END;
```

On registering this XML schema, Oracle XML DB generates the following types and `XMLType` tables:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            SYS_XDBBODY$ VARCHAR2(4000));
```

Mapping complexType: any and anyAttribute

Oracle XML DB maps the element declaration, `any`, and the attribute declaration, `anyAttribute`, to `VARCHAR2` attributes (or optionally to Large Objects (LOBs)) in the created object type. The object attribute stores the text of the XML fragment that matches the `any` declaration.

- The `namespace` attribute can be used to restrict the contents so that they belong to a specified namespace.
- The `processContents` attribute within the `any` element declaration, indicates the level of validation required for the contents matching the `any` declaration.

Example 8–16 Oracle XML DB XML Schema: Mapping complexType to any/anyAttribute

This XML schema example declares an `any` element and maps it to the column `SYS_XDBANY$`, in object type `obj_t`. This element also declares that the attribute `processContents` skips validating contents that match the `any` declaration.

```
DECLARE
  doc VARCHAR2(3000) :=
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/any.xsd"
             xmlns:emp="http://www.oracle.com/any.xsd"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <complexType name="Employee" xdb:SQLType="OBJ_T">
         <sequence>
           <element name="Name" type="string"/>
           <element name="Age" type="decimal"/>
           <any namespace="http://www/w3.org/2001/xhtml"
                processContents="skip"/>
         </sequence>
       </complexType>
     </schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/emp.xsd', doc);
END;
```

This results in the following statement:

```
CREATE TYPE obj_t AS OBJECT(SYS_XDBPD$ XDB.XDB$RAW_LIST_T,
                            Name VARCHAR2(4000),
                            Age NUMBER,
                            SYS_XDBANY$ VARCHAR2(4000));
```

Oracle XPath Extension Functions to Examine Type Information

Oracle XML DB supports XML schema-based data, where elements and attributes have XML Schema data-type information associated with them. However, XPath 1.0 is not aware of data-type information. Oracle XML DB extends XPath 1.0 with the following Oracle extension functions to support examining data-type information:

- `instanceof`
- `instanceof-only`

These XPath functions are in namespace `http://xmlns.oracle.com/xdb`, which has the predefined prefix `ora`.

An element is an **instance** of a specified XML Schema data type if its type is the same as the specified type or is a subtype of the specified type. A **subtype** of type *`T`* in the

context of XML Schema is a type that extends or restricts *T*, or extends or restricts another subtype of *T*.

For XPath expressions involving XML schema-based data, you can use Oracle XPath function `ora:instanceof-only` to restrict the result set to nodes of a certain data type, and `ora:instanceof` to restrict the result set to nodes of a certain data type or its subtypes. For *non*-schema-based XML data, elements and attributes do not have data-type information, so these functions return *false* for non-schema-based data.

ora:instanceof-only XPath Function

Syntax

```
ora:instanceof-only(nodeset-expr, typename [, schema-url])
```

On XML schema-based data, `ora:instanceof-only` evaluates XPath expression *nodeset-expr* and determines the XML Schema data type for each of the resultant nodes. Expression *nodeset-expr* is typically a *relative* XPath expression. If the data type of *any* of the nodes exactly matches data type *typename* (a string), which can be qualified with a namespace prefix, then `instanceof-only` returns true; otherwise, it returns false. It returns false for non-schema-based data.

Optional parameter *schema-url* (a string) indicates the schema location URL for the data type to be matched. If specified, then the *schema-url* parameter must specify the location of the XML schema that defines the node data type. If *schema-url* is not specified, the schema location of the node is not checked.

Example 8–17 Using ora:instanceof-only

The following query selects the `Name` attributes of `AE` children of element `Person` that are of data type `PersonType` (subtypes of `PersonType` are not matched).

```
SELECT extract(OBJECT_VALUE,
               '/p9:Person[ora:instanceof-only(AE,"p9:PersonType")]/AE/Name',
               'xmlns:p9="person9.xsd" xmlns:ora="http://xmlns.oracle.com/xdb"')
  FROM po_table;
```

ora:instanceof XPath Function

Syntax

```
ora:instanceof(nodeset-expr, typename [, schema-url])
```

Oracle XPath function `ora:instanceof` is similar to `ora:instanceof-only`, but it also returns true if the data type of any of the matching nodes exactly matches a *subtype* of data type *typename*.

Example 8–18 Using ora:instanceof

The following query selects the `Name` attributes of `AE` children of element `Person` that are of data type `PersonType` or of one of its subtypes.

```
SELECT extract(OBJECT_VALUE,
               '/p9:Person[ora:instanceof(AE, "p9:PersonType")]/AE/Name',
               'xmlns:p9="person9.xsd" xmlns:ora="http://xmlns.oracle.com/xdb"')
  FROM po_table;
```

The schema-location parameter is typically used in a heterogeneous XML Schema scenario. Heterogeneous XML schema-based data can be present in a single table. If

your scenario involves a schema-based table, consider omitting the schema location parameter.

Consider a non-schema-based table of XMLType. Each row in the table is an XML document. Suppose that each row contains data for which XML schema information has been specified. If the data in the table is converted to XML schema-based data through a subsequent operation, then the rows in the table could pertain to different XML schemas. In such a case, you can specify not only the name and the namespace of the data type to be matched, but also the schema-location URL.

Example 8–19 Using ora:instanceof with Heterogeneous XML Schema-Based Data

In the non-schema-based table non_sch_p_tab, the following query matches elements of type PersonType that pertain to XML schema person9.xsd.

```
SELECT extract(
         createSchemaBased(
           OBJECT_VALUE),
           '/p9:Person/AE[ora:instanceof(.,"p9:PersonType", "person9.xsd")]',
           'xmlns:p9="person9.xsd" xmlns:ora="http://xmlns.oracle.com/xdb"')
  FROM non_sch_p_tab;
```

XML Schema: Working With Circular and Cyclical Dependencies

The W3C XML Schema Recommendation lets complexTypes and global elements contain recursive references. For example, a complexType definition can *contain* an element based on that same complexType, or a global element can contain a reference to itself. In both cases the reference can be direct or indirect. This kind of structure allows for instance documents where the element in question can appear an infinite number of times in a recursive hierarchy.

Example 8–20 An XML Schema With Circular Dependency

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:element name="person" type="personType" xdb:defaultTable="PERSON_TABLE"/>
  <xs:complexType name="personType" xdb:SQLType="PERSON_T">
    <xs:sequence>
      <xs:element name="descendant" type="personType" minOccurs="0"
                  maxOccurs="unbounded" xdb:SQLName="DESCENDANT"
                  xdb:defaultTable="DESCENDANT_TABLE"/>
    </xs:sequence>
    <xs:attribute name="personName" use="required" xdb:SQLName="PERSON_NAME">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:maxLength value="20"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
  </xs:complexType>
</xs:schema>
```

The XML schema in Example 8–20 includes a circular dependency. The complexType personType consists of a personName attribute and a collection of descendant elements. The descendant element is defined as being of type personType.

For Circular XML Schema Dependencies Set Parameter GENTABLES to TRUE

Oracle XML DB supports XML schemas that define this kind of structure. It does this by detecting the cycles, breaking them, and storing the recursive elements as rows in a separate `XMLType` table that is created during XML schema registration.

Consequently, it is important to ensure that parameter `GENTABLES` is set to `TRUE` when registering an XML schema that defines this kind of structure. The name of the table used to store the recursive elements can be specified by adding an `xdb:defaultTable` annotation to the XML schema.

Handling Cycling Between complexTypes in XML Schema

SQL object types do not allow cycles. Cycles in an XML schema are broken while generating the object types, by introducing a `REF` attribute at the point where the cycle would be completed. Thus, part of the data is stored out of line, but it is still retrieved as part of the parent XML document.

Example 8–21 XML Schema: Cycling Between complexTypes

XML schemas permit cycling between definitions of `complexTypes`. Figure 8–3 shows this example, where the definition of `complexType CT1` can reference another `complexType CT2`, whereas the definition of `CT2` references the first type `CT1`.

XML schemas permit cycling between definitions of `complexTypes`. This is an example of cycle of length two:

```
DECLARE
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="CT1" xdb:SQLType="CT1">
         <xs:sequence>
           <xs:element name="e1" type="xs:string"/>
           <xs:element name="e2" type="CT2"/>
         </xs:sequence>
       </xs:complexType>
       <xs:complexType name="CT2" xdb:SQLType="CT2">
         <xs:sequence>
           <xs:element name="e1" type="xs:string"/>
           <xs:element name="e2" type="CT1"/>
         </xs:sequence>
       </xs:complexType>
     </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/emp.xsd', doc);
END;
```

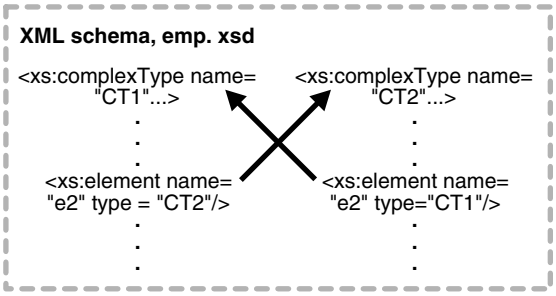
SQL types do not allow cycles in type definitions. However, they do support **weak cycles**, that is, cycles involving `REF` (reference) attributes. Cyclic XML schema definitions are mapped to SQL object types in such a way that cycles are avoided by forcing `SQLInline = "false"` at the appropriate points. This creates a weak SQL cycle.

For the preceding XML schema, the following SQL types are generated:

```
CREATE TYPE ct1 AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                           "e1"        VARCHAR2(4000),
                           "e2"        REF XMLType) NOT FINAL;
CREATE TYPE ct2 AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                           "e1"        VARCHAR2(4000),
```

```
                              "e2"        CT1) NOT FINAL;
```

Figure 8–3 Cross Referencing Between Different complexTypes in the Same XML Schema



Example 8–22 XML Schema: Cycling Between complexTypes, Self-Reference

Another example of a cyclic `complexType` involves the declaration of the `complexType` having a reference to itself. In this example, type `<SectionT>` references itself:

```
DECLARE
  doc VARCHAR2(3000) :=
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:complexType name="SectionT" xdb:SQLType="SECTION_T">
         <xs:sequence>
           <xs:element name="title" type="xs:string"/>
           <xs:choice maxOccurs="unbounded">
             <xs:element name="body" type="xs:string"
                         xdb:SQLCollType="BODY_COLL"/>
             <xs:element name="section" type="SectionT"/>
           </xs:choice>
         </xs:sequence>
       </xs:complexType>
     </xs:schema>';
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/section.xsd', doc);
END;
```

The following SQL types are generated.

```
CREATE TYPE body_coll AS VARRAY(32767) OF VARCHAR2(4000);
CREATE TYPE section_t AS OBJECT (SYS_XDBPD$  XDB.XDB$RAW_LIST_T,
                                 "title"     VARCHAR2(4000),
                                 "body"      BODY_COLL,
                                 "section"   XDB.XDB$REF_LIST_T) NOT FINAL;
```

> **Note:** The `section` attribute is declared as a `varray` of `REF` references to `XMLType` instances. Because there can be more than one occurrence of embedded sections, the attribute is a `varray`. It is a `varray` of `REF` references to `XMLType` instances, to avoid forming a cycle of SQL objects.

How a complexType Can Reference Itself

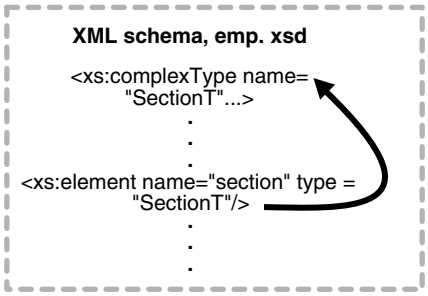
Assume that your XML schema, identified by "`http://www.oracle.com/PO.xsd`", has been registered. An `XMLType` table, `purchaseorder`, can then be created to store

instances conforming to element `PurchaseOrder` of this XML schema, in an object-relational format:

```
CREATE TABLE purchaseorder OF XMLType
   ELEMENT "http://www.oracle.com/PO.xsd#PurchaseOrder";
```

Figure 8–4 illustrates schematically how a `complexType` can reference itself.

Figure 8–4 complexType Self Referencing Within an XML Schema



See Also: "Cyclical References Between XML Schemas" on page 8-20

Hidden columns are created that correspond to the object type to which the `PurchaseOrder` element has been mapped. In addition, an `XMLExtra` object column is created, to store top-level instance data such as namespace declarations.

Note: `XMLDATA` is a pseudo-attribute of `XMLType` that enables direct access to the underlying object column. See Chapter 4, "XMLType Operations".

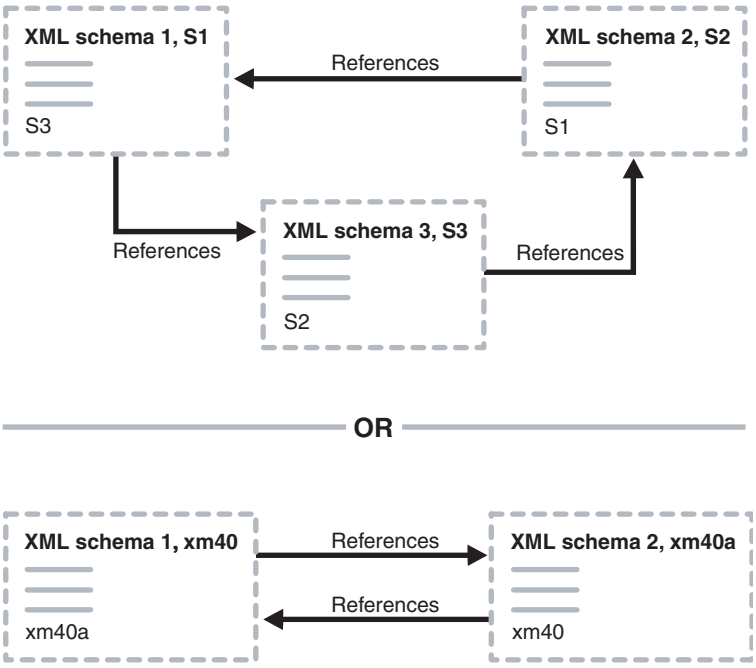
Cyclical References Between XML Schemas

XML schemas can depend on each other in such a way that they cannot be registered one after the other in the usual manner. Illustrations of such XML schemas follow in Figure 8–5.

In the top half of the illustration, an example of indirect cyclical references between three XML schemas is shown.

In the bottom half of the illustration, an example of cyclical dependencies between two XML schemas is shown. This simpler example is next presented with details.

Figure 8–5 Cyclical References Between XML Schemas



Example 8–23 Cyclic Dependencies

An XML schema that includes another XML schema cannot be created if the included XML schema does not exist.

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  'xm40.xsd',
  '<schema xmlns="http://www.w3.org/2001/XMLSchema"
           xmlns:my="xm40"
           targetNamespace="xm40">
     <include schemaLocation="xm40a.xsd"/>
     <!-- Define a global complextype here -->
     <complexType name="Company">
       <sequence>
         <element name="Name" type="string"/>
         <element name="Address" type="string"/>
       </sequence>
     </complexType>
     <!-- Define a global element depending on included schema -->
     <element name="Emp" type="my:Employee"/>
   </schema>',
  TRUE,
  TRUE,
  FALSE,
  TRUE);
END;
/
```

It can, however, be created with the `FORCE => TRUE` option (the last argument):

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  'xm40.xsd',
  '<schema xmlns="http://www.w3.org/2001/XMLSchema"
           xmlns:my="xm40"
           targetNamespace="xm40">
```

```
    <include schemaLocation="xm40a.xsd"/>
    <!-- Define a global complextype here -->
    <complexType name="Company">
      <sequence>
        <element name="Name" type="string"/>
        <element name="Address" type="string"/>
      </sequence>
    </complexType>
    <!-- Define a global element depending on included schema -->
    <element name="Emp" type="my:Employee"/>
  </schema>',
  TRUE,
  TRUE,
  FALSE,
  TRUE,
  TRUE);
END;
/
```

Attempts to use this schema and recompile will fail:

```
CREATE TABLE foo OF XMLType XMLSCHEMA "xm40.xsd" ELEMENT "Emp";
```

Now, create the second XML schema with the `FORCE` option. This should also make the first XML schema valid:

```
BEGIN DBMS_XMLSCHEMA.registerSchema(
  'xm40a.xsd',
  '<schema xmlns="http://www.w3.org/2001/XMLSchema"
           xmlns:my="xm40"
           targetNamespace="xm40">
    <include schemaLocation="xm40.xsd"/>
    <!-- Define a global complextype here -->
    <complexType name="Employee">
      <sequence>
        <element name="Name" type="string"/>
        <element name="Age" type="positiveInteger"/>
        <element name="Phone" type="string"/>
      </sequence>
    </complexType>
    <!-- Define a global element depending on included schema -->
    <element name="Comp" type="my:Company"/>
  </schema>',
  TRUE,
  TRUE,
  FALSE,
  TRUE,
  TRUE);
END;
/
```

The XML schemas can each be used to create a table:

```
CREATE TABLE foo  OF XMLType XMLSCHEMA "xm40.xsd"  ELEMENT "Emp";
CREATE TABLE foo2 OF XMLType XMLSCHEMA "xm40a.xsd" ELEMENT "Comp";
```

To register both of these XML schemas, which depend on each other, you must use the `FORCE` parameter in `DBMS_XMLSCHEMA.registerSchema` as follows:

1. Register `xm40.xsd` with `FORCE` mode set to `TRUE`:

   ```
   DBMS_XMLSCHEMA.registerSchema("xm40.xsd", "<schema ...", ..., FORCE => TRUE)
   ```

At this point, xm40.xsd is *invalid* and cannot be used.

2. Register xm40a.xsd in FORCE mode set to TRUE:

```
DBMS_XMLSCHEMA.registerSchema("xm40a.xsd", "<schema ...", ..., FORCE => TRUE)
```

The second operation automatically compiles xm40.xsd and makes both XML schemas valid.

Support for Recursive Schemas

Storing a REF to a recursive structure that is in an out-of-line table has the disadvantage that XPath queries against such documents cannot easily be rewritten, because it is not known how deep the structure can be at compile time. To enable rewrite of such XPath queries, a DOCID column is used to store a pointer back to the root document in any recursive structure, enabling some queries to use the out-of-line tables directly and join back using this column. Consider this schema:

Example 8–24 Recursive Schema

```
<schema targetNamespace="AbcNS" xmlns="http://www.w3.org/2001/XMLSchema"
          xmlns:abc="AbcNS" xmlnm:xdb="http://xmlns.oracle.com.xdb">
  <element name="AbcCode" xdb:defaultTable="ABCCODETAB">
    <complexType>
      <sequence>
        <element ref="abc:AbcSection"/>
      </sequence>
    </complexType>
  </element>

  <element name="AbcSection">
    <complexType>
      <sequence>
        <element name="ID" type="integer"/>
        <element name="Contents" type="string"/>
        <element ref="abc:AbcSection"/>
      </sequence>
    </complexType>
  </element>
</schema>
```

A **document-correlated recursive query** is a query using a SQL function that accepts an XPath or XQuery expression and an XMLType instance, where that XPath or XQuery expression contains '//'. A document-correlated recursive query can be *rewritten* if it can be determined at query compilation time that both of the following conditions are met:

- All fragments of the XMLType instance that are targeted by the XPath or XQuery expression reside in a single out-of-line table.
- No other fragments of the XMLType instance reside in the same out-of-line table.

The rewritten query is a join with the out-of-line table, based on the DOCID column.

Other queries with '//' can also be rewritten. For example, if there are several address elements, all of the same type, in different sections of a schema, and you often query all address elements with '//', not caring about their specific location in the document, rewrite can occur.

During schema registration, an additional DOCID column is generated for out-of-line XMLType tables This column stores the OID (Object Identifier Values) of the document, that is, the root element. This column is automatically populated when data is inserted in the tables. You can export tables containing DOCID columns and import them later.

Sharing defaultTable Among Common Out-of-line Elements

The out-of-line elements of the same qualified name (namespace and local name) and same type are stored in the same default table. As a special case, users can store the root element of a cyclic element structure out of line also, and in the same table as the sub-elements (if the root element is stored out of line also).

Both the elements sharing the default table must be out-of-line elements, that is, the default table for an out-of-line element cannot be the same as the table for a top-level element. To do this, specify xdb:SQLInline ='FALSE" for both elements and specify an explicit xdb:defaultTable attribute having the same value in both elements.

Consider the example where an out-of-line table is stored in ABCSECTIONTAB:

Example 8–25 Out-of-line Table

```
<schema targetNamespace="AbcNS" xmlns="http://www.w3.org/2001/XMLSchema"
          xmlns:abc="AbcNS" xmlns:xdb="http://xmlns.oracle.com/xdb">
  <element name="AbcCode" xdb:defaultTable="ABCCODETAB">
    <complexType>
      <sequence>
        <element ref="abc:AbcSection" xdb:SQLInline="false"/>
      </sequence>
    </complexType>
  </element>

  <element name="AbcSection" xdb:defaultTable="">
    <complexType>
      <sequence>
        <element name="ID" type="integer"/>
        <element name="Contents" type="string"/>
        <element ref="abc:AbcSection" xdb:SQLInline="false"
                 xdb:defaultTable="ABCSECTIONTAB"/>
      </sequence>
    </complexType>
  </element>
</schema>
```

Both of the out-of-line AbcSection elements in the preceding example share the same default table, ABCSECTIONTAB.

However, the following example illustrates invalid default table sharing recursive elements (XyZSection) do not share the same out-of-line table.:

Example 8–26 Invalid Default Table Sharing

```
<schema targetNamespace="XyzNS" xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xyz="XyzNS" xmlns:xdb="http://xmlns.oracle.com/xdb">
  <element name="XyzCode" xdb:defaultTable="XYZCODETAB">
  <complexType>
  <sequence>
     <element name="CodeNumber" type="integer" minOccurs="0"/>
     <element ref="xyz:XyzChapter" xdb:SQLInline="false"/>
     <element ref="xyz:XyzPara" xdb:SQLInline="false" />
```

```
</sequence>
</complexType>
</element>

 <element name="XyzChapter" xdb:defaultTable="XYZCHAPTAB">
  <complexType>
  <sequence>
      <element name="Title" type="string"/>
      <element ref="xyz:XyzSection" xdb:SQLInline="false"
               xdb:defaultTable="XYZSECTIONTAB"/>
   </sequence>
   </complexType>
 </element>

 <element name="XyzPara" xdb:defaultTable="XYZPARATAB">
  <complexType>
  <sequence>
      <element name="Title" type="string"/>
      <element ref="xyz:XyzSection" xdb:SQLInline="false"
               xdb:defaultTable="Other_XYZSECTIONTAB"/>
   </sequence>
   </complexType>
 </element>

 <element name="XyzSection">
 <complexType>
 <sequence>
     <element name="ID" type="integer"/>
     <element name="Contents" type="string"/>
     <element ref="xyz:XyzSection" xdb:defaultTable="XYZSECTIONTAB"/>
  </sequence>
  </complexType>
 </element>
</schema>
```

The following query cannot be rewritten:

```
SELECT extract(value(p), '//XyzSection') FROM xyzcode p;
```

Query Rewrite When DOCID is Present

Before processing `//` XPath expressions, check to find multiple occurrences of the same element. If all occurrences under the `//` share the same `defaultTable`, then the query can be rewritten to go against that table, using the `DOCID`. If there are other occurrences of the same element under the root sharing that table, but not under `//`, then the query cannot be rewritten. For example, consider this element structure:

`<Book>` contains a `<Chapter>` and a `<Part>`. `<Part>` contains a `<Chapter>`.

Assume that both of the `<Chapter>` elements are stored out of line and they share the same default table. The query `/Book//Chapter` can be rewritten to go against the default table for the `<Chapter>` elements because all of the `<Chapter>` elements under `<Book>` share the same default table. Thus, this XPath query is a document-correlated recursive XPath query.

However, a query such as `/Book/Part//Chapter` cannot be rewritten, even though all the `<Chapter>` elements under `<Part>` share the same table, because there is another `<Chapter>` element under `<Book>`, which is the document root that also shares that table.

Consider the case where you are extracting `//AbcSection` with `DOCID` present, as in the XML schema described in Example 8–25:

```
SELECT extract(value(x), '//AbcSection') FROM abccodetab;
```

Both of the `AbcSection` elements are stored in the same table, `abcsectiontab`. The extract goes to the underlying `abcsectiontab` table.

Consider this query when `DOCID` is present:

```
SELECT extract(value(x), '/AbcCode/AbcSection//AbcSection') FROM abccodetab;
```

In both this case and the previous case, all reachable `AbcSection` elements are stored in the same out-of-line table. However, the first `AbcSection` element at `/AbcCode/AbcSection` cannot be retrieved by this query. Since the join condition is a `DOCID`, which cannot distinguish between different positions in the parent document, the correct result cannot be achieved by a direct query on table `abcsectiontab`. In this case, query rewrite does not occur since it is not a document-correlated recursive XPath. If this top-level `AbcSection` were not stored out of line with the rest, then the query could be rewritten.

Disabling DOCID Column Creation

You can disable the creation of the `DOCID` column by specifying an optional last parameter of `DBMS_XMLSCHEMA.registerSchema` when calling this procedure. This disables `DOCID` creation in all `XMLType` tables generated during schema registration. The parameters of the procedure `registerSchema` are:

```
PROCEDURE registerSchema(
          SCHEMAURL IN VARCHAR2,
          SCHEMADOC IN VARCHAR2,
          LOCAL IN BOOLEAN := TRUE,
          GENTYPES IN BOOLEAN := TRUE,
          GENBEAN IN BOOLEAN := FALSE,
          GENTABLES IN BOOLEAN := TRUE,
          FORCE IN BOOLEAN := FALSE,
          OWNER IN VARCHAR2 := '',
          OPTIONS IN pls_integer := 0);
```

For `DOCID` columns not to be generated, set the parameter `options` to:

```
DBMS_XMLSCHEMA.REGISTER_NODOCID
```

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Guidelines for Using XML Schema with Oracle XML DB

This section describes guidelines for using XML schema with Oracle XML DB.

Using Bind Variables in XPath Expressions

When you use a bind variable, Oracle Database rewrites the queries for the cases where the bind variable is used in place of a string literal value. You can also use the `CURSOR_SHARING` set to force Oracle Database to always use bind variables for all string expressions.

XPath Rewrite with Bind Variables

When bind variables are used as string literals in XPath, the expression can be rewritten to use the bind variables. The bind variable must used in place of the string

literal using the concatenation operator (||), and it must be surrounded by single quotation marks (') or double-quotes (") inside the XPath string. The following example illustrates the use of the bind variable with XPath rewrite.

Example 8–27 Using Bind Variables in XPath

```
BEGIN
  DBMS_XMLSCHEMA.registerschema(
    'bindtest.xsd',
    '<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
                xmlns:xdb="http://xmlns.oracle.com/xdb">
       <xs:element name="Employee" xdb:SQLType="EMP_BIND_TYPE">
         <xs:complexType>
           <xs:sequence>
             <xs:element name="EmployeeId"  type="xs:positiveInteger"/>
             <xs:element name="PhoneNumber" type="xs:string"/>
           </xs:sequence>
         </xs:complexType>
       </xs:element>
     </xs:schema>',
    TRUE,
    TRUE,
    FALSE,
    FALSE);
END;
/

-- Create table corresponding to the Employee element
CREATE TABLE emp_bind_tab OF XMLType
  ELEMENT "bindtest.xsd#Employee";

-- Create an index to illustrate the use of bind variables
CREATE INDEX employeeId_idx ON emp_bind_tab
  (extractValue(OBJECT_VALUE, '/Employee/EmployeeId'));

EXPLAIN PLAN FOR
  SELECT extractValue(OBJECT_VALUE, '/Employee/PhoneNumber')
    FROM emp_bind_tab
    WHERE existsNode(OBJECT_VALUE, '/Employee[EmployeeId="'||:1||'"] ') = 1;

SELECT PLAN_TABLE_OUTPUT
  FROM table(DBMS_XPLAN.display('plan_table', NULL, 'serial'))
/

PLAN_TABLE_OUTPUT
--------------------------------------------------------------------------------
| Id | Operation | Name |
--------------------------------------------------------------------------------
| 0 | SELECT STATEMENT |
| 1 | TABLE ACCESS BY INDEX ROWID| EMP_BIND_TAB |
|* 2 | INDEX RANGE SCAN | EMPLOYEEID_IDX |
--------------------------------------------------------------------------------
Predicate Information (identified by operation id):
---------------------------------------------------
   2 - access("SYS_ALIAS_1"."SYS_NC00008$"=TO_NUMBER(:1))
```

The bind variable `:1` is used as a string literal value enclosed by double-quotes ("). This lets Oracle XML DB rewrite the XPath expression `'/Employee[EmployeeId="' || :1 || '"]'`, and the optimizer can use the `EmployeeId_idx` index to satisfy the predicate.

Setting CURSOR_SHARING to FORCE

With XPath rewrite, Oracle Database changes the input XPath expression to use the underlying columns. This means that for a given XPath there is a particular set of columns or tables that is referenced underneath. This is a compile-time operation, because the shared cursor must know *exactly* which tables and columns it references. This cannot change with each row or instantiation of the cursor.

Hence if the XPath expression is itself a bind variable, Oracle Database cannot do any rewrites, because each instantiation of the cursor can have totally different XPath expressions. This is similar to binding the name of the column or table in a SQL query. For example, `SELECT * FROM table(:1)`.

Note: You can specify bind variables on the right side of the query. For example, this query uses the usual bind variable sharing:

```
SELECT * FROM purchaseorder
  WHERE extractValue(OBJECT_VALUE, '/PurchaseOrder/Reference')
        = :1;
```

When `CURSOR_SHARING` is set to `FORCE`, by default each string constant including XPath becomes a bind variable. When Oracle Database then encounters SQL functions `extractValue`, `existsNode`, and so on, it looks at the XPath bind variables to check if they are really constants. If so, it uses them and rewrites the query. Hence there is a large difference depending on where the bind variable is used.

Loading and Retrieving Large Documents with Collections

Configuration file `/xdbconfig.xml` has parameters that control the amount of memory used by the loading operation. These let you optimize the loading process, provided the following conditions are met:

- The document is loaded using either protocols (FTP, HTTP(S), or DAV) or PL/SQL function `DBMS_XDB.createResource`.
- The document is XML schema-based and contains large collections (elements with `maxoccurs` set to a large number).
- Collections in the document are stored as OCTs. This is the default behavior.

These optimizations are most useful when there are no triggers on the base table. For situations where triggers appear, the performance may be suboptimal.

The basic idea behind this optimization is that it lets the collections be swapped into or out of the memory in bounded sizes. As an illustration of this idea consider the following example conforming to a purchase-order XML schema:

```
<PurchaseOrder>
  <LineItem itemID="1">
    ...
  </LineItem>
    .
    .
  <LineItem itemID="10240">
    ...
  </LineItem>
</PurchaseOrder>
```

The purchase-order document here contains a collection of 10240 `LineItem` elements. Instead of creating the entire document in memory and then pushing it out to disk (a

process that leads to excessive memory usage and in some instances a load failure due to inadequate system memory), we create the documents in finite chunks of memory called **loadable units**. In the example case, if we assume that each line item needs 1 KB of memory and we want to use loadable units of size 512 KB each, then each loadable unit will contain 512 line items, and there will be approximately 20 such units. Moreover, if we want the entire memory representation of the document never to exceed 2 MB in size, then we ensure that at any time no more than 4 loadable units are maintained in the memory. We use an LRU mechanism to swap out the loadable units.

By controlling the size of the loadable unit and the bound on the size of the document you can tune the memory usage and performance of the load or retrieval. Typically a larger loadable unit size translates into lesser number of disk accesses but takes up more memory. This is controlled by the parameter `xdbcore-loadableunit-size` whose default value is 16 KB. The user can indicate the amount of memory to be given to the document by setting the `xdbcore-xobmem-bound` parameter which defaults to 1 MB. The values to these parameters are specified in Kilobytes. So, the default value of `xdbcore-xobmem-bound` is 1024 and that of `xdbcore-loadableunit-size` is 16. These are soft limits that provide some guidance to the system as to how to use the memory optimally.

In the preceding example, when we do the FTP load of the document, the pattern in which the loadable units (LU) are created and flushed to the disk is as follows:

```
No LUs
Create LU1[LineItems(LI):1-512]
LU1[LI:1-512], Create LU2[LI:513-1024]
.
.
LU1[LI:1-512],...,Create LU4[LI:1517:2028]    <-   Total memory size = 2M
Swap Out LU1[LI:1-512], LU2[LI:513-1024],...,LU4[LI:1517-2028], Create
LU5[LI:2029-2540]
Swap Out LU2[LI:513-1024], LU3, LU4, LU5, Create LU6[LI:2541-2052]
.
.
.
Swap Out LU16, LU17, LU18, LU10, Create LU20[LI:9729-10240]
Flush LU17,LU18,LU19,LU20
```

Guidelines for Setting xdbcore Parameters

Typically if you have 1 GB of addressable PGA, give about 1/10th of PGA to the document. So, `xobcore-xobmem-bound` should be set to 1/10 of addressable PGA which equals 100M. During full document retrievals and loads, the `xdbcore-loadableunit-size` should be as close to the `xobcore-xobmem-bound` size as possible, within some error. However, in practice, we set it to half the value of `xdbcore-xobmem-bound`; in this case this is 50 MB. Starting with these values, try to load the document. In case you run out of memory, lower the `xdbcore-xobmem-bound` and set the `xdbcore-loadableunot-size` to half of its value, and continue until the documents load. In case the load succeeds, try to see if you can increase the `xdbcore-loadableunit-size` to squeeze out better performance. If `xdbcore-loadableunit-size` equals `xdbcore-xobmem-bound`, then try to increase both parameters for further performance improvements.

9

XML Schema Evolution

This chapter describes how you can update your XML schema after you have registered it with Oracle XML DB. XML schema evolution is the process of updating your registered XML schema.

This chapter contains these topics:

- Overview of XML Schema Evolution
- Using Copy-Based Schema Evolution
- Using In-Place XML Schema Evolution

Oracle XML DB supports the W3C XML Schema recommendation. XML instance documents that conform to an XML schema can be stored and retrieved using SQL and protocols such as FTP, HTTP(S), and WebDAV. In addition to specifying the structure of XML documents, XML schemas determine the mapping between XML and object-relational storage.

See Also: Chapter 6, "XML Schema Storage and Query: Basic"

Overview of XML Schema Evolution

A major challenge for developers using an XML schema with Oracle XML DB is how to deal with changes in the content or structure of XML documents. In some environments, the need for changes may be frequent or extensive, arising from new regulations, internal needs, or external opportunities. For example, new elements or attributes may need to be added to an XML schema definition, a data type may need to be modified, or certain minimum and maximum occurrence requirements may need to be relaxed or tightened.

In such cases, you need to "evolve" the XML schema so that new requirements are accommodated, while any existing instance documents (the data) remain valid (or can be made valid), and existing applications can continue to run.

If you do not care about any existing documents, you can of course simply drop the `XMLType` tables that are dependent on the XML schema, delete the old XML schema, and register the new XML schema at the same URL. In most cases, however, you need to keep the existing documents, possibly transforming them to accommodate the new XML schema.

Oracle XML DB supports two kinds of schema evolution:

- **Copy-based schema evolution**, in which all instance documents that conform to the schema are copied to a temporary location in the database, the old schema is deleted, the modified schema is registered, and the instance documents are inserted into their new locations from the temporary area

- **In-place schema evolution**, which does not require copying, deleting, and inserting existing data and thus is much faster than copy-based evolution, but which has restrictions that do not apply to copy-based evolution

  In general, in-place evolution is permitted if you are not changing the storage model and if the changes do not invalidate existing documents (that is, if existing documents are conformant with the new schema or can be made conformant with it). A more detailed explanation of restrictions and guidelines is presented in "Using In-Place XML Schema Evolution" on page 9-15.

Each approach has its own PL/SQL procedure: `DBMS_XMLSCHEMA.copyEvolve` for copy-based evolution and `DBMS_XMLSCHEMA.inPlaceEvolve` for in-place evolution. Separate sections in this chapter explain the use of each procedure, as well as guidelines for using its associated approach to schema evolution.

Using Copy-Based Schema Evolution

You perform copy-based XML schema evolution using procedure `copyEvolve` of PL/SQL package `DBMS_XMLSCHEMA`. Procedure `copyEvolve` copies existing instance documents to temporary `XMLType` tables to back them up, drops the old version of the XML schema (which also deletes the associated instance documents), registers the new version, and copies the backed-up instance documents to new `XMLType` tables. In case of a problem, the backup copies are restored—see "Rollback When Procedure DBMS_XMLSCHEMA.COPYEVOLVE Raises an Error" on page 9-9.

With procedure `copyEvolve` you can evolve your registered XML schema in such a way that existing XML instance documents continue to be valid.

Scenario for Copy-Based Evolution

Example 9–1 shows a *partial* listing of a revised version of the purchase-order XML schema of Example 3–8. See Example A–2 on page A-29 for the *complete* revised schema listing. Text that is in **bold** here is new or different from that in the original schema.

Example 9–1 Revised Purchase-Order XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
  <xs:element
    name="PurchaseOrder" type="PurchaseOrderType"
    xdb:defaultTable="PURCHASEORDER"
    xdb:columnProps=
      "CONSTRAINT purchaseorder_pkey PRIMARY KEY (XMLDATA.reference),
       CONSTRAINT valid_email_address FOREIGN KEY (XMLDATA.userid)
         REFERENCES hr.employees (EMAIL)"
    xdb:tableProps=
      "VARRAY XMLDATA.ACTIONS.ACTION STORE AS TABLE ACTION_TABLE
        ((CONSTRAINT action_pkey PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       VARRAY XMLDATA.LINEITEMS.LINEITEM STORE AS TABLE LINEITEM_TABLE
        ((constraint LINEITEM_PKEY primary key (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       lob (XMLDATA.NOTES) STORE AS (ENABLE STORAGE IN ROW STORAGE(INITIAL 4K NEXT 32K))"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="BillingAddress" type="AddressType" minOccurs="0"
```

```
                xdb:SQLName="BILLING_ADDRESS"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
      <xs:element name="Notes" type="NotesType" minOccurs="0" xdb:SQLType="CLOB"
                xdb:SQLName="NOTES"/>
    </xs:sequence>
    <xs:attribute name="Reference" type="ReferenceType" use="required" xdb:SQLName="REFERENCE"/>
    <xs:attribute name="DateCreated" type="xs:dateTime" use="required"
                xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded" xdb:SQLName="LINEITEM"
                xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
      <xs:element name="Quantity" type="quantityType"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:simpleContent>
      <xs:extension base="UPCCodeType">
        <xs:attribute name="Description" type="DescriptionType" use="required"
                  xdb:SQLName="DESCRIPTION"/>
        <xs:attribute name="UnitCost" type="moneyType" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <xs:simpleType name="ReferenceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="18"/>
      <xs:maxLength value="30"/>
    </xs:restriction>
  </xs:simpleType>

. . .

  <xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
    <xs:all>
      <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
      <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
      <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
    </xs:all>
  </xs:complexType>
  <xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
    <xs:sequence>
      <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
      <xs:choice>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="fullAddress" type="FullAddressType" minOccurs="0"
                  xdb:SQLName="SHIP_TO_ADDRESS"/>
      </xs:choice>
      <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
    </xs:sequence>
  </xs:complexType>

. . .
```

```
  <xs:simpleType name="NameType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="20"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="FullAddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>

. . .

  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="AddressType" xdb:SQLType="ADDRESS_T">
    <xs:sequence>
      <xs:element name="StreetLine1" type="StreetType"/>
      <xs:element name="StreetLine2" type="StreetType" minOccurs="0"/>
      <xs:element name="City" type="CityType"/>
      <xs:choice>
        <xs:sequence>
          <xs:element name="State" type="StateType"/>
          <xs:element name="ZipCode" type="ZipCodeType"/>
        </xs:sequence>
        <xs:sequence>
          <xs:element name="Province" type="ProvinceType"/>
          <xs:element name="PostCode" type="PostCodeType"/>
        </xs:sequence>
        <xs:sequence>
          <xs:element name="County" type="CountyType"/>
          <xs:element name="Postcode" type="PostCodeType"/>
        </xs:sequence>
      </xs:choice>
      <xs:element name="Country" type="CountryType"/>
    </xs:sequence>
  </xs:complexType>
  <xs:simpleType name="StreetType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="128"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CityType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="StateType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
      <xs:enumeration value="AK"/>
      <xs:enumeration value="AL"/>
      <xs:enumeration value="AR"/>

 . . . -- A value for each US state abbreviation

      <xs:enumeration value="WY"/>
```

```
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ZipCodeType">
    <xs:restriction base="xs:string">
      <xs:pattern value="\d{5}"/>
      <xs:pattern value="\d{5}-\d{4}"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountryType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountyType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PostCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="12"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ProvinceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="UPCCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="11"/>
      <xs:maxLength value="14"/>
      <xs:pattern value="\d{11}"/>
      <xs:pattern value="\d{12}"/>
      <xs:pattern value="\d{13}"/>
      <xs:pattern value="\d{14}"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

copyEvolve Parameters and Errors

This is the signature of procedure `DBMS_XMLSCHEMA.copyEvolve`:

```
procedure copyEvolve(schemaURLs       IN XDB$STRING_LIST_T,
                     newSchemas       IN XMLSequenceType,
                     transforms       IN XMLSequenceType := NULL,
                     preserveOldDocs  IN BOOLEAN := FALSE,
                     mapTabName       IN VARCHAR2 := NULL,
                     generateTables   IN BOOLEAN := TRUE,
                     force            IN BOOLEAN := FALSE,
                     schemaOwners     IN XDB$STRING_LIST_T := NULL
                     parallelDegree   IN PLS_INTEGER := 0,
                     options          IN PLS_INTEGER := 0);
```

Table 9–1 describes the individual parameters. Table 9–2 describes the errors associated with the procedure.

Table 9–1 Parameters of Procedure DBMS_XMLSCHEMA.COPYEVOLVE

Parameter	Description
`schemaURLs`	Varray of URLs of XML schemas to be evolved (varray of `VARCHAR2(4000)`. This should include the dependent schemas as well. Unless the force parameter is `TRUE`, the URLs should be in the dependency order, that is, if URL A comes before URL B in the varray, then schema A should not be dependent on schema B but schema B may be dependent on schema A.
`newSchemas`	Varray of new XML schema documents (`XMLType` instances). Specify this in exactly the same order as the corresponding URLs. If no change is necessary in an XML schema, provide the unchanged schema.
`transforms`	Varray of XSL documents (`XMLType` instances) that will be applied to XML schema based documents to make them conform to the new schemas. Specify these in exactly the same order as the corresponding URLs. If no transformations are required, this parameter need not be specified.
`preserveOldDocs`	If this is `TRUE`, then the temporary tables holding old data are not dropped at the end of schema evolution. See also "Guidelines for Using copyEvolve".
`mapTabName`	Specifies the name of table that maps old `XMLType` table or column names to names of corresponding temporary tables.
`generateTables`	By default this parameter is `TRUE`; if this is `FALSE`, `XMLType` tables or columns will not be generated after registering new schemas. If this is `FALSE`, `preserveOldDocs` must be `TRUE` and `mapTabName` must not be `NULL`.
`force`	If this is `TRUE`, then errors during the registration of new schemas are ignored. If there are circular dependencies among the schemas, set this flag to `TRUE` to ensure that each schema is stored even though there may be errors in registration.
`schemaOwners`	Varray of names of schema owners. Specify these in exactly the same order as the corresponding URLs.
`parallelDegree`	Specifies the degree of parallelism to be used in a `PARALLEL` hint during the data-copy stage. If this is `0` (default value), a `PARALLEL` hint is absent from the data-copy statements.
`options`	Miscellaneous options. The only option is `COPYEVOLVE_BINARY_XML`, which means to register the new XML schemas for binary XML data and create the new tables or columns with binary XML as the storage model.

Table 9–2 Errors Associated with Procedure DBMS_XMLSCHEMA.COPYEVOLVE

Error Number and Message	Cause	Action
30942 XML Schema Evolution error for schema '<schema_url>' table "<owner_name>.<table_name>" column '<column_name>'	The given `XMLType` table or column that conforms to the given schema had errors during evolution. In the case of a table the column name will be empty. See also the more specific error that follows this.	Based on the schema, table, and column information in this error and the more specific error that follows, take corrective action.

Table 9–2 (Cont.) Errors Associated with Procedure DBMS_XMLSCHEMA.COPYEVOLVE

Error Number and Message	Cause	Action
30943 XML Schema '<schema_url>' is dependent on XML schema '<schema_url>'	Not all dependent XML schemas were specified or the schemas were not specified in dependency order, that is, if schema S1 is dependent on schema S, S must appear before S1.	Include the previously unspecified schema in the list of schemas or correct the order in which the schemas are specified. Then retry the operation.
30944 Error during rollback for XML schema '<schema_url>' table "<owner_name>.<table_name>" column '<column_name>'	The given `XMLType` table or column that conforms to the given schema had errors during a rollback of XML schema evolution. For a table the column name will be empty. See also the more specific error that follows this.	Based on the schema, table, and column information in this error and the more specific error that follows, take corrective action.
30945 Could not create mapping table '<table_name>'	A mapping table could not be created during XML schema evolution. See also the more specific error that follows this.	Ensure that a table with the given name does not exist and retry the operation.
30946 XML Schema Evolution warning: temporary tables not cleaned up	An error occurred after the schema was evolved while cleaning up temporary tables. The schema evolution was successful.	If you need to remove the temporary tables, use the mapping table to get the temporary table names and drop them.

Limitations When Using copyEvolve

Keep in mind the following limitations when you use procedure `DBMS_XMLSCHEMA.copyEvolve`:

- Indexes, triggers, constraints, row-level security (RLS) policies, and other metadata related to the `XMLType` tables that are dependent on the schemas are not preserved. These must be re-created after evolution.
- If top-level element names are changed, additional steps are required after `copyEvolve` finishes executing. See "Top-Level Element Name Changes" on page 9-8.
- Copy-based evolution cannot be used if there is a table with an object-type column that has an `XMLType` attribute that is dependent on any of the schemas to be evolved. For example, consider this table:

```
CREATE TYPE t1 AS OBJECT (n NUMBER, x XMLType);
CREATE TABLE tab1 (e NUMBER, o t1) XMLType
 COLUMN o.x XMLSchema "s1.xsd" ELEMENT "Employee";
```

  This assumes that an XML schema with a top-level element `Employee` has been registered under URL `s1.xsd`. It is not possible to evolve this XML schema, because table `tab1` with column `o` with `XMLType` attribute `x` is dependent on the XML schema. Note that although `copyEvolve` does not handle `XMLType` object attributes, it does raise an error in such cases.

Guidelines for Using copyEvolve

The following general guideline applies to using procedure `DBMS_XMLSCHEMA.copyEvolve`. The rest of this section describes specific guidelines that can also be appropriate in particular contexts.

1. Turn off the recycle bin, to prevent dropped tables from being copied to it:

   ```
   ALTER SESSION SET RECYCLEBIN=off;
   ```

2. Identify the XML schemas that are dependent on the XML schema that is to be evolved. You can acquire the URLs of the dependent XML schemas using the following query, where *`schema_to_be_evolved`* is the schema to be evolved, and *`owner_of_schema_to_be_evolved`* is its owner (database user).

   ```
   SELECT dxs.SCHEMA_URL, dxs.OWNER
       FROM DBA_DEPENDENCIES dd, DBA_XML_SCHEMAS dxs
       WHERE dd.REFERENCED_NAME = (SELECT INT_OBJNAME
                                     FROM DBA_XML_SCHEMAS
                                     WHERE SCHEMA_URL = schema_to_be_evolved
                                       AND OWNER = owner_of_schema_to_be_evolved)
         AND dxs.INT_OBJNAME = dd.NAME;
   ```

   In many cases, no changes are needed in the dependent XML schemas. But if the dependent XML schemas need to be changed, you must also prepare new versions of those XML schemas.

3. If the existing instance documents do not conform to the new XML schema, then you must provide an XSL style sheet that, when applied to an instance document, transforms it to conform to the new schema. You must do this for each XML schema identified in Step 2. The transformation must handle documents that conform to all top-level elements in the new XML schema.

4. Call procedure `DBMS_XMLSCHEMA.copyEvolve`, specifying the XML schema URLs, new schemas, and transformation style sheet.

Top-Level Element Name Changes

Procedure `DBMS_XMLSCHEMA.copyEvolve` assumes that top-level elements have not been dropped and that their names have not been changed in the new XML schemas. If there are such changes in your new XML schemas, then you can call procedure `copyEvolve` with parameter `generateTables` set to `FALSE` and parameter `preserveOldDocs` set to `TRUE`. In this way, new tables are not generated, and the temporary tables holding the old documents (backup copies) are not dropped at the end of the procedure. You can then store the old documents in whatever form is appropriate and drop the temporary tables. See "copyEvolve Parameters and Errors" on page 9-5 for more details on using these parameters.

User-Created Virtual Columns of Nondefault Tables

For nondefault tables, any virtual columns that you create are not re-created during copy-based evolution. If the columns are needed, then set parameter `preserveOldDocs` to `TRUE`, create the tables, and copy the old documents after procedure `copyEvolve` has finished.

Ensure that the XML Schema and Dependents Are Not Used by Concurrent Sessions

Ensure that the XML schema and its dependents are not used by any concurrent session during the XML schema evolution process. If other, concurrent sessions have

shared locks on this schema at the beginning of the evolution process, then procedure DBMS_XMLSCHEMA.copyEvolve waits for these sessions to release the locks so that it can acquire an exclusive lock. However, this lock is released immediately to allow the rest of the process to continue.

Rollback When Procedure DBMS_XMLSCHEMA.COPYEVOLVE Raises an Error

Procedure DBMS_XMLSCHEMA.copyEvolve either completely succeeds or raises an error, in which case it attempts to roll back as much of the operation as possible. Evolving an XML schema involves many database DDL statements. When an error occurs, compensating DDL statements are executed to undo the effect of all steps executed to that point. If the old tables or schemas have been dropped, they are re-created, but any table, column, and storage properties and any auxiliary structures (such as indexes, triggers, constraints, and RLS policies) associated with the tables and columns are lost.

Failed Rollback From Insufficient Privileges

In certain cases you cannot roll back the copy-based evolution operation. For example, if table creation fails due to reasons not related to the new XML schema, then there is no way to roll back. An example is failure due to insufficient privileges. The temporary tables are not deleted even if preserveOldDocs is FALSE, so the data can be recovered. If the mapTabName parameter is null, the mapping table name is XDB$MAPTAB followed by a sequence number. The exact table name can be found using a query such as the following:

```
SELECT TABLE_NAME FROM USER_TABLES WHERE TABLE_NAME LIKE 'XDB$MAPTAB%';
```

Privileges Needed for XML Schema Evolution

Copy-based XML schema evolution may involve dropping or creating data types. Hence, you need type-related privileges such as DROP TYPE, CREATE TYPE, and ALTER TYPE.

You need privileges to delete and register the XML schemas involved in the evolution. You need all privileges on XMLType tables that conform to the schemas being evolved. For XMLType columns, the ALTER TABLE privilege is needed on corresponding tables. If there are schema-based XMLType tables or columns in other database schemas, you need privileges such as the following:

- CREATE ANY TABLE
- CREATE ANY INDEX
- SELECT ANY TABLE
- UPDATE ANY TABLE
- INSERT ANY TABLE
- DELETE ANY TABLE
- DROP ANY TABLE
- ALTER ANY TABLE
- DROP ANY INDEX

To avoid needing to grant all these privileges to the database- schema owner, Oracle recommends that a DBA perform the evolution if there are XML schema-based XMLType table or columns belonging to other database schemas.

Using a Style Sheet to Update Existing Instance Documents

After you modify a registered XML schema, you must update any existing XML instance documents that use the schema. You do this by applying an XSLT style sheet to each of the instance documents. The style sheet represents the difference between the old and new schemas.

Example 9–2 is a style sheet, in file `evolvePurchaseOrder.xsl`, that transforms existing purchase-order documents that use the old schema, so they will use the new schema instead.

Example 9–2 evolvePurchaseOrder.xsl: Style Sheet to Update Instance Documents

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet
  version="1.0"
  xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:output method="xml" encoding="UTF-8"/>
  <xsl:template match="/PurchaseOrder">
    <PurchaseOrder>
      <xsl:attribute name="xsi:noNamespaceSchemaLocation">
        http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
      </xsl:attribute>
      <xsl:for-each select="Reference">
        <xsl:attribute name="Reference">
          <xsl:value-of select="."/>
        </xsl:attribute>
      </xsl:for-each>
      <xsl:variable name="V264_394" select="'2004-01-01T12:00:00.000000-08:00'"/>
      <xsl:attribute name="DateCreated">
        <xsl:value-of select="$V264_394"/>
      </xsl:attribute>
      <xsl:for-each select="Actions">
        <Actions>
          <xsl:for-each select="Action">
            <Action>
              <xsl:for-each select="User">
                <User>
                  <xsl:value-of select="."/>
                </User>
              </xsl:for-each>
              <xsl:for-each select="Date">
                <Date>
                  <xsl:value-of select="."/>
                </Date>
              </xsl:for-each>
            </Action>
          </xsl:for-each>
        </Actions>
      </xsl:for-each>
      <xsl:for-each select="Reject">
        <Reject>
          <xsl:for-each select="User">
            <User>
              <xsl:value-of select="."/>
            </User>
          </xsl:for-each>
          <xsl:for-each select="Date">
            <Date>
              <xsl:value-of select="."/>
            </Date>
          </xsl:for-each>
          <xsl:for-each select="Comments">
            <Comments>
```

```
        <xsl:value-of select="."/>
      </Comments>
    </xsl:for-each>
  </Reject>
</xsl:for-each>
<xsl:for-each select="Requestor">
  <Requestor>
    <xsl:value-of select="."/>
  </Requestor>
</xsl:for-each>
<xsl:for-each select="User">
  <User>
    <xsl:value-of select="."/>
  </User>
</xsl:for-each>
<xsl:for-each select="CostCenter">
  <CostCenter>
    <xsl:value-of select="."/>
  </CostCenter>
</xsl:for-each>
<ShippingInstructions>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="name">
      <name>
        <xsl:value-of select="."/>
      </name>
    </xsl:for-each>
  </xsl:for-each>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="address">
      <fullAddress>
        <xsl:value-of select="."/>
      </fullAddress>
    </xsl:for-each>
  </xsl:for-each>
  <xsl:for-each select="ShippingInstructions">
    <xsl:for-each select="telephone">
      <telephone>
        <xsl:value-of select="."/>
      </telephone>
    </xsl:for-each>
  </xsl:for-each>
</ShippingInstructions>
<xsl:for-each select="SpecialInstructions">
  <SpecialInstructions>
    <xsl:value-of select="."/>
  </SpecialInstructions>
</xsl:for-each>
<xsl:for-each select="LineItems">
  <LineItems>
    <xsl:for-each select="LineItem">
      <xsl:variable name="V22" select="."/>
      <LineItem>
        <xsl:for-each select="@ItemNumber">
          <xsl:attribute name="ItemNumber">
            <xsl:value-of select="."/>
          </xsl:attribute>
        </xsl:for-each>
        <xsl:for-each select="$V22/Part">
          <xsl:variable name="V24" select="."/>
          <xsl:for-each select="@Id">
            <Part>
              <xsl:for-each select="$V22/Description">
                <xsl:attribute name="Description">
                  <xsl:value-of select="."/>
                </xsl:attribute>
```

```
                </xsl:for-each>
                <xsl:for-each select="$V24/@UnitPrice">
                  <xsl:attribute name="UnitCost">
                    <xsl:value-of select="."/>
                  </xsl:attribute>
                </xsl:for-each>
                <xsl:value-of select="."/>
              </Part>
            </xsl:for-each>
          </xsl:for-each>
          <xsl:for-each select="$V22/Part">
            <xsl:for-each select="@Quantity">
              <Quantity>
                <xsl:value-of select="."/>
              </Quantity>
            </xsl:for-each>
          </xsl:for-each>
        </LineItem>
      </xsl:for-each>
    </LineItems>
  </xsl:for-each>
 </PurchaseOrder>
</xsl:template>
</xsl:stylesheet>
```

Examples of Using Procedure copyEvolve

Example 9–3 loads a revised XML schema and evolution XSL style sheet into Oracle XML DB Repository.

Example 9–3 Loading Revised XML Schema and XSL Style Sheet

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB.createResource(               -- Load revised XML schema
           '/source/schemas/poSource/revisedPurchaseOrder.xsd',
           bfilename('XMLDIR', 'revisedPurchaseOrder.xsd'),
           nls_charset_id('AL32UTF8'));
  res := DBMS_XDB.createResource(               -- Load revised XSL style sheet
           '/source/schemas/poSource/evolvePurchaseOrder.xsl',
           bfilename('XMLDIR', 'evolvePurchaseOrder.xsl'),
           nls_charset_id('AL32UTF8'));
END;
/
```

Example 9–4 shows how to use procedure `DBMS_XMLSCHEMA.copyEvolve` to evolve the XML schema `purchaseOrder.xsd` to `revisedPurchaseOrder.xsd` using the XSL style sheet `evolvePurchaseOrder.xsl`.

Example 9–4 Using DBMS_XMLSCHEMA.COPYEVOLVE to Update an XML Schema

```
BEGIN
  DBMS_XMLSCHEMA.copyEvolve(
    xdb$string_list_t('http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd'),
    XMLSequenceType(XDBURIType('/source/schemas/poSource/revisedPurchaseOrder.xsd').getXML()),
    XMLSequenceType(XDBURIType('/source/schemas/poSource/evolvePurchaseOrder.xsl').getXML()));
END;

SELECT extract(object_value, '/PurchaseOrder/LineItems/LineItem[1]') LINE_ITEM
  FROM purchaseorder
  WHERE existsNode(object_value, '/PurchaseOrder[@Reference="SBELL-20030309123336O1PDT"]') = 1
```

```
/

LINE_ITEM
--------------------------------------------------------------------------------
<LineItem ItemNumber="1">
  <Part Description="A Night to Remember" UnitCost="39.95">715515009058</Part>
  <Quantity>2</Quantity>
</LineItem>
```

The same query would have produced the following result before the schema evolution:

```
LINE_ITEM
------------------------------------------------------------
<LineItem ItemNumber="1">
  <Description>A Night to Remember</Description>
  <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
</LineItem>
```

Procedure `DBMS_XMLSCHEMA.copyEvolve` evolves registered XML schemas in such a way that existing instance documents continue to remain valid.

> **Caution:** Before executing procedure `DBMS_XMLSCHEMA.copyEvolve`, always *back up* all registered XML schemas and all XML documents that conform to them. Procedure `copyEvolve` *deletes* all documents that conform to registered XML schemas.

First, procedure `copyEvolve` copies the data in XML schema-based `XMLType` tables and columns to temporary tables. It then drops the original tables and columns, and deletes the old XML schemas. After registering the new XML schemas, it creates `XMLType` tables and columns and populates them with data (unless parameter `GENTABLES` is `FALSE`) but it does not create any auxiliary structures such as indexes, constraints, triggers, and row-level security (RLS) policies. Procedure `copyEvolve` creates the tables and columns as follows:

- It creates default tables while registering the new schemas.
- It creates nondefault tables using a statement of the following form:

  ```
  CREATE TABLE <TABLE_NAME> OF XMLType OID '<OID>'
     XMLSCHEMA <SCHEMA_URL> ELEMENT <ELEMENT_NAME>
  ```

  where `<OID>` is the original OID of the table, before it was dropped.
- It adds `XMLType` columns using a statement of the following form:

  ```
  ALTER TABLE <Table_Name> ADD (<Column_Name> XMLType) XMLType column
    <Column_Name> xmlschema <Schema_Url> ELEMENT <Element_Name>
  ```

When a new XML schema is registered, types are generated if the registration of the corresponding old schema had generated types. If an XML schema was global before the evolution, then it will also be global after the evolution. Similarly, if an XML schema was local before the evolution, then it will also be local (owned by the same user) after the evolution.

You have the option to preserve the temporary tables that contain the old documents, by setting parameter `preserveOldDocs` to `TRUE`. All temporary tables are created in

the database schema of the current user. For XMLType tables, the temporary table has the columns shown in Table 9–3.

Table 9–3 XML Schema Evolution: XMLType Table Temporary Table Columns

Name	Type	Comment
Data	CLOB	XML document from the old table, in CLOB format.
OID	RAW(16)	OID of the corresponding row in the old table.
ACLOID	RAW(16)	This column is present only if the old table is hierarchy enabled. ACLOID of corresponding row in old table.
OWNERID	RAW(16)	This column is present only if old table is hierarchy enabled. OWNERID of corresponding row in old table.

For XMLType columns, the temporary table has the columns shown in Table 9–4.

Table 9–4 XML Schema Evolution: XMLType Column Temporary Table Columns

Name	Type	Comment
Data	CLOB	XML document from the old column, in CLOB format.
RID	ROWID	ROWID of the corresponding row in the table containing this column.

Procedure copyEvolve stores information about the mapping from the old table or column name to the corresponding temporary table name in a separate table specified by parameter mapTabName. If preserveOldDocs is TRUE, then the mapTabName parameter must not be NULL, and it must not be the name of any existing table in the current database schema. Each row in the mapping table has information about one of the old tables/columns. Table 9–5 shows the mapping table columns.

Table 9–5 Procedure copyEvolve Mapping Table

Column Name	Column Type	Comment
SCHEMA_URL	VARCHAR2(700)	URL of the schema to which this table or column conforms.
SCHEMA_OWNER	VARCHAR2(30)	Owner of the schema.
ELEMENT_NAME	VARCHAR2(256)	Element to which this table or column conforms.
TABLE_NAME	VARCHAR2(65)	Qualified name of the table (<owner_name>.<table_name>).
TABLE_OID	RAW(16)	OID of table.
COLUMN_NAME	VARCHAR2(4000)	Name of the column (NULL for XMLType tables).
TEMP_TABNAME	VARCHAR2(30)	Name of temporary table that holds the data for this table or column.

You can avoid generating any tables or columns after registering the new XML schema by setting parameter GENTABLES to FALSE. If GENTABLES is FALSE, parameter PRESERVEOLDDOCS must be TRUE and parameter MAPTABNAME must not be NULL.

This ensures that the data in the old tables is not lost. This is useful if you do not want the tables to be created by the procedure, as described in section "copyEvolve Parameters and Errors" on page 9-5.

By default, it is assumed that all XML schemas are owned by the current user. If this is not true, then you must specify the owner of each XML schema in the `schemaOwners` parameter.

> **See Also:** *Oracle Database SQL Language Reference* for the complete description of `ALTER TABLE`

Using In-Place XML Schema Evolution

In-place XML schema evolution makes changes to an XML schema without requiring that existing data be copied, deleted, and reinserted. In-place evolution is thus much faster than copy-based evolution. However, in-place evolution also has several restrictions that do not apply to copy-based evolution.

You use procedure `DBMS_XMLSCHEMA.inPlaceEvolve` to perform in-place evolution. Using this procedure, you identify the changes to be made to an existing XML schema by specifying an XML schema-differences document, and you optionally specify flags to be applied to the evolution process.

In-place evolution constructs a new version of an XML schema by applying changes specified in a `diffXML` document, validates that new XML schema (against the XML schema for XML schemas), constructs DDL statements to evolve the disk structures used to store the XML instance documents associated with the XML schema, executes these DDL statements, and replaces the old version of the XML schema with the new, in that order. If the new version of the XML schema is not a valid schema, then in-place evolution fails.

Restrictions for In-Place XML Schema Evolution

Because in-place XML schema evolution avoids copying data, it does not permit arbitrary changes to an XML schema. This section describes why certain changes are not permitted. It does not list the supported XML schema changes; for that, see "Supported Operations for In-Place XML Schema Evolution" on page 9-17.

The primary restriction on using in-place evolution can be stated generally as a requirement that a given XML schema can be evolved in place in only a **backward-compatible** way. This means that any possible instance document that would validate against a given XML schema must also validate against a later (evolved) version of that XML schema. Note that this applies not only to existing instance documents; it applies to *all possible* conforming instance documents. For XML data that is stored as binary XML, backward compatibility also means that any XML schema annotations that affect binary XML treatment must not change during evolution. Backward compatibility is described in section "Backward-Compatibility Restrictions" on page 9-15.

In addition to this general backward-compatibility restriction, there are some other restrictions for in-place evolution. These are described in section "Other Restrictions on In-Place Evolution" on page 9-17.

Backward-Compatibility Restrictions

The restrictions described in this section ensure backward compatibility of an evolved XML schema, so that any possible instance documents that satisfy the old XML schema also satisfy the new schema.

Changes in On-Disk Data Layout Certain changes to an XML schema alter the layout of the associated instance documents on disk, and are therefore not permitted. This situation is more common when the storage layer is tightly integrated with information derived from the XML schema, as is the case for object-relational storage.

One such example is an XML schema, registered for object-relational storage mapping, that is evolved by splitting a complex type into two complex types. In Example 9–5, complex type `ShippingInstructionsType` is split into two complex types, `Person-Name` and `Contact-Info`, and the `ShippingInstructionsType` complex type is deleted.

Example 9–5 Splitting a Complex Type into Two Complex Types

These code excerpts show the definitions of the original `ShippingInstructionsType` type and the new `Person-Name` and `Contact-Info` types.

```
<complexType name="ShippingInstructionsType">
    <sequence>
        <element name="name"   type="NameType" minOccurs="0"/>
        <element name="address" type="AddressType" minOccurs="0"/>
        <element name="telephone" type="TelephoneType" minOccurs="0"/>
    </sequence>
</complexType>

<complexType name="Person-Name">
    <sequence>
        <element name="name" type="NameType" minOccurs="0"/>
    </sequence>
</complexType>

<complexType name="Contact-Info">
    <sequence>
        <element name="address" type="AddressType" minOccurs="0"/>
        <element name="telephone" type="TelephoneType" minOccurs="0"/>
    </sequence>
</complexType>
```

Even if this XML schema has no associated instance documents, and therefore no data copy is required, a change in the layout of existing tables is required to accommodate future instance documents.

Reordering of XML Schema Constructs You cannot use in-place evolution to reorder schema elements in a way that affects the DOM fidelity of instance documents. For example, you cannot change the order of elements within a `<sequence>` element in a complex type definition. As an example, if a complex type named `ShippingInstructionsType` requires that its child elements `name`, `address`, and `telephone` be in that order, you cannot use in-place evolution to change the order to `name`, `telephone`, and `address`.

Changes from a Collection to a Non-Collection You cannot use in-place evolution to change a collection to a non-collection. An example would be changing from a `maxOccurs` value greater than one to a `maxOccurs` value of one. You cannot use in-place evolution to delete an element from a complex type if the deletion requires that a collection be evolved to a non-collection.

Other Restrictions on In-Place Evolution

The restrictions on in-place XML schema evolution that are described in this section are necessary for reasons other than backward compatibility of the evolved XML schema.

Changes to Attributes in Namespace xdb Except for attribute `xdb:defaultTable`, you cannot use in-place evolution to modify any attributes in namespace `http://xmlns.oracle.com/xdb` (which has the predefined prefix `xdb`).

Changes from a Non-Collection to a Collection When XML data is stored object-relationally, you cannot use in-place evolution to change a non-collection object type to a collection object type. An example would be adding an element to a complex type with the element name matching the name of an element already present in the type (or in another type that is related to the first type through inheritance).

Supported Operations for In-Place XML Schema Evolution

This section describes operations that are supported for in-place schema evolution. This list of supported operations is not necessarily exhaustive. Some of the operations listed here are not permitted in specific contexts; these contexts are specified. In particular, some of the operations described here are not permitted for XML schemas that are used with binary XML.

- **Add an optional element to a complex type or group:** Always permitted. An example is the addition of the optional element `shipmethod` in the following complex type definition:

```
<xs:complexType name="ShippingInstructionsType">
    <xs:sequence>
        <xs:element name="name" type="NameType" minOccurs="0"/>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
        <xs:element name = "shipmethod" type = "xs:string" minOccurs = "0"/>
    </xs:sequence>
</xs:complexType>
```

- **Add an optional attribute to a complex type or attribute group:** Always permitted. An example is the addition of the optional attribute `shipbydate` in the following complex type definition:

```
<xs:complexType name="ShippingInstructionsType">
    <xs:sequence>
        <xs:element name="name" type="NameType" minOccurs="0"/>
        <xs:element name="address" type="AddressType" minOccurs="0"/>
        <xs:element name="telephone" type="TelephoneType" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="shipbydate" type="DateType" use="optional"/>
</xs:complexType>
```

- **Convert an element from simple type to complex type with simple content:** Supported only if the storage model is binary XML.
- **Modify the value attribute of an existing maxLength element:** Always permitted. The value can only be increased, not decreased.
- **Add an enumeration value:** You can add a new enumeration value only to the end of an enumeration list.

- **Add a global element:** Always permitted. An example is the addition of the global element `PurchaseOrderComment` in the following schema definition:

```
<xs:schema ...>
...
    <xs:element name="PurchaseOrderComment" type="string" xdb:defaultTable=""/>
..
</xs:schema>
```

- **Add a global attribute:** Always permitted.
- **Add or delete a global complex type:** Always permitted. An example is the addition of the global complex type `ComplexAddressType` in the following schema definition:

```
<xs:schema ...>
....
    <xs:complexType name="ComplexAddressType">
        <xs:sequence>
            <xs:element name="street" type="string"/>
            <xs:element name="city" type="string"/>
            <xs:element ref="zip" type="positiveInteger"/>
            <xs:element name="country"  type="string"/>
        </xs:sequence>
     </xs:complexType>
...
</xs:schema>
```

- **Add or delete a global simple type:** Always permitted.
- **Change the minOccurs attribute value:** The value of `minOccurs` can only be decreased.
- **Change the maxOccurs attribute value:** The value of `maxOccurs` can only be increased, and this is only possible for data stored as binary XML. That is, you cannot make any change to the `maxOccurs` attribute for data stored object-relationally.
- **Add or delete a global group or attributeGroup:** Always permitted. An example is the addition of an `Instructions` group in the following type definition:

```
<xsd:schema ...>
...
  <xsd:group name="Instructions">
    <xsd:sequence>
     <xsd:element name="ShippingInstructions" type="ShippingInstructionsType"/>
      <xsd:element name="SpecialInstructions" type=" SpecialInstructionsType"/>
    </xsd:sequence>
  </xsd:group>
...
</xsd:schema>
```

- **Change the xdb:defaultTable attribute value:** Always permitted. Changes are *not* permitted to any other attributes in the `xdb` namespace.
- **Add, modify, or delete a comment or processing instruction:** Always permitted.

Guidelines for Using In-Place XML Schema Evolution

The following guidelines apply to in-place XML-schema evolution:

- *Before* you perform an in-place XML-schema evolution:

- *Back up all existing data* (instance documents) for the XML schema that will be evolved.

  Caution: Make sure that you back up your data before performing in-place XML schema evolution, in case the result is not what you intended. There is *no rollback* possible after an in-place evolution. If any errors occur during evolution, or if you make a major mistake and need to redo the entire operation, you must be able to go back to the backup copy of your original data.

- *Perform a dry run* using trace only, that is, without actually evolving the XML schema or updating any instance documents, produce a trace of the update operations that would be performed during evolution. To do this, set the `flag` parameter value to only `INPLACE_TRACE`. Do not also use `INPLACE_EVOLVE`.

  After performing the dry run, examine the trace file, verifying that the listed DDL operations are in fact those that you intend.

- *After* you perform an in-place XML-schema evolution:

  If you are accessing the database using a client that caches data, or if you are not sure whether this is the case, then *restart your client*. Otherwise, the pre-evolution version of the XML schema might continue to be used locally, with unpredictable results.

  See Also: *Oracle Database Administrator's Guide* for information about using trace files

inPlaceEvolve Parameters

This is the signature of procedure `DBMS_XMLSCHEMA.inPlaceEvolve`:

```
procedure inPlaceEvolve(schemaURL IN VARCHAR2,
                        diffXML   IN XMLType,
                        flags     IN NUMBER);
```

Table 9–6 describes the individual parameters.

Table 9–6 Parameters of Procedure DBMS_XMLSCHEMA.INPLACEEVOLVE

Parameter	Description
`schemaURL`	URL of the XML schema to be evolved (`VARCHAR2`).
`diffXML`	XML document (`XMLType` instance) that conforms to the `xdiff` XML schema, and that specifies the changes to apply and the locations in the XML schema where the changes are to be applied. For information about how to create the document for this parameter, see "Creating the Document for the diffXML Parameter" on page 9-20.

Table 9–6 (Cont.) Parameters of Procedure DBMS_XMLSCHEMA.INPLACEEVOLVE

Parameter	Description
flags	A bit mask that controls the behavior of the procedure. You can set the following bit values in this mask independently, summing them to define the overall effect. The default flags value is 1 (bit 1 on, bit 2 off), meaning that in-place evolution is performed and no trace is written. ■ INPLACE_EVOLVE (value 1, meaning that bit 1 is on) – Perform in-place XML schema evolution: construct a new XML schema and validate it (against the XML schema for XML schemas); construct the DDL statements needed to evolve the instance-document disk structures, execute the DDL statements, and replace the old XML schema with the new. ■ INPLACE_TRACE (value 2, meaning that bit 2 is on) – Perform all steps necessary for in-place evolution, *except* executing the DDL statements and overwriting the old XML schema with the new, then write both the DDL statments and the new XML schema to a trace file. That is, each of the bits constructs the new XML schema, validates it, and determines the steps needed to evolve the disk structures underlying the instance documents. In addition: ■ Bit INPLACE_EVOLVE carries out those evolution steps and replaces the old XML schema with the new. ■ Bit INPLACE_TRACE saves the evolution steps and the new XML schema in a trace file (it does not carry out the evolution steps).

Procedure DBMS_XMLSCHEMA.inPlaceEvolve raises an error in the following cases:

- An XPath expression is invalid, or is syntactically correct but does not target a node in the XML schema.
- The diffXML document does not conform to the xdiff XML schema.
- The change makes the XML schema invalid or not well formed.
- A generated DDL statement (CREATE TYPE, ALTER TYPE, and so on) causes a problem when it is executed.

Creating the Document for the diffXML Parameter

The value of the diffXML parameter to procedure DBMS_XMLSCHEMA.inPlaceEvolve is an XML document (as an XMLType instance) that specifies the changes to be applied to an XML schema for in-place evolution. This diffXML document contains a sequence of operations that describe the changes between the old XML schema and the new (the intended evolution result). The changes specified by the diffXML document are applied in order.

You must create the XML document to be used for the diffXML parameter. To do this, you can use any of the following methods:

- The XMLDiff JavaBean (oracle.xml.differ.XMLDiff)
- The xmldiff command-line utility
- SQL function XMLDiff

The diffXML parameter document must conform to the xdiff XML schema.

The rest of this section presents examples of some operations in a document that conforms to the xdiff XML schema.

See Also:

- "xdiff.xsd: XML Schema for Comparing Schemas for In-Place Evolution" on page A-24
- *Oracle XML Developer's Kit Programmer's Guide* for information on using the `XMLDiff` JavaBean
- *Oracle XML Developer's Kit Programmer's Guide* for information on command-line utility `xmldiff`
- *Oracle Database SQL Language Reference* for information on SQL function `XMLDiff`

diffXML Operations and Examples

This section describes some operations that can be specified in the document for the `diffXML` document supplied to procedure `DBMS_XMLSCHEMA.inPlaceEvolve`. It presents an example XML document that conforms to the `xdiff` XML schema.

The `<append-node>` element is used for most of the supported changes, such as adding a new attribute to a complex type or appending a new element to a group.

The `<insert-node-before>` element specifies that a node of the given type should be inserted before the specified node. The `xpath` attribute specifies the location of the specified node and the `node-type` attribute specifies the type of node to be inserted. The node to be inserted is specified by the `<content>` child element. The `<insert-node-before>` element is mainly used for inserting comments and processing instructions, and for changing and adding add annotation elements.

The `<delete-node>` element specifies that the node with the given XPath (specified by the `xpath` attribute) should be deleted along with all its children. For example, you can use this element to delete comments and annotation elements. You can also use this element, in conjunction with `<append-node>` or `<insert-node-before>`, to make changes to an existing node.

Example 9–6 shows an XML document for the `diffXML` parameter that specifies the following changes:

- Delete complex type `PartType`.
- Add complex type `PartType` with a maximum length of 28.
- Add a comment before element `ShippingInstructions`.
- Add a required element `shipmethod` to element `ShippingInstructions`.

Example 9–6 diffXML Parameter Document

```
<xd:xdiff  xmlns="http://www.w3c.org/2001/XMLSchema"
           xmlns:xd="http://xmlns.oracle.com/xdb/xdiff.xsd"
           xmlns:xsi="http://www.w3c.org/2001/XMLSchema-Instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/xdiff.xsd
           http://xmlns.oracle.com/xdb/xdiff.xsd">
 <xd:delete-node xpath="/schema/complexType[@name=&quote;PartType&quote;]//maxLength/>
 <xd:append-node
  parent-xpath = "/schema/complexType[@name=&quote;PartType&quote;]//restriction"
  node-type = "element">
  <xd:content>
    <xs:maxLength value = "28"/>
  </xd:content>
 </xd:append-node>
 <xd:insert-node-before
```

```
  xpath="/schema/complexType[@name =&quote;ShippingInstructionsType&quote;]/sequence"
  node-type="comment">
  <xd:content>
    <!-- A type representing instructions for shipping -->
  </xd:content>
 </xd:insert-node-before>
 <xd:append-node
  parent-xpath="/schema/complexType[@name=&quote;ShippingInstructionsType&quote;]/sequence"
  node-type="element">
  <xd:content>
   <xs:element name = "shipmethod" type = "xs:string" minOccurs = "1"/>
  </xd:content>
 </xd:append-node>
</xd:xdiff>
```

10

Transforming and Validating XMLType Data

This chapter describes the SQL functions and `XMLType` APIs for transforming `XMLType` data using XSLT style sheets. It also explains the various functions and APIs available for validating the `XMLType` instance against an XML schema.

This chapter contains these topics:

Transforming XMLType Instances

XML documents have structure but no format. To add format to the XML documents you can use Extensible Stylesheet Language (XSL). XSL provides a way of displaying XML semantics. It can map XML elements into other formatting or mark-up languages such as HTML.

In Oracle XML DB, `XMLType` instances or XML data stored in `XMLType` tables, columns, or views in Oracle Database, can be (formatted) transformed into HTML, XML, and other mark-up languages, using XSL style sheets and the `XMLType` method `transform()`. This process conforms to the W3C XSL Transformations 1.0 Recommendation.

`XMLType` instance can be transformed in the following ways:

- Using SQL function `XMLtransform` (or `XMLType` method `transform()`) in the database.
- Using XDK transformation options in the middle tier, such as XSLT Processor for Java.

Note: PL/SQL package `DBMS_XSLPROCESSOR` provides a convenient and efficient way of applying a single style sheet to multiple documents. The performance of this package is better than that of method `transform()`, because the style sheet is parsed only once.

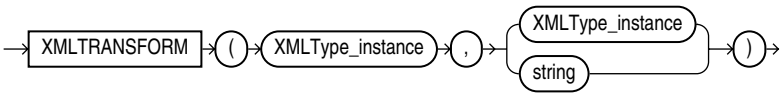
See Also:

- Chapter 3, "Using Oracle XML DB", the section, "XSL Transformation and Oracle XML DB" on page 3-71
- "PL/SQL XSLT Processor for XMLType (DBMS_XSLPROCESSOR)" on page 12-20
- *Oracle XML Developer's Kit Programmer's Guide*, the chapter on XSQL Pages Publishing Framework

SQL Function XMLTRANSFORM and XMLType Method transform()

Figure 10–1 shows the syntax of SQL function `XMLtransform`. This function takes as arguments an `XMLType` instance and an XSLT style sheet. The style sheet can be an `XMLType` instance or a `VARCHAR2` string literal. It applies the style sheet to the instance and returns an `XMLType` instance.

Figure 10–1 XMLtransform Syntax



You can alternatively use `XMLType` method `transform()` as an alternative to SQL function `XMLtransform`; it has the same functionality.

Figure 10–2 shows how `XMLtransform` transforms an XML document by using an XSLT style sheet. It returns the processed output as XML, HTML, and so on, as specified by the XSLT style sheet. You typically use `XMLtransform` when retrieving or generating XML documents stored as `XMLType` in the database.

See Also: Figure 1–1, "XMLType Storage and Oracle XML DB Repository" in Chapter 1, "Introduction to Oracle XML DB"

Figure 10–2 Using XMLTRANSFORM

XMLTRANSFORM and XMLType.transform(): Examples

The examples in this section illustrate how to use SQL function `XMLtransform` and XMLType method `transform()` to transform XML data stored as `XMLType` to various formats.

Example 10–1 Registering XML Schema and Inserting XML Data

This example sets up the XML schema and tables needed to run other examples in this chapter. (The call to `deleteSchema` here ensures that there is no existing XML schema before creating one. If no such schema exists, then `deleteSchema` produces an error.)

```
BEGIN
  -- Delete the schema, if it already exists; otherwise, this produces an error.
  DBMS_XMLSCHEMA.deleteSchema('http://www.example.com/schemas/ipo.xsd',4);
END;
```

```
/
BEGIN
-- Register the schema
DBMS_XMLSCHEMA.registerSchema('http://www.example.com/schemas/ipo.xsd',
'<schema targetNamespace="http://www.example.com/IPO"
         xmlns="http://www.w3.org/2001/XMLSchema"
         xmlns:ipo="http://www.example.com/IPO">
  <!-- annotation>
   <documentation xml:lang="en">
    International Purchase order schema for Example.com
    Copyright 2000 Example.com. All rights reserved.
   </documentation>
  </annotation -->
  <element name="purchaseOrder" type="ipo:PurchaseOrderType"/>
  <element name="comment" type="string"/>
  <complexType name="PurchaseOrderType">
   <sequence>
    <element name="shipTo"     type="ipo:Address"/>
    <element name="billTo"     type="ipo:Address"/>
    <element ref="ipo:comment" minOccurs="0"/>
    <element name="items"      type="ipo:Items"/>
   </sequence>
   <attribute name="orderDate" type="date"/>
  </complexType>
  <complexType name="Items">
   <sequence>
    <element name="item" minOccurs="0" maxOccurs="unbounded">
     <complexType>
      <sequence>
       <element name="productName" type="string"/>
       <element name="quantity">
        <simpleType>
         <restriction base="positiveInteger">
          <maxExclusive value="100"/>
         </restriction>
        </simpleType>
       </element>
       <element name="USPrice"    type="decimal"/>
       <element ref="ipo:comment" minOccurs="0"/>
       <element name="shipDate"   type="date" minOccurs="0"/>
      </sequence>
      <attribute name="partNum" type="ipo:SKU" use="required"/>
     </complexType>
    </element>
   </sequence>
  </complexType>
  <complexType name="Address">
   <sequence>
    <element name="name"    type="string"/>
    <element name="street"  type="string"/>
    <element name="city"    type="string"/>
    <element name="state"   type="string"/>
    <element name="country" type="string"/>
    <element name="zip"     type="string"/>
   </sequence>
  </complexType>
  <simpleType name="SKU">
   <restriction base="string">
    <pattern value="[0-9]{3}-[A-Z]{2}"/>
   </restriction>
```

```
  </simpleType>
</schema>',
   TRUE, TRUE, FALSE);
END;
/

-- Create table to hold XML instance documents
DROP TABLE po_tab;

CREATE TABLE po_tab (id NUMBER, xmlcol XMLType)
 XMLType COLUMN xmlcol
 XMLSCHEMA "http://www.example.com/schemas/ipo.xsd"
 ELEMENT "purchaseOrder";

INSERT INTO po_tab
  VALUES(1, XMLType(
              '<?xml version="1.0"?>
               <ipo:purchaseOrder
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:ipo="http://www.example.com/IPO"
                 xsi:schemaLocation="http://www.example.com/IPO
                                     http://www.example.com/schemas/ipo.xsd"
                 orderDate="1999-12-01">
                 <shipTo>
                   <name>Helen Zoe</name>
                   <street>121 Broadway</street>
                   <city>Cardiff</city>
                   <state>Wales</state>
                   <country>UK</country>
                   <zip>CF2 1QJ</zip>
                 </shipTo>
                 <billTo>
                   <name>Robert Smith</name>
                   <street>8 Oak Avenue</street>
                   <city>Old Town</city>
                   <state>CA</state>
                   <country>US</country>
                   <zip>95819</zip>
                 </billTo>
                 <items>
                   <item partNum="833-AA">
                     <productName>Lapis necklace</productName>
                     <quantity>1</quantity>
                     <USPrice>99.95</USPrice>
                     <ipo:comment>Want this for the holidays!</ipo:comment>
                     <shipDate>1999-12-05</shipDate>
                   </item>
                 </items>
               </ipo:purchaseOrder>'));
```

Example 10–2 Using XMLTRANSFORM and DBURITYPE to Retrieve a Style Sheet

`DBURIType` is described in Chapter 20, "Accessing Data Through URIs".

```
DROP TABLE stylesheet_tab;

CREATE TABLE stylesheet_tab(id NUMBER, stylesheet XMLType);

INSERT INTO stylesheet_tab
  VALUES (1,
          XMLType(
```

```
            '<?xml version="1.0" ?>
             <xsl:stylesheet version="1.0"
                             xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
               <xsl:template match="*">
                 <td>
                   <xsl:choose>
                     <xsl:when test="count(child::*) > 1">
                       <xsl:call-template name="nested"/>
                     </xsl:when>
                     <xsl:otherwise>
                       <xsl:value-of select="name(.)"/>:<xsl:value-of
                                                          select="text()"/>
                     </xsl:otherwise>
                   </xsl:choose>
                 </td>
               </xsl:template>
               <xsl:template match="*" name="nested" priority="-1" mode="nested2">
                 <b>
                   <!-- xsl:value-of select="count(child::*)"/ -->
                   <xsl:choose>
                     <xsl:when test="count(child::*) > 1">
                       <xsl:value-of select="name(.)"/>:<xsl:apply-templates
                                                          mode="nested2"/>
                     </xsl:when>
                     <xsl:otherwise>
                       <xsl:value-of select="name(.)"/>:<xsl:value-of
                                                          select="text()"/>
                     </xsl:otherwise>
                   </xsl:choose>
                 </b>
               </xsl:template>
             </xsl:stylesheet>'));

SELECT
  XMLtransform(x.xmlcol,
               DBURIType('/XDB/STYLESHEET_TAB/ROW
                           [ID=1]/STYLESHEET/text()').getXML()).getStringVal()
  AS result
  FROM po_tab x;
```

This produces the following output (pretty-printed here for readability):

```
RESULT
------------------------------------------------------------
<td>
  <b>ipo:purchaseOrder:
    <b>shipTo:
      <b>name:Helen Zoe</b>
      <b>street:100 Broadway</b>
      <b>city:Cardiff</b>
      <b>state:Wales</b>
      <b>country:UK</b>
      <b>zip:CF2 1QJ</b>
    </b>
    <b>billTo:
      <b>name:Robert Smith</b>
      <b>street:8 Oak Avenue</b>
      <b>city:Old Town</b>
      <b>state:CA</b>
      <b>country:US</b>
      <b>zip:95819</b>
```

```
    </b>
    <b>items:</b>
  </b>
</td>
```

Example 10–3 Using XMLTRANSFORM and a Subquery to Retrieve a Style Sheet

This example illustrates the use of a stored style sheet to transform `XMLType` instances. Unlike the previous example, this example uses a scalar subquery to retrieve the stored style sheet:

```
SELECT XMLtransform(x.xmlcol,
    (SELECT stylesheet FROM stylesheet_tab WHERE id = 1)).getStringVal()
     AS result
   FROM po_tab x;
```

Example 10–4 Using Method transform() with a Transient Style Sheet

This example uses XMLType method `transform()` to transform an `XMLType` instance using a transient style sheet:

```
SELECT x.xmlcol.transform(XMLType(
'<?xml version="1.0" ?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
<xsl:template match="*">
    <td>
    <xsl:choose>
      <xsl:when test="count(child::*) > 1">
        <xsl:call-template name="nested"/>
      </xsl:when>
      <xsl:otherwise>
        <xsl:value-of select="name(.)"/>:<xsl:value-of select="text()"/>
      </xsl:otherwise>
    </xsl:choose>
    </td>
</xsl:template>
<xsl:template match="*" name="nested" priority="-1" mode="nested2">
    <b>
    <!-- xsl:value-of select="count(child::*)"/ -->
    <xsl:choose>
      <xsl:when test="count(child::*) > 1">
        <xsl:value-of select="name(.)"/>:<xsl:apply-templates mode="nested2"/>
      </xsl:when>
      <xsl:otherwise>
        <xsl:value-of select="name(.)"/>:<xsl:value-of select="text()"/>
      </xsl:otherwise>
    </xsl:choose>
    </b>
</xsl:template>
</xsl:stylesheet>'
)).getStringVal()
FROM po_tab x;
```

Validating XMLType Instances

Often, besides knowing that a particular XML document is well-formed, it is necessary to know if a particular document conforms to a specific XML schema, that is, is VALID with respect to a specific XML schema.

By default, the database checks to ensure that XMLType instances are well-formed. In addition, for schema-based XMLType instances, the database performs few basic validation checks. Because full XML schema validation (as specified by the W3C) is an expensive operation, when XMLType instances are constructed, stored, or retrieved, they are not also fully validated.

To validate and manipulate the validation status of XML documents, the following functions and procedures are provided:

XMLIsValid

PL/SQL function XMLIsValid checks if the input instance conforms to a specified XML schema. It does not change the validation status of the XML instance. If an XML schema URL is not specified and the XML document is schema-based, the conformance is checked against the own schema of the XMLType instance. If any of the arguments are specified to be NULL, then the result is NULL. If validation fails, then 0 is returned and no errors are reported explaining why the validation has failed.

Syntax

```
XMLIsValid (XMLType_inst [, schemaurl [, elem]])
```

Parameters:

- *XMLType_inst* - The XMLType instance to be validated against the specified XML schema.
- *schurl* - The URL of the XML schema against which to check conformance.
- *elem* - Element of a specified schema, against which to validate. This is useful when we have a XML schema which defines more than one top level element, and we want to check conformance against a specific one of these elements.

schemaValidate

PL/SQL procedure schemaValidate validates an XML instance against its XML schema if it has not already been done. For non-schema-based documents an error is raised. If validation fails an error is raised otherwise, then the document status is changed to VALIDATED.

Syntax

```
MEMBER PROCEDURE schemaValidate
```

isSchemaValidated

PL/SQL function isSchemaValidated returns the validation status of the XMLType instance and tells if a schema-based instance has been validated against its schema. It returns 1 if the instance has been validated against the schema, 0 otherwise.

Syntax

```
MEMBER FUNCTION isSchemaValidated return NUMBER deterministic
```

setSchemaValidated

PL/SQL procedure setSchemaValidated sets the VALIDATION state of the input XML instance.

Syntax

```
MEMBER PROCEDURE setSchemaValidated(flag IN BINARY_INTEGER := 1)
```

Parameters:

flag, 0 - not validated; 1 - validated; The default value is 1.

isSchemaValid

PL/SQL function `isSchemaValid` checks if the input instance conforms to a specified XML schema. It does not change the validation status of the XML instance. If an XML schema URL is not specified and the XML document is schema-based, then the conformance is checked against the own schema of the `XMLType` instance. If the validation fails, then exceptions are thrown with the reason why the validation has failed.

Syntax

```
MEMBER FUNCTION isSchemaValid(schurl IN VARCHAR2 := NULL,
                              elem IN VARCHAR2 := NULL)
  RETURN NUMBER DETERMINISTIC
```

Parameters:

schurl - The URL of the XML schema against which to check conformance.

elem - Element of a specified schema, against which to validate. This is useful when we have an XML schema which defines more than one top level element, and we want to check conformance against a specific one of these elements.

Validating XML Data Stored as XMLType: Examples

The following examples illustrate how to use `XMLType` methods `isSchemaValid()` and `schemaValidate()`, as well as PL/SQL function `XMLIsValid`, to validate XML data being stored as `XMLType` in Oracle XML DB.

Example 10–5 Using Method isSchemaValid()

```
SELECT x.xmlcol.isSchemaValid('http://www.example.com/schemas/ipo.xsd',
               'purchaseOrder')
    FROM po_tab x;
```

Example 10–6 Validating XML Using Method isSchemaValid()

The following PL/SQL example validates an XML instance against XML schema `PO.xsd`:

```
DECLARE
  xmldoc XMLType;
BEGIN
  -- Populate xmldoc (for example, by fetching from table).
  -- Validate against XML schema
  xmldoc.isSchemaValid('http://www.oracle.com/PO.xsd');
  IF xmldoc.isSchemaValid = 1 THEN  --
  ELSE --
  END IF;
END;
```

Example 10–7 Using Method schemaValidate() Within Triggers

XMLType method schemaValidate() can be used within INSERT and UPDATE TRIGGERS to ensure that all instances stored in the table are validated against the XML schema:

```
DROP TABLE po_tab;

CREATE TABLE po_tab OF XMLType
  XMLSCHEMA "http://www.example.com/schemas/ipo.xsd" ELEMENT "purchaseOrder";

CREATE TRIGGER emp_trig BEFORE INSERT OR UPDATE ON po_tab FOR EACH ROW

DECLARE
  newxml XMLType;
BEGIn
  newxml := :new.OBJECT_VALUE;
  XMLTYPE.schemavalidate(newxml);
END;
/
```

Example 10–8 Using PL/SQL Function XMLISVALID Within CHECK Constraints

This example uses PL/SQL function XMLIsValid to:

- Verify that the XMLType instance conforms to the specified XML schema
- Ensure that the incoming XML documents are valid by using CHECK constraints

```
DROP TABLE po_tab;

CREATE TABLE po_tab OF XMLType
   (CHECK (XMLIsValid(OBJECT_VALUE) = 1))
   XMLSCHEMA "http://www.example.com/schemas/ipo.xsd" ELEMENT "purchaseOrder";
```

> **Note:** The validation functions and procedures described in the preceding section facilitate validation checking. Of these, isSchemaValid is the only one that throws errors that indicate why the validation has failed.

11

Full-Text Search Over XML Data

This chapter describes full-text search over XML using Oracle. It explains how to use SQL function `contains` and XPath function `ora:contains`, the two functions used by Oracle Database to do full-text search over XML data.

> **See Also:** *Oracle Text Reference* and *Oracle Text Application Developer's Guide* for more information about Oracle Text

This chapter contains these topics:

Overview of Full-Text Search for XML

Oracle supports full-text search on documents that are managed by the Oracle Database.

If your documents are XML, then you can use the XML structure of the document to restrict the full-text search. For example, you may want to find all purchase orders that contain the word "electric" using full-text search. If the purchase orders are in XML form, then you can restrict the search by finding all purchase orders that contain the word "electric" in a comment, or by finding all purchase orders that contain the word "electric" in a comment under line items.

If your XML documents are of type `XMLType`, then you can project the results of your query using the XML structure of the document. For example, after finding all purchase orders that contain the word "electric" in a comment, you may want to return just the comments, or just the comments that contain the word "electric".

Comparison of Full-Text Search and Other Search Types

Full-text search differs from structured search or substring search in the following ways:

- A full-text search looks for whole *words* rather than substrings. A substring search for comments that contain the *string* "law" might return a comment that contains "my *law*n is going wild". A full-text search for the *word* "law" will not.
- A full-text search will support some language-based and word-based searches which substring searches cannot. You can use a language-based search, for example, to find all the comments that contain a word with the same linguistic stem as "mouse", and Oracle Text will find "mouse" and "mice". You can use a word-based search, for example, to find all the comments that contain the word "lawn" within 5 words of "wild".
- A full-text search generally involves some notion of relevance. When you do a full-text search for all the comments that contain the word "lawn", for example, some results are more relevant than others. Relevance is often related to the number of times the search word (or similar words) occur in the document.

Searching XML Data

XML search is different from unstructured document search. In unstructured document search you generally search across a set of documents to return the documents that satisfy your text predicate. In XML search you often want to use the structure of the XML document to restrict the search. And you often want to return just the part of the document that satisfies the search.

Searching Documents Using Full-Text Search and XML Structure

There are two ways to do a search that includes full-text search and XML structure:

- Include the structure inside the full-text predicate, using SQL function `contains`:

  ```
  ... WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)')
            > 0 ...
  ```

  Function `contains` is an extension to SQL, and can be used in any query. It requires a `CONTEXT` full-text index.

- Include the full-text predicate inside the structure, using the `ora:contains` XPath function:

  ```
  ... '/purchaseOrder/items/item/comment[ora:contains(text(), "electric")>0]' ...
  ```

  The `ora:contains` XPath function is an extension to XPath, and can be used in any call to `existsNode`, `extract`, or `extractValue`.

About the Full-Text Search Examples

This section describes details about the examples included in this chapter.

Roles and Privileges

To run the examples you will need the `CTXAPP` role, as well as `CONNECT` and `RESOURCE`. You must also have `EXECUTE` privilege on the `CTXSYS` package `CTX_DDL`.

Schema and Data for Full-Text Search Examples

Examples in this chapter are based on "The Purchase Order Schema", W3C XML Schema Part 0: Primer.

See Also:

http://www.w3.org/TR/xmlschema-0/#POSchema

The data in the examples is "Purchase-Order XML Document, po001.xml" on page 11-27. Some of the performance examples are based on a larger table (PURCHASE_ORDERS_xmltype_big), which is included in the downloadable version only.

See Also: http://www.w3.org/TR/xmlschema-0/#po.xml

Some examples here use data type VARCHAR2; others use XMLType. All examples that use VARCHAR2 will also work with XMLType.

Overview of CONTAINS and ora:contains

This section contains these topics:

- Overview of SQL Function CONTAINS
- Overview of XPath Function ora:contains
- Comparison of CONTAINS and ora:contains

Overview of SQL Function CONTAINS

SQL function contains returns a positive number for rows where [schema.]column matches text_query, and zero otherwise. It is a user-defined function, a standard extension method in SQL. It *requires* an index of type CONTEXT. If there is no CONTEXT index on the column being searched, then contains raises an error.

Syntax

```
contains([schema.]column, text_query VARCHAR2 [,label NUMBER])
RETURN NUMBER
```

Example 11–1 Simple CONTAINS Query

A typical query looks like this:

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn') > 0;
```

This query uses table purchase_orders and index po_index. It returns the ID for each row in table purchase_orders where the doc column contains the word "lawn".

Example 11–2 CONTAINS With a Structured Predicate

SQL function contains can be used in any SQL query. Here is an example using table purchase_orders and index po_index:

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn') > 0 AND id < 25;
```

Example 11–3 CONTAINS Using XML Structure to Restrict the Query

Suppose doc is a column that contains a set of XML documents. You can do full-text search over doc, using its XML structure to restrict the query. This query uses table purchase_orders and index po_index-path-section:

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn WITHIN comment') > 0;
```

Example 11–4 CONTAINS With Structure Inside Full-Text Predicate

More complex structure restrictions can be applied with the `INPATH` operator and an XPath expression. This query uses table `purchase_orders` and index `po_index-path-section`:

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

Overview of XPath Function ora:contains

XPath function `ora:contains` can be used in an *XPath expression* inside an XQuery expression or in a call to SQL function `existsNode`, `extract`, or `extractValue`. It is used to restrict a structural search with a full-text predicate. It extends XPath through a standard mechanism: it is a user-defined function in the Oracle XML DB namespace, `ora`. It requires no index, but you can use an index with it to improve performance.

Syntax

```
ora:contains(input_text NODE*, text_query STRING
             [,policy_name STRING]
             [,policy_owner STRING])
```

Function `ora:contains` returns a positive integer when the *`input_text`* matches *`text_query`* (the higher the number, the more relevant the match), and zero otherwise. When used in an XQuery expression, the XQuery return type is `xs:integer()`; when used in an XPath expression outside of an XQuery expression, the XPath return type is `number`.

Argument *`input_text`* must evaluate to a single text node or an attribute. The syntax and semantics of *`text_query`* in `ora:contains` are the same as *`text_query`* in `contains`, with the following restrictions:

- Argument *`text_query`* cannot include any structure operators (`WITHIN`, `INPATH`, or `HASPATH`).
- If the `weight` score-weighting operator is used, the weights are *ignored*.

Example 11–5 shows a call to `ora:contains` in the XPath parameter to `existsNode`. Note that the third parameter to `existsNode` (the Oracle XML DB namespace, `ora`) is required. This example uses table `purchase_orders_xmltype`.

Example 11–5 ora:contains with an Arbitrarily Complex Text Query

```
SELECT id
  FROM purchase_orders_xmltype
  WHERE
    existsNode(doc,
               '/purchaseOrder/comment
                  [ora:contains(text(), "($lawns AND wild) OR flamingo") > 0]',
               'xmlns:ora="http://xmlns.oracle.com/xdb"')
    = 1;
```

> **See Also:** "ora:contains XPath Function" on page 11-18 for more on the `ora:contains` XPath function

Comparison of CONTAINS and ora:contains

Both contains and ora:contains let you combine searching on XML structure with full-text searching.

SQL function `contains`:

- Needs a `CONTEXT` index to run. If there is no index, then an error is raised.
- Does an indexed search and is generally very fast.
- Returns a score (through SQL function `score`).
- Restricts a search based on documents (rows in a table) rather than nodes.
- *Cannot* be used for XML structure-based projection (extracting parts of an XML document).

XPath function `ora:contains`:

- Does not need an index to run, but you can use an index to improve performance.
- Might do an unindexed search, so it might be resource-intensive.
- Separates application logic from storing and indexing considerations.
- Does *not* return a score.
- Can be used for XML structure-based projection (extracting parts of an XML document).

Use `contains` when you want a fast, index-based, full-text search over XML documents, possibly with simple XML structure constraints. Use `ora:contains` when you need the flexibility of full-text search combined with XPath navigation (possibly without an index) or when you need to do projection, and you do not need a score.

CONTAINS SQL Function

This section contains these topics:

Full-Text Search Using SQL Function CONTAINS

The second argument to SQL function `contains`, `text_query`, is a string that specifies the full-text search. `text_query` has its own language, based on the SQL/MM Full-Text standard.

See Also:

- ISO/IEC 13249-2:2000, Information technology - Database languages - SQL Multimedia and Application Packages - Part 2: Full-Text, International Organization For Standardization, 2000
- *Oracle Text Reference* for more information about the operators in the `text_query` language

The examples in the rest of this section show some of the power of full-text search. They use just a few of the available operators: Boolean operators `AND`, `OR`, and `NOT`;

and stemming. The example queries search over a VARCHAR2 column (PURCHASE_ORDERS.doc) with a text index (index type CTXSYS.CONTEXT).

Full-Text Boolean Operators AND, OR, and NOT

The text_query language supports arbitrary combinations of AND, OR, and NOT. Precedence can be controlled using parentheses. The Boolean operators can be written in any of the following ways:

- AND, OR, NOT
- and, or, not
- &, |, ~

Note that NOT is a *binary*, not a unary operator here. The expression alpha NOT(beta) is equivalent to alpha AND *unary-not*(beta), where unary-not stands for unary negation.

> **See Also:** *Oracle Text Reference* for complete information about the operators you can use in contains and ora:contains

Example 11–6 CONTAINS Query with Simple Boolean

```
SELECT id FROM purchase_orders WHERE contains(doc, 'lawn AND wild') > 0;
```

This example uses table purchase_orders and index po_index.

Example 11–7 CONTAINS Query with Complex Boolean

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '((lawn OR garden) AND (wild OR flooded)) NOT(flamingo)')
        > 0;
```

This example uses table purchase_orders and index po_index.

Full-Text Stemming: $

The text_query language supports stemmed search. Example 11–8 returns all documents that contain some word with the same linguistic stem as "lawns", so it will find "lawn" or "lawns". The stem operator is written as a dollar sign ($). There is no operator STEM or stem.

Example 11–8 CONTAINS Query with Stemming

```
SELECT id FROM purchase_orders WHERE contains(doc, '$(lawns)') > 0;
```

This example uses table purchase_orders and index po_index.

Combining Boolean and Stemming Operators

operators in the text_query language can be arbitrarily combined, as shown in Example 11–9.

Example 11–9 CONTAINS Query with Complex Query Expression

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '($lawns AND wild) OR flamingo') > 0;
```

This example uses table purchase_orders and index po_index.

See Also: *Oracle Text Reference* for a full list of text_query operators

SCORE SQL Function

SQL function `contains` has a related function, `score`, which can be used anywhere in the query. It is a measure of relevance, and it is especially useful when doing full-text searches across large document sets. `score` is typically returned as part of the query result, used in the `ORDER BY` clause, or both.

Syntax

```
score(label NUMBER) RETURN NUMBER
```

In Example 11–10, `score(10)` returns the score for each row in the result set. SQL function `score` returns the relevance of a row in the result set with respect to a particular call to function `contains`. A call to `score` is linked to a call to `contains` by a `LABEL` (in this case the number 10).

Example 11–10 Simple CONTAINS Query with SCORE

```
SELECT score(10), id FROM purchase_orders
  WHERE contains(doc, 'lawn', 10) > 0 AND score(10) > 2
  ORDER BY score(10) DESC;
```

This example uses table `purchase_orders` and index `po_index`.

Function `score` always returns `0` if, for the corresponding `contains` expression, argument `text_query` does not match `input_text`, according to the matching rules dictated by the text index. If the `contains` `text_query` does match the `input_text`, then `score` will return a number greater than `0` and less than or equal to `100`. This number indicates the relevance of the `text_query` to the `input_text`. A higher number means a better match.

If the `contains` `text_query` consists of only the `HASPATH` operator and a Text Path, the score will be either `0` or `100`, because `HASPATH` tests for an exact match.

See Also: *Oracle Text Reference* for details on how the score is calculated

Restricting the Scope of a CONTAINS Search

SQL function `contains` does a full-text search across the whole document by default. In our examples, a search for "lawn" with no structure restriction will find all purchase orders with the word "lawn" anywhere in them.

Oracle offers three ways to restrict `contains` queries using XML structure:

- `WITHIN`
- `INPATH`
- `HASPATH`

Note: For the purposes of this discussion, consider *section* to be the same as an *XML node*.

WITHIN Structure Operator

The WITHIN operator restricts a query to some section within an XML document. A search for purchase orders that contain the word "lawn" somewhere inside a comment section might use WITHIN. Section names are case-sensitive.

Example 11–11 WITHIN

```
SELECT id FROM purchase_orders WHERE contains(DOC, 'lawn WITHIN comment') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Nested WITHIN You can restrict the query further by nesting WITHIN. Example 11–12 finds all documents that contain the word "lawn" within a section "comment", where that occurrence of "lawn" is also within a section "item".

Example 11–12 Nested WITHIN

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn WITHIN comment) WITHIN item') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Example 11–12 returns no rows. Our sample purchase order does contain the word "lawn" within a comment. But the only comment within an item is "Confirm this is electric". So the nested WITHIN query will return no rows.

WITHIN Attributes You can also search within attributes. Example 11–13 finds all purchase orders that contain the word 10 in the orderDate attribute of a purchaseOrder element.

Example 11–13 WITHIN an Attribute

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '10 WITHIN purchaseOrder@orderDate') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

By default, the minus sign ("-") is treated as a word separator: "1999-10-20" is treated as the three words "1999", "10" and "20". So this query returns one row.

Text in an attribute is not a part of the main searchable document. If you search for 10 without qualifying the text_query with WITHIN purchaseOrder@orderDate, then you will get no rows.

You cannot search attributes in a nested WITHIN.

WITHIN and AND Suppose you want to find purchase orders that contain two words within a comment section: "lawn" and "electric". There can be more than one comment section in a purchaseOrder. So there are two ways to write this query, with two distinct results.

If you want to find purchase orders that contain both words, where each word occurs in *some comment section*, you would write a query like Example 11–14.

Example 11–14 WITHIN and AND: Two Words in Some Comment Section

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn WITHIN comment) AND (electric WITHIN comment)') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

If you run this query against the `purchaseOrder` data, then it returns 1 row. Note that the parentheses are not needed in this example, but they make the query more readable.

If you want to find purchase orders that contain both words, where both words occur *in the same comment*, you would write a query like Example 11–15.

Example 11–15 WITHIN and AND: Two Words in the Same Comment

```
SELECT id FROM purchase_orders
  WHERE contains(doc, '(lawn AND electric) WITHIN comment') > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

Example 11–15 will return no rows. Example 11–16, which omits the parentheses around `lawn AND electric`, on the other hand, will return one row.

Example 11–16 WITHIN and AND: No Parentheses

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawn AND electric WITHIN comment') > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

Operator `WITHIN` has a higher precedence than `AND`, so Example 11–16 is parsed as Example 11–17.

Example 11–17 WITHIN and AND: Parentheses Illustrating Operator Precedence

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawn AND (electric WITHIN comment)') > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

Definition of Section The preceding examples have used the `WITHIN` operator to search within a section. A **section** can be a:

- **path** or **zone** section

  This is a concatenation, in document order, of all text nodes that are descendants of a node, with whitespace separating the text nodes. To convert from a node to a zone section, you must serialize the node and replace all tags with whitespace. path sections have the same scope and behavior as zone sections, except that path sections support queries with `INPATH` and `HASPATH` structure operators.

- **field** section

  This is the same as a zone section, except that repeating nodes in a document are concatenated into a single section, with whitespace as a separator.

- attribute section

- special section (sentence or paragraph)

  See Also: *Oracle Text Reference* for more information about special sections

INPATH Structure Operator

Operator `WITHIN` provides an easy and intuitive way to express simple structure restrictions in the `text_query`. For queries that use abundant XML structure, you can use operator `INPATH` plus a text path instead of nested `WITHIN` operators.

Operator INPATH takes a text_query on the left and a Text Path, enclosed in parentheses, on the right. Example 11–18 finds purchaseOrders that contain the word "electric" in the path /purchaseOrder/items/item/comment.

Example 11–18 Structure Inside Full-Text Predicate: INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

The scope of the search is the section indicated by the Text Path. If you choose a broader path, such as /purchaseOrder/items, you will still get 1 row returned, as shown in Example 11–19.

Example 11–19 Structure Inside Full-Text Predicate: INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items)') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Text Path The syntax and semantics of the Text Path are based on the w3c XPath 1.0 recommendation. Simple path expressions are supported (abbreviated syntax only), but functions are not. The following examples are meant to give the general flavor.

See Also:

- http://www.w3.org/TR/xpath for information about the W3C XPath 1.0 recommendation
- "Text Path BNF Specification" on page 11-26 for the Text Path grammar

Example 11–20 finds all purchase orders that contain the word "electric" in a comment element that is the child of an item element with a partNum attribute whose value is "872-AA", which in turn is the child of an items element that is any number of levels under the root node.

Example 11–20 INPATH with Complex Path Expression (1)

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (//items/item[@partNum="872-AA"]/comment)')
        > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Example 11–21 finds all purchase orders that contain the word "lawnmower" in a third-level item element (or any of its descendants) that has a comment element descendant at any level. This query returns one row. The scope of the query is *not* a comment element, but the set of items elements that each have a comment element as a descendant.

Example 11–21 INPATH with Complex Path Expression (2)

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'lawnmower INPATH (/*/*/item[.//comment])') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Text Path Compared to XPath The Text Path language differs from the XPath language in the following ways:

- Not all XPath operators are included in the Text Path language.
- XPath built-in functions are not included in the Text Path language.
- Text Path language operators are case-insensitive.
- If you use = inside a filter (brackets), then matching follows text-matching rules.

  Rules for case-sensitivity, normalization, stopwords and whitespace depend on the text index definition. To emphasize this difference, this kind of equality is referred to here as text-equals.
- Namespace support is not included in the Text Path language.

  The name of an element, including a namespace prefix if it exists, is treated as a string. So two namespace prefixes that map to the same namespace URI will not be treated as equivalent in the Text Path language.
- In a Text Path, the context is always the root node of the document.

  So in the purchase-order data, `purchaseOrder/items/item`, `/purchaseOrder/items/item`, and `./purchaseOrder/items/item` are all equivalent.
- If you want to search within an attribute value, then the direct parent of the attribute must be specified (wildcards cannot be used).
- A Text Path may not end in a wildcard (`*`).

> **See Also:** "Text Path BNF Specification" on page 11-26 for the Text Path grammar

Nested INPATH You can nest `INPATH` expressions. The context for the Text Path is always the root node. It is not changed by a nested `INPATH`.

Example 11–22 finds purchase orders that contain the word "`electric`" inside a `comment` element at any level, where the occurrence of that word is also in an `items` element that is a child of the top-level `purchaseOrder` element.

Example 11–22 Nested INPATH

```
SELECT id FROM purchase_orders
  WHERE contains(doc,
                 '(electric INPATH (//comment)) INPATH (/purchaseOrder/items)')
        > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

This nested `INPATH` query could be written more concisely as shown in Example 11–23.

Example 11–23 Nested INPATH Rewritten

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items//comment)') > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

HASPATH Structure Operator

Operator HASPATH takes only one operand: a Text Path, enclosed in parentheses, on the right. Use HASPATH when you want to find documents that contain a particular section in a particular path, possibly with predicate =. This is a path search rather than a full-text search. You can check for existence of a section, or you can match the contents of a section, but you cannot do word searches. If your data is of type XMLType, then consider using SQL function existsNode instead of structure operator HASPATH.

Example 11–24 finds purchaseOrders that have some item that has a USPrice.

Example 11–24 Simple HASPATH

```
SELECT id FROM purchase_orders
  WHERE contains(DOC, 'HASPATH (/purchaseOrder//item/USPrice)') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Example 11–25 finds purchaseOrders that have some item that has a USPrice that text-equals "148.95".

> **See Also:** "Text Path Compared to XPath" on page 11-11 for an explanation of text-equals

Example 11–25 HASPATH Equality

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'HASPATH (/purchaseOrder//item/USPrice="148.95")') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

HASPATH can be combined with other contains operators such as INPATH. Example 11–26 finds purchaseOrders that contain the word electric anywhere in the document *and* have some item that has a USPrice that text-equals 148.95 *and* contain 10 in the purchaseOrder attribute orderDate.

Example 11–26 HASPATH with Other Operators

```
SELECT id FROM purchase_orders
  WHERE contains(doc,
                 'electric
                  AND HASPATH (/purchaseOrder//item/USPrice="148.95")
                  AND 10 INPATH (/purchaseOrder/@orderDate)')
        > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Projecting the CONTAINS Result

The result of a SQL query with a contains expression in the WHERE clause is always a set of rows (and possibly score information), or a projection over the rows that match the query. If you want to return only a part of each XML document that satisfies the contains expression, then use SQL functions extract and extractValue. Note that extract and extractValue operate on XMLType, so the following examples use the table purchase_orders_xmltype.

Example 11–27 finds purchaseOrders that contain the word "electric" inside a comment element that is a descendant of the top-level element purchaseOrder. Instead of returning the ID of the row for each result, extract is used to return only the comment element.

Example 11–27 Using EXTRACT to Scope the Results of a CONTAINS Query

```
SELECT extract(doc,
               '/purchaseOrder//comment',
               'xmlns:ora="http://xmlns.oracle.com/xdb"') "Item Comment"
  FROM purchase_orders_xmltype
  WHERE contains(doc, 'electric INPATH (/purchaseOrder//comment)') > 0;
```

This example uses table `purchase_orders_xmltype` and index `po_index_xmltype`.

Note that the result of Example 11–27 is *two* instances of element `comment`. Function `contains` indicates which rows contain the word "`electric`" inside a `comment` element (the row with `ID = 1`), and function `extract` extracts all of the instances of element `comment` in the document at that row. There are two instances of element `comment` inside the `purchaseOrder` element, and the query returns both of them.

This might not be what you want. If you want the query to return only the instances of element `comment` that satisfy the `contains` expression, then you must repeat that predicate in the `extract` expression. You do that with XPath function `ora:contains`.

Example 11–28 returns only the `comment` element that matches the `contains` expression.

Example 11–28 Using EXTRACT and ora:contains to Project the Result of a CONTAINS Query

```
SELECT
  extract(doc,
          '/purchaseOrder/items/item/comment
            [ora:contains(text(), "electric") > 0]',
          'xmlns:ora="http://xmlns.oracle.com/xdb"') "Item Comment"
  FROM purchase_orders_xmltype
  WHERE contains(doc, 'electric INPATH (/purchaseOrder/items/item/comment)') > 0;
```

This example uses table `purchase_orders` and index `po_index-path-section`.

Indexing With a CONTEXT Index

This section contains these topics:

- Introduction to CONTEXT Indexes
- Effect of a CONTEXT Index on CONTAINS
- CONTEXT Index Preferences
- Introduction to Section Groups

Introduction to CONTEXT Indexes

The general-purpose full-text index type is `CONTEXT`, which is owned by database user `CTXSYS`. To create a default full-text index, use the regular SQL `CREATE INDEX` command, and add the clause `INDEXTYPE IS CTXSYS.CONTEXT`, as shown in Example 11–29.

Example 11–29 Simple CONTEXT Index on Table PURCHASE_ORDERS

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT ;
```

This example uses table PURCHASE_ORDERS.

You have many choices available when building a full-text index. These choices are expressed as indexing **preferences**. To use an indexing preference, add the PARAMETERS clause to CREATE INDEX, as shown in Example 11–30.

> **See Also:** "CONTEXT Index Preferences" on page 11-15

Example 11–30 Simple CONTEXT Index on Table PURCHASE_ORDERS with Path Section Group

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS ('section group CTXSYS.PATH_SECTION_GROUP');
```

This example uses table purchase_orders.

Oracle Text provides other index types, such as CTXCAT and CTXRULE, which are outside the scope of this chapter.

> **See Also:** *Oracle Text Reference* for more information about CONTEXT indexes

CONTEXT Index on XMLType Table You can build a CONTEXT index on any data that contains text. Example 11–29 creates a CONTEXT index on a VARCHAR2 column. The syntax to create a CONTEXT index on a column of type CHAR, VARCHAR, VARCHAR2, BLOB, CLOB, BFILE, XMLType, or URIType is the same. Example 11–31 creates a CONTEXT index on a column of type XMLType.

Example 11–31 Simple CONTEXT Index on Table PURCHASE_ORDERS_xmltype

```
CREATE INDEX po_index_xmltype ON purchase_orders_xmltype(doc)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

This example uses table purchase_orders_xmltype. The section group defaults to PATH_SECTION_GROUP.

If you have a table of type XMLType, then you need to use object syntax to create the CONTEXT index as shown in Example 11–32.

Example 11–32 Simple CONTEXT Index on XMLType Table

```
CREATE INDEX po_index_xmltype_table
  ON purchase_orders_xmltype_table (OBJECT_VALUE)
  INDEXTYPE IS CTXSYS.CONTEXT;
```

This example uses table purchase_orders_xmltype.

You can query the table using the syntax in Example 11–33.

Example 11–33 CONTAINS Query on XMLType Table

```
SELECT extract(OBJECT_VALUE, '/purchaseOrder/@orderDate') "Order Date"
  FROM purchase_orders_xmltype_table
  WHERE contains(OBJECT_VALUE, 'electric INPATH (/purchaseOrder//comment)') > 0;
```

This example uses table purchase_orders_xmltype_table and index po_index_xmltype_table.

Maintaining a CONTEXT Index The CONTEXT index, like most full-text indexes, is asynchronous. When indexed data is changed, the CONTEXT index might not change

until you take some action, such as calling a procedure to synchronize the index. There are a number of ways to manage changes to the CONTEXT index, including some options that are new for this release.

The CONTEXT index can get fragmented over time. A fragmented index uses more space, and it leads to slower queries. There are a number of ways to optimize (defragment) the CONTEXT index, including some options that are new for this release.

> **See Also:** *Oracle Text Reference* for more information about CONTEXT index maintenance

Roles and Privileges You do not need any special privileges to create a CONTEXT index. You need the CTXAPP role to create and delete preferences and to use the Oracle Text PL/SQL packages. You must also have EXECUTE privilege on the CTXSYS package CTX_DDL.

Effect of a CONTEXT Index on CONTAINS

To use SQL function contains, you must create an index of type CONTEXT. If you call contains, and the column given in the first argument does not have an index of type CONTEXT, then an error is raised.

The syntax and semantics of text_query depend on the choices you make when you build the CONTEXT index. For example:

- What counts as a word?
- Are very common words processed?
- What is a common word?
- Is the text search case-sensitive?
- Can the text search include themes (concepts) as well as keywords?

CONTEXT Index Preferences

A preference can be considered a collection of indexing choices. Preferences include section group, datastore, filter, wordlist, stoplist and storage. This section shows how to set up a lexer preference to make searches case-sensitive.

You can use procedure CTX_DDL.create_preference (or CTX_DDL.create_stoplist) to create a preference. Override default choices in that preference group by setting attributes of the new preference, using procedure CTX_DDL.set_attribute. Then use the preference in a CONTEXT index by including *preference type preference_name* in the PARAMETERS string of CREATE INDEX.

Once a preference has been created, you can use it to build any number of indexes.

Making Search Case-Sensitive Full-text searches with contains are *case-insensitive* by default. That is, when matching words in text_query against words in the document, case is not considered. Section names and attribute names, however, are always *case-sensitive*.

If you want full-text searches to be case-sensitive, then you need to make that choice when building the CONTEXT index. Example 11–34 returns 1 row, because "HURRY" in text_query matches "Hurry" in the purchaseOrder with the default case-insensitive index.

Example 11–34 CONTAINS: Default Case Matching

```
SELECT id FROM purchase_orders
```

```
  WHERE contains(doc, 'HURRY INPATH (/purchaseOrder/comment)') > 0;
```

This example uses table purchase_orders and index po_index-path-section.

Example 11–35 creates a new lexer preference my_lexer, with the attribute mixed_case set to TRUE. It also sets printjoin characters to "-" and "!" and ",". You can use the same preferences for building CONTEXT indexes and for building policies.

See Also: *Oracle Text Reference* for a full list of lexer attributes

Example 11–35 Create a Preference for Mixed Case

```
BEGIN
  CTX_DDL.create_preference(PREFERENCE_NAME  =>  'my_lexer',
                            OBJECT_NAME      =>  'BASIC_LEXER');

  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'mixed_case',
                        ATTRIBUTE_VALUE  =>  'TRUE');

  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'printjoins',
                        ATTRIBUTE_VALUE  =>  '-,!');
END ;
/
```

Example 11–36 builds a CONTEXT index using the new my_lexer lexer preference.

Example 11–36 CONTEXT Index on PURCHASE_ORDERS Table, Mixed Case

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS('lexer my_lexer section group CTXSYS.PATH_SECTION_GROUP');
```

This example uses table purchase_orders and preference preference-case-mixed.

Example 11–34 returns no rows, because "HURRY" in text_query no longer matches "Hurry" in the purchaseOrder. Example 11–37 returns one row, because the text_query term "Hurry" exactly matches the word "Hurry" in the purchaseOrder.

Example 11–37 CONTAINS: Mixed (Exact) Case Matching

```
SELECT id FROM purchase_orders
  WHERE contains(doc, 'Hurry INPATH (/purchaseOrder/comment)') > 0;
```

This example uses table purchase_orders and index po_index-case-mixed.

Introduction to Section Groups

One of the choices you make when creating a CONTEXT index is section group. A section group instance is based on a section group type. The section group type specifies the kind of structure in your documents, and how to index (and therefore search) that structure. The section group instance may specify which structure elements are indexed. Most users will either take the default section group or use a pre-defined section group.

Choosing a Section Group Type The section group types useful in XML searching are:

- PATH_SECTION_GROUP

Choose this when you want to use WITHIN, INPATH and HASPATH in queries, and you want to be able to consider all sections to scope the query.

- XML_SECTION_GROUP

  Choose this when you want to use WITHIN, but not INPATH and HASPATH, in queries, and you want to be able to consider only explicitly-defined sections to scope the query. XML_SECTION_GROUP section group type supports FIELD sections in addition to ZONE sections. In some cases FIELD sections offer significantly better query performance.

- AUTO_SECTION_GROUP

  Choose this when you want to use WITHIN, but not INPATH and HASPATH, in queries, and you want to be able to consider most sections to scope the query. By default all sections are indexed (available for query restriction). You can specify that some sections are *not* indexed (by defining STOP sections).

- NULL_SECTION_GROUP

  Choose this when defining no XML sections.

Other section group types include:

- BASIC_SECTION_GROUP
- HTML_SECTION_GROUP
- NEWS_SECTION_GROUP

Oracle recommends that most users with XML full-text search requirements use PATH_SECTION_GROUP. Some users may prefer XML_SECTION_GROUP with FIELD sections. This choice will generally give better query performance and a smaller index, but it is limited to documents with fielded structure (searchable nodes are all leaf nodes that do not repeat).

> **See Also:** *Oracle Text Reference* for a detailed description of the XML_SECTION_GROUP section group type

Choosing a Section Group When choosing a section group to use with your index, you can choose a supplied section group, take the default, or create a new section group based on the section group type you have chosen.

There are supplied section groups for section group types PATH_SECTION_GROUP, AUTO_SECTION_GROUP, and NULL_SECTION_GROUP. The supplied section groups are owned by CTXSYS and have the same name as their section group types. For example, the supplied section group of section group type PATH_SECTION_GROUP is CTXSYS.PATH_SECTION_GROUP.

There is no supplied section group for section group type XML_SECTION_GROUP, because a default XML_SECTION_GROUP would be empty and therefore meaningless. If you want to use section group type XML_SECTION_GROUP, then you must create a new section group and specify each node that you want to include as a section.

When you create a CONTEXT index on data of type XMLType, the default section group is the supplied section group CTXSYS.PATH_SECTION_GROUP. If the data is VARCHAR or CLOB, then the default section group is CTXSYS.NULL_SECTION_GROUP.

> **See Also:** *Oracle Text Reference* for instructions on creating your own section group

To associate a section group with an index, add `section group <section group name>` to the `PARAMETERS` string, as in Example 11–38.

Example 11–38 Simple CONTEXT Index on purchase_orders Table with Path Section Group

```
CREATE INDEX po_index ON purchase_orders(doc)
  INDEXTYPE IS CTXSYS.CONTEXT
  PARAMETERS ('section group CTXSYS.PATH_SECTION_GROUP');
```

This example uses table `purchase_orders`.

ora:contains XPath Function

Function `ora:contains` is an Oracle-defined XPath function for use in the XPath argument to the SQL functions `existsNode`, `extract`, and `extractValue`.

The `ora:contains` function name consists of a name (`contains`) plus a namespace prefix (`ora:`). When you use `ora:contains` in `existsNode`, `extract` or `extractValue` you must also supply a namespace mapping parameter, `xmlns:ora="http://xmlns.oracle.com/xdb"`.

`ora:contains` returns a number; it does *not* return a score. It returns a positive number if the `text_query` matches the `input_text`. Otherwise it returns zero.

Full-Text Search Using XPath Function ora:contains

The `ora:contains` argument *`text_query`* is a string that specifies the full-text search. The `ora:contains` *`text_query`* is the same as the `contains` *`text_query`*, with the following restrictions:

- `ora:contains` *`text_query`* must *not* include any of the structure operators `WITHIN`, `INPATH`, or `HASPATH`
- `ora:contains` *`text_query`* may include the score weighting operator `weight(*)`, but weights will be *ignored*

If you include any of the following in the `ora:contains` *`text_query`*, the query *cannot* use a `CONTEXT` index:

- Score-based operator `MINUS` (`-`) or `threshold` (`>`)
- Selective, corpus-based expansion operator `FUZZY` (`?`) or `soundex` (`!`)

> **See Also:** "XPath Rewrite and CONTEXT Indexes" on page 11-24

Example 11–39 shows a full-text search using an arbitrary combination of Boolean operators and `$` (stemming).

Example 11–39 ora:contains with an Arbitrarily Complex Text Query

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment
                     [ora:contains(text(), "($lawns AND wild) OR flamingo") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

This example uses table `purchase_orders_xmltype`.

See Also:

- "Full-Text Search Using SQL Function CONTAINS" on page 11-5 for a description of full-text operators
- *Oracle Text Reference* for a full list of the operators you can use in `contains` and `ora:contains`

Matching rules are defined by the *policy*, *`policy_owner.policy_name`*. If *`policy_owner`* is absent, then the policy owner defaults to the current user. If both *`policy_name`* and *`policy_owner`* are absent, then the policy defaults to `CTXSYS.DEFAULT_POLICY_ORACONTAINS`.

Restricting the Scope of an ora:contains Query

When you use `ora:contains` in an XPath expression, the scope is defined by argument *`input_text`*. This argument is evaluated in the current XPath context. If the result is a single text node or an attribute, then that node is the target of the `ora:contains` search. If *`input_text`* does not evaluate to a single text node or an attribute, an error is raised.

The policy determines the matching rules for `ora:contains`. The section group associated with the default policy for `ora:contains` is of type `NULL_SECTION_GROUP`.

`ora:contains` can be used anywhere in an XPath expression, and its *`input_text`* argument can be any XPath expression that evaluates to a single text node or an attribute.

Projecting the ora:contains Result

If you want to return only a part of each XML document, then use `extract` to project a node sequence or `extractValue` to project the value of a node.

Example 11–40 ora:contains in EXISTSNODE and EXTRACT

This example returns the `orderDate` for each `purchaseOrder` that has a `comment` that contains the word "`lawn`". It uses table `purchase_orders_xmltype`.

```
SELECT extract(doc, '/purchaseOrder/@orderDate') "Order date"
  FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment[ora:contains(text(), "lawn") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

Function `existsNode` restricts the result to rows (documents) where the `purchaseOrder` element includes some `comment` that contains the word "`lawn`". Function `extract` then returns the value of attribute `orderDate` from those `purchaseOrder` elements. If `//comment` had been extracted, then both comments from the sample document would have been returned, not just the comment that matches the `WHERE` clause.

See Also: Example 11–27, "Using EXTRACT to Scope the Results of a CONTAINS Query" on page 11-13

Policies for ora:contains Queries

The CONTEXT index on a column determines the semantics of contains queries on that column. Because ora:contains does not rely on a supporting index, some other means must be found to provide many of the same choices when doing ora:contains queries. A **policy** is a collection of preferences that can be associated with an ora:contains query to give the same sort of semantic control as the indexing choices give to the contains user.

Introduction to Policies for ora:contains Queries

When using SQL function contains, indexing preferences affect the semantics of the query. You create a preference using procedure CTX_DDL.create_preference (or CTX_DDL.create_stoplist). You override default choices by setting attributes of the new preference, using procedure CTX_DDL.set_attribute. Then you use the preference in a CONTEXT index by including *preference_type preference_name* in the PARAMETERS string of CREATE INDEX.

See Also: "CONTEXT Index Preferences" on page 11-15

Because ora:contains does not have a supporting index, a different mechanism is needed to apply preferences to a query. That mechanism is a policy, consisting of a collection of preferences, and it is used as a parameter to ora:contains.

Policy Example: Supplied Stoplist Example 11–41 creates a policy with an empty stopwords list.

Example 11–41 Create a Policy to Use with ora:contains

```
BEGIN
  CTX_DDL.create_policy(POLICY_NAME  =>  'my_nostopwords_policy',
                        STOPLIST     =>  'CTXSYS.EMPTY_STOPLIST');
END;
/
```

For simplicity, this policy consists of an empty stoplist, which is owned by user CTXSYS. You could create a new stoplist to include in this policy, or you could reuse a stoplist (or lexer) definition that you created for a CONTEXT index.

Refer to this policy in an ora:contains expression to search for all words, including the most common ones (stopwords). Example 11–42 returns zero comments, because "is" is a stopword by default and cannot be queried.

Example 11–42 Query on a Common Word with ora:contains

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment[ora:contains(text(), "is") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

This example uses table purchase_orders_xmltype.

Example 11–43 uses the policy created in Example 11–41 to specify an empty stopword list. This query finds "is" and returns 1 comment.

Example 11–43 Query on a Common Word with ora:contains and Policy my_nostopwords_policy

```
SELECT id FROM purchase_orders_xmltype
```

```
WHERE existsNode(doc,
                 '/purchaseOrder/comment
                   [ora:contains(text(), "is", "MY_NOSTOPWORDS_POLICY") > 0]',
                 'xmlns:ora="http://xmlns.oracle.com/xdb"')
      = 1;
```

This example uses table `purchase_orders_xmltype` and policy `my_nostopwords_policy`. (This policy was implicitly named as all uppercase in Example 11–41. Because XPath is case-sensitive, it must be referred to in the XPath predicate using all uppercase: `MY_NOSTOPWORDS_POLICY`, not `my_nostopwords_policy`.)

Effect of Policies on ora:contains

The `ora:contains` policy affects the matching semantics of `text_query`. The `ora:contains` policy may include a lexer, stoplist, wordlist preference, or any combination of these. Other preferences that can be used to build a `CONTEXT` index are not applicable to `ora:contains`. The effects of the preferences are as follows:

- The wordlist preference tweaks the semantics of the stem operator.
- The stoplist preference defines which words are too common to be indexed (searchable).
- The lexer preference defines how words are tokenized and matched. For example, it defines which characters count as part of a word and whether matching is case-sensitive.

See Also:

- "Policy Example: Supplied Stoplist" on page 11-20 for an example of building a policy with a predefined stoplist
- "Policy Example: User-Defined Lexer" on page 11-21 for an example of a case-sensitive policy

Policy Example: User-Defined Lexer When you search for a document that contains a particular word, you usually want the search to be case-insensitive. If you do a search that is case-sensitive, then you will often miss some expected results. For example, if you search for `purchaseOrders` that contain the phrase "baby monitor", then you would not expect to miss our example document just because the phrase is written "Baby Monitor".

Full-text searches with `ora:contains` are case-insensitive by default. Section names and attribute names, however, are always case-sensitive.

If you want full-text searches to be case-sensitive, then you need to make that choice when you create a policy. You can use this procedure:

1. Create a preference using the procedure `CTX_DDL.create_preference` (or `CTX_DDL.create_stoplist`).
2. Override default choices in that preference object by setting attributes of the new preference, using procedure `CTX_DDL.set_attribute`.
3. Use the preference as a parameter to `CTX_DDL.create_policy`.
4. Use the policy name as the third argument to `ora:contains` in a query.

Once you have created a preference, you can reuse it in other policies or in `CONTEXT` index definitions. You can use any policy with any `ora:contains` query.

Example 11–44 returns 1 row, because "HURRY" in text_query matches "Hurry" in the purchaseOrder with the default case-insensitive index.

Example 11–44 ora:contains, Default Case-Sensitivity

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment[ora:contains(text(), "HURRY") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

This example uses table purchase_orders_xmltype.

Example 11–45 creates a new lexer preference my_lexer, with the attribute mixed_case set to TRUE. It also sets printjoin characters to "-" and "!" and ",". You can use the same preferences for building CONTEXT indexes and for building policies.

See Also: *Oracle Text Reference* for a full list of lexer attributes

Example 11–45 Create a Preference for Mixed Case

```
BEGIN
  CTX_DDL.create_preference(PREFERENCE_NAME  =>  'my_lexer',
                            OBJECT_NAME      =>  'BASIC_LEXER');
  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'MY_LEXER',
                        ATTRIBUTE_NAME   =>  'MIXED_CASE',
                        ATTRIBUTE_VALUE  =>  'TRUE');
  CTX_DDL.set_attribute(PREFERENCE_NAME  =>  'my_lexer',
                        ATTRIBUTE_NAME   =>  'printjoins',
                        ATTRIBUTE_VALUE  =>  '-,!');
END ;
/
```

Example 11–46 creates a new policy my_policy and specifies only the lexer. All other preferences are defaulted.

Example 11–46 Create a Policy with Mixed Case (Case-Insensitive)

```
BEGIN
  CTX_DDL.create_policy(POLICY_NAME  => 'my_policy',
                        LEXER        => 'my_lexer');
END ;
/
```

This example uses preference-case-mixed.

Example 11–47 uses the new policy in a query. It returns no rows, because "HURRY" in text_query no longer matches "Hurry" in the purchaseOrder.

Example 11–47 ora:contains, Case-Sensitive (1)

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment
                     [ora:contains(text(), "HURRY", "my_policy") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

This example uses table purchase_orders_xmltype.

Example 11–48 returns one row, because the text_query term "Hurry" exactly matches the text "Hurry" in the comment element.

Example 11–48 ora:contains, Case-Sensitive (2)

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/comment
                     [ora:contains(text(), "Hurry") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

This example uses table purchase_orders_xmltype.

Policy Defaults

The policy argument to ora:contains is optional. If it is omitted, then the query uses the default policy CTXSYS.DEFAULT_POLICY_ORACONTAINS.

When you create a policy for use with ora:contains, you do not need to specify every preference. In Example 11–46 on page 11-22, for example, only the lexer preference was specified. For the preferences that are not specified, CREATE_POLICY uses the default preferences:

- CTXSYS.DEFAULT_LEXER
- CTXSYS.DEFAULT_STOPLIST
- CTXSYS.DEFAULT_ WORDLIST

Creating a policy follows copy semantics for preferences and their attributes, just as creating a CONTEXT index follows copy semantics for index metadata.

Performance of ora:contains

The ora:contains XPath function does not depend on a supporting index. ora:contains is very flexible. But if you use it to search across large amounts of data without an index, then it can also be resource-intensive. In this section we discuss how to get the best performance from queries that include XPath expressions with ora:contains.

> **Note:** Function-based indexes can also be very effective in speeding up XML queries, but they are not generally applicable to Text queries.

The examples in this section use table PURCHASE_ORDERS_xmltype_big. This has the same table structure and XML schema as PURCHASE_ORDERS_xmltype, but it has around 1,000 rows. Each row has a unique ID (in column id), and some different text in /purchaseOrder/items/item/comment. Where an execution plan is shown, it was produced using the SQL*Plus command AUTOTRACE. Execution plans can also be produced using SQL commands TRACE and TKPROF. A description of commands AUTOTRACE, trace and tkprof is outside the scope of this chapter.

This section contains these topics:

- Use a Primary Filter in the Query
- XPath Rewrite and CONTEXT Indexes

Use a Primary Filter in the Query

Because `ora:contains` is relatively expensive to process, Oracle recommends that you write queries that include a primary filter wherever possible. This minimizes the number of rows processed by `ora:contains`.

Example 11–49 examines every row in the table (does a full table scan), as we can see from the Plan in Example 11–50. In this example, `ora:contains` is evaluated for every row.

Example 11–49 ora:contains in EXISTSNODE, Large Table

```
SELECT id FROM purchase_orders_xmltype_big
  WHERE existsNode(doc,
                   '/purchaseOrder/items/item/comment
                     [ora:contains(text(), "constitution") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1;
```

Example 11–50 EXPLAIN PLAN: EXISTSNODE

```
Execution Plan
----------------------------------------------------------
0      SELECT STATEMENT Optimizer=CHOOSE
1     0   TABLE ACCESS (FULL) OF 'PURCHASE_ORDERS_XMLTYPE_BIG' (TABLE)
```

If you create an index on the `id` column, as shown in Example 11–51, and add a selective `id` predicate to the query, as shown in Example 11–52, then it is apparent from Example 11–53 that Oracle will drive off the `id` index. `ora:contains` will be executed only for the rows where the `id` predicate is true (where `id` is less than 5).

Example 11–51 B-tree Index on ID

```
CREATE INDEX id_index ON purchase_orders_xmltype_big(id);
```

This example uses table `purchase_orders`.

Example 11–52 ora:contains in EXISTSNODE, Mixed Query

```
SELECT id FROM purchase_orders_xmltype_big
  WHERE existsNode(doc,
                   '/purchaseOrder/items/item/comment
                     [ora:contains(text(), "constitution") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1
    AND id > 5;
```

Example 11–53 EXPLAIN PLAN: EXISTSNODE

```
Execution Plan
----------------------------------------------------------
   0      SELECT STATEMENT Optimizer=CHOOSE
   1    0    TABLE ACCESS (BY INDEX ROWSELECT ID) OF 'PURCHASE_ORDERS_XMLTYPE_BIG' (TABLE)
   2    1         INDEX (RANGE SCAN) OF 'SELECT ID_INDEX' (INDEX)
```

XPath Rewrite and CONTEXT Indexes

`ora:contains` does not rely on a supporting index. But under some circumstances an `ora:contains` may use an existing `CONTEXT` index for better performance.

Benefits of XPath Rewrite Oracle will, in some circumstances, rewrite a SQL/XML query into an object-relational query. This is done as part of query optimization and is transparent to the user. Two of the benefits of XPath rewrite are:

- The rewritten query can directly access the underlying object-relational tables instead of processing the whole XML document.
- The rewritten query can make use of any available indexes.

XPath rewrite is a performance optimization. XPath rewrite is performed only when XML data is stored object-relationally, which in turn means that the data must be XML schema-based.

See Also:

- "Rewriting of XQuery and XPath Expressions" on page 1-20 for more on the benefits of XPath rewrite
- Chapter 7, "XPath Rewrite" for a full discussion of XPath rewrite

From Documents to Nodes Consider Example 11–54, a simple `ora:contains` query. To naively process the XPath expression in this query, each cell in the `doc` column must be considered, and each cell must be tested to see if it matches this XPath expression:

```
/purchaseOrder/items/item/comment[ora:contains(text(), "electric")>0]
```

Example 11–54 ora:contains in EXISTSNODE

```
SELECT id FROM purchase_orders_xmltype
  WHERE existsNode(doc,
                   '/purchaseOrder/items/item/comment
                     [ora:contains(text(), "electric") > 0]',
                   'xmlns:ora="http://xmlns.oracle.com/xdb"')
        = 1 ;
```

This example uses table `purchase_orders_xmltype`.

But if `doc` is schema-based, and the `purchaseOrder` documents are physically stored in object-relational tables, then it makes sense to go straight to column `/purchaseOrder/items/item/comment` (if such a column exists) and test each cell there to see if it matches "`electric`".

This is the first XPath-rewrite step. If the first argument to `ora:contains` (`text_input`) maps to a single relational column, then `ora:contains` executes against that column. Even if there are no indexes involved, this can significantly improve query performance.

From ora:contains to contains As noted in "From Documents to Nodes" on page 11-25, Oracle XML DB might rewrite a query so that an XPath expression passed to function `existsNode` can be resolved by applying `ora:contains` to an underlying column, instead of applying the complete XPath expression to the entire XML document. This section shows how that such query can make use of a `CONTEXT` index on the underlying column.

If you are running `ora:contains` against a text node or an attribute that maps to a column that has a `CONTEXT` index, why would you not use that index? One reason is that a rewritten query should give the same results as the original query. To ensure consistent results, the following conditions must be true, in order for a `CONTEXT` index to be used.

- The ora:contains target (input_text) must be either a single text node whose parent node maps to a column or an attribute that maps to a column. The column must be a single relational column (possibly in an ordered collection table).
- As noted in "Policies for ora:contains Queries" on page 11-20, the indexing choices (for contains) and policy choices (for ora:contains) affect the semantics of queries. A simple mismatch might be that the index-based contains would do a *case-sensitive* search, while ora:contains specifies a *case-insensitive* search. To ensure that the ora:contains and the rewritten contains have the same semantics, the ora:contains policy must exactly match the index choices of the CONTEXT index.

Both the ora:contains policy and the CONTEXT index must also use the NULL_SECTION_GROUP section group type. The default section group for an ora:contains policy is ctxsys.NULL_SECTION_GROUP.

Third, the CONTEXT index is generally asynchronous. If you add a new document that contains the word "dog", but do not synchronize the CONTEXT index, then a contains query for "dog" will not return that document. But an ora:contains query against the same data will. To ensure that the ora:contains and the rewritten contains will always return the same results, the CONTEXT index must be built with the TRANSACTIONAL keyword in the PARAMETERS string.

See Also: *Oracle Text Reference*

Summary of Using XPath Rewrite With ora:contains A query with existsNode, extract or extractValue, where the XPath includes ora:contains, may be considered for XPath rewrite if:

- The XML is schema-based
- The first argument to ora:contains (text_input) is either a single text node whose parent node maps to a column, or an attribute that maps to a column. The column must be a single relational column (possibly in an ordered collection table).

The rewritten query will use a CONTEXT index if:

- There is a CONTEXT index on the column that the parent node (or attribute node) of text_input maps to.
- The ora:contains policy exactly matches the index choices of the CONTEXT index.
- The CONTEXT index was built with the TRANSACTIONAL keyword in the PARAMETERS string.

XPath rewrite can speed up queries significantly, especially if there is a suitable CONTEXT index.

Text Path BNF Specification

```
HasPathArg           ::=   LocationPath
                         |  EqualityExpr
InPathArg            ::=   LocationPath
LocationPath         ::=   RelativeLocationPath
                         |  AbsoluteLocationPath
AbsoluteLocationPath ::=   ("/" RelativeLocationPath)
                         |  ("//" RelativeLocationPath)
RelativeLocationPath ::=   Step
                         |  (RelativeLocationPath "/" Step)
```

```
                          |  (RelativeLocationPath "//" Step)
Step                ::=   ("@" NCName)
                          |  NCName
                          |  (NCName Predicate)
                          |  Dot
                          |  "*"
Predicate           ::=   ("[" OrExp "]")
                          |  ("[" Digit+ "]")
OrExpr              ::=   AndExpr
                          |  (OrExpr "or" AndExpr)
AndExpr             ::=   BooleanExpr
                          |  (AndExpr "and" BooleanExpr)
BooleanExpr         ::=   RelativeLocationPath
                          |  EqualityExpr
                          |  ("(" OrExpr ")")
                          |  ("not" "(" OrExpr ")")
EqualityExpr        ::=   (RelativeLocationPath "=" Literal)
                          |  (Literal "=" RelativeLocationPath)
                          |  (RelativeLocationPath "=" Literal)
                          |  (Literal "!=" RelativeLocationPath)
                          |  (RelativeLocationPath "=" Literal)
                          |  (Literal "!=" RelativeLocationPath)
Literal             ::=   (DoubleQuote [~"]* DoubleQuote)
                          |  (SingleQuote [~']* SingleQuote)
NCName              ::=   (Letter |  Underscore) NCNameChar*
NCNameChar          ::=   Letter
                          |  Digit
                          |  Dot
                          |  Dash
                          |  Underscore
Letter              ::=   ([a-z] | [A-Z])
Digit               ::=   [0-9]
Dot                 ::=   "."
Dash                ::=   "-"
Underscore          ::=   "_"
```

Support for Full-Text XML Examples

This section contains these topics:

- Purchase-Order XML Document, po001.xml
- CREATE TABLE Statements
- Purchase-Order XML Schema for Full-Text Search Examples

Purchase-Order XML Document, po001.xml

Example 11–55 Purchase Order XML Document, po001.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<purchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
               orderDate="1999-10-20">
  <shipTo country="US">
    <name>Alice Smith</name>
    <street>123 Maple Street</street>
    <city>Mill Valley</city>
    <state>CA</state>
    <zip>90952</zip>
```

```
  </shipTo>
  <billTo country="US">
    <name>Robert Smith</name>
    <street>8 Oak Avenue</street>
    <city>Old Town</city>
    <state>PA</state>
    <zip>95819</zip>
  </billTo>
  <comment>Hurry, my lawn is going wild!</comment>
  <items>
    <item partNum="872-AA">
      <productName>Lawnmower</productName>
      <quantity>1</quantity>
      <USPrice>148.95</USPrice>
      <comment>Confirm this is electric</comment>
    </item>
    <item partNum="926-AA">
      <productName>Baby Monitor</productName>
      <quantity>1</quantity>
      <USPrice>39.98</USPrice>
      <shipDate>1999-05-21</shipDate>
    </item>
  </items>
</purchaseOrder>
```

CREATE TABLE Statements

Example 11–56 CREATE TABLE purchase_orders

```
CREATE TABLE purchase_orders (id   NUMBER,
                              doc  VARCHAR2(4000));
INSERT INTO purchase_orders (id, doc)
  VALUES (1,
          '<?xml version="1.0" encoding="UTF-8"?>
           <purchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                          xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
                          orderDate="1999-10-20">
             <shipTo country="US">
               <name>Alice Smith</name>
               <street>123 Maple Street</street>
               <city>Mill Valley</city>
               <state>CA</state>
               <zip>90952</zip>
             </shipTo>
             <billTo country="US">
               <name>Robert Smith</name>
               <street>8 Oak Avenue</street>
               <city>Old Town</city>
               <state>PA</state>
               <zip>95819</zip>
             </billTo>
             <comment>Hurry, my lawn is going wild!</comment>
             <items>
               <item partNum="872-AA">
                 <productName>Lawnmower</productName>
                 <quantity>1</quantity>
                 <USPrice>148.95</USPrice>
                 <comment>Confirm this is electric</comment>
               </item>
```

```
              <item partNum="926-AA">
                <productName>Baby Monitor</productName>
                <quantity>1</quantity>
                <USPrice>39.98</USPrice>
                <shipDate>1999-05-21</shipDate>
              </item>
            </items>
          </purchaseOrder>');
COMMIT;
```

Example 11–57 CREATE TABLE purchase_orders_xmltype

```
CREATE TABLE purchase_orders_xmltype (id  NUMBER ,
                                      doc XMLType);
INSERT INTO purchase_orders_xmltype (id, doc)
  VALUES (1,
          XMLTYPE ('<?xml version="1.0" encoding="UTF-8"?>
                     <purchaseOrder
                       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                       xsi:noNamespaceSchemaLocation="po.xsd"
                       orderDate="1999-10-20">
                       <shipTo country="US">
                         <name>Alice Smith</name>
                         <street>123 Maple Street</street>
                         <city>Mill Valley</city>
                         <state>CA</state>
                         <zip>90952</zip>
                       </shipTo>
                       <billTo country="US">
                         <name>Robert Smith</name>
                         <street>8 Oak Avenue</street>
                         <city>Old Town</city>
                         <state>PA</state>
                         <zip>95819</zip>
                       </billTo>
                       <comment>Hurry, my lawn is going wild!</comment>
                       <items>
                         <item partNum="872-AA">
                           <productName>Lawnmower</productName>
                           <quantity>1</quantity>
                           <USPrice>148.95</USPrice>
                           <comment>Confirm this is electric</comment>
                         </item>
                         <item partNum="926-AA">
                           <productName>Baby Monitor</productName>
                           <quantity>1</quantity>
                           <USPrice>39.98</USPrice>
                           <shipDate>1999-05-21</shipDate>
                         </item>
                       </items>
                     </purchaseOrder>'));
COMMIT;
```

Example 11–58 CREATE TABLE purchase_orders_xmltype_table

```
CREATE TABLE purchase_orders_xmltype_table OF XMLType;

INSERT INTO purchase_orders_xmltype_table
  VALUES (
    XMLType ('<?xml version="1.0" encoding="UTF-8"?>
              <purchaseOrder
```

```
                    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                    xsi:noNamespaceSchemaLocation="xmlschema/po.xsd"
                    orderDate="1999-10-20">
                    <shipTo country="US">
                      <name>Alice Smith</name>
                      <street>123 Maple Street</street>
                      <city>Mill Valley</city>
                      <state>CA</state>
                      <zip>90952</zip>
                    </shipTo>
                    <billTo country="US">
                      <name>Robert Smith</name>
                      <street>8 Oak Avenue</street>
                      <city>Old Town</city>
                      <state>PA</state>
                      <zip>95819</zip>
                    </billTo>
                    <comment>Hurry, my lawn is going wild!</comment>
                    <items>
                      <item partNum="872-AA">
                        <productName>Lawnmower</productName>
                        <quantity>1</quantity>
                        <USPrice>148.95</USPrice>
                        <comment>Confirm this is electric</comment>
                      </item>
                      <item partNum="926-AA">
                        <productName>Baby Monitor</productName>
                        <quantity>1</quantity>
                        <USPrice>39.98</USPrice>
                        <shipDate>1999-05-21</shipDate>
                      </item>
                    </items>
                  </purchaseOrder>'));
COMMIT;
```

Purchase-Order XML Schema for Full-Text Search Examples

Example 11–59 Purchase-Order XML Schema for Full-Text Search Examples

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:annotation>
    <xsd:documentation xml:lang="en">
      Purchase order schema for Example.com.
      Copyright 2000 Example.com. All rights reserved.
    </xsd:documentation>
  </xsd:annotation>
  <xsd:element name="purchaseOrder" type="PurchaseOrderType"/>
  <xsd:element name="comment" type="xsd:string"/>
  <xsd:complexType name="PurchaseOrderType">
    <xsd:sequence>
      <xsd:element name="shipTo" type="USAddress"/>
      <xsd:element name="billTo" type="USAddress"/>
      <xsd:element ref="comment" minOccurs="0"/>
      <xsd:element name="items" type="Items"/>
    </xsd:sequence>
    <xsd:attribute name="orderDate" type="xsd:date"/>
  </xsd:complexType>
  <xsd:complexType name="USAddress">
```

```
    <xsd:sequence>
      <xsd:element name="name" type="xsd:string"/>
      <xsd:element name="street" type="xsd:string"/>
      <xsd:element name="city" type="xsd:string"/>
      <xsd:element name="state" type="xsd:string"/>
      <xsd:element name="zip" type="xsd:decimal"/>
    </xsd:sequence>
    <xsd:attribute name="country" type="xsd:NMTOKEN" fixed="US"/>
  </xsd:complexType>
  <xsd:complexType name="Items">
    <xsd:sequence>
      <xsd:element name="item" minOccurs="0" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="productName" type="xsd:string"/>
            <xsd:element name="quantity">
              <xsd:simpleType>
                <xsd:restriction base="xsd:positiveInteger">
                  <xsd:maxExclusive value="100"/>
                </xsd:restriction>
              </xsd:simpleType>
            </xsd:element>
            <xsd:element name="USPrice" type="xsd:decimal"/>
            <xsd:element ref="comment" minOccurs="0"/>
            <xsd:element name="shipDate" type="xsd:date" minOccurs="0"/>
          </xsd:sequence>
          <xsd:attribute name="partNum" type="SKU" use="required"/>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
  <!-- Stock Keeping Unit, a code for identifying products -->
  <xsd:simpleType name="SKU">
    <xsd:restriction base="xsd:string">
      <xsd:pattern value="\d{3}-[A-Z]{2}"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:schema>
```

Part III

Using XMLType APIs

Part III of this manual introduces you to ways you can use Oracle XML DB XMLType PL/SQL, Java, C APIs, and Oracle Data Provider for .NET (ODP.NET) to access and manipulate XML data. It contains the following chapters:

12

PL/SQL APIs for XMLType

This chapter describes the use of the APIs for XMLType in PL/SQL.

This chapter contains these topics:

Overview of PL/SQL APIs for XMLType

This chapter describes the PL/SQL Application Program Interfaces (APIs) for XMLType. These include the following:

- PL/SQL Document Object Model (DOM) API for XMLType (package DBMS_XMLDOM): For accessing XMLType objects. You can access both XML schema-based and non-schema-based documents. Before database startup, you must specify the read-from and write-to directories in the initialization.ORA file; for example:

  ```
  UTL_FILE_DIR=/mypath/insidemypath
  ```

  The read-from and write-to files must be on the server file system.

  DOM is an in-memory tree-based object representation of an XML document that enables programmatic access to its elements and attributes. The DOM object and its interface is a W3C recommendation. It specifies the Document Object Model of an XML document including APIs for programmatic access. DOM views the parsed document as a tree of objects.

- PL/SQL XML Parser API for XMLType (package DBMS_XMLPARSER): For accessing the content and structure of XML documents.
- PL/SQL XSLT Processor for XMLType (package DBMS_XSLPROCESSOR): For transforming XML documents to other formats using XSLT.

API Features

The PL/SQL APIs for XMLType allow you to perform the following tasks:

- Create XMLType tables, columns, and views
- Construct XMLType instances from data encoded in different character sets.

- Access `XMLType` data
- Manipulate `XMLType` data

See Also:

- "Oracle XML DB Features", for an overview of the Oracle XML DB architecture and new features.
- Chapter 4, "XMLType Operations"
- *Oracle Database PL/SQL Packages and Types Reference*

Lazy Loading of XML Data (Lazy Manifestation)

Because `XMLType` provides an in-memory or virtual Document Object Model (DOM), it can use a memory conserving process called **lazy XML loading**, also sometimes referred to as **lazy manifestation**. This process optimizes memory usage by only loading rows of data when they are requested. It throws away previously-referenced sections of the document if memory usage grows too large. Lazy XML loading supports highly scalable applications that have many concurrent users needing to access large XML documents.

XMLType Data Type Supports XML Schema

The `XMLType` data type includes support for XML schemas. You can create an XML schema and annotate it with mappings from XML to object-relational storage. To take advantage of the PL/SQL DOM API, first create an XML schema and register it. Then, when you create `XMLType` tables and columns, you can specify that these conform to the registered XML schema.

XMLType Supports Data in Different Character Sets

`XMLType` instances can be created from data encoded in any Oracle-supported character set by using the PL/SQL `XMLType` constructor or `XMLType` method `createXML()`. The source XML data must be supplied using data type `BFILE` or `BLOB`. The encoding of the data is specified through argument `csid`. When this argument is zero (`0`), the encoding of the source data is determined from the XML prolog, as specified in Appendix F of the XML 1.0 Reference.

Method `getBLOBVal()` retrieves the XML contents in the requested character set.

Caution: *AL32UTF8* is the Oracle Database character set that is appropriate for `XMLType` data. It is equivalent to the IANA registered standard UTF-8 encoding, which supports all valid XML characters.

Do not confuse Oracle Database database character set UTF8 (no hyphen) with database character set AL32UTF8 or with character *encoding* UTF-8. Database character set UTF8 has been *superseded* by AL32UTF8. Do *not* use UTF8 for XML data. UTF8 supports only Unicode version 3.1 and earlier; it does not support all valid XML characters. AL32UTF8 has no such limitation.

Using database character set UTF8 for XML data could potentially *stop a system or affect security negatively*. If a character that is not supported by the database character set appears in an input-document element name, a replacement character (usually "?") will be substituted for it. This will terminate parsing and raise an exception. It could cause a fatal error.

PL/SQL DOM API for XMLType (DBMS_XMLDOM)

This section describes the PL/SQL DOM API for `XMLType`, `DBMS_XMLDOM`.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual `DBMS_XMLDOM` methods

Overview of the W3C Document Object Model (DOM) Recommendation

Skip this section if you are familiar with the generic DOM specifications recommended by the World Wide Web Consortium (W3C).

The Document Object Model (DOM) recommended by the W3C is a universal API for accessing the structure of XML documents. It was originally developed to formalize Dynamic HTML, which is used for animation, interaction, and dynamic updating of Web pages. DOM provides a language-neutral and platform-neutral object model for Web pages and XML documents. DOM describes language-independent and platform-independent interfaces to access and operate on XML components and elements. It expresses the structure of an XML document in a universal, content-neutral way. Applications can be written to dynamically delete, add, and edit the content, attributes, and style of XML documents. DOM makes it possible to create applications that work properly on all browsers, servers, and platforms.

Oracle XDK Extensions to the W3C DOM Standard

Oracle XML Developer's Kit (Oracle XDK) extends the W3C DOM API in various ways. All of these extensions are supported by Oracle XML DB except those relating to client-side operations that are not applicable in the database. This type of procedural processing is available through the SAX interface in the Oracle XDK Java and C components.

> **See Also:** *Oracle XML Developer's Kit Programmer's Guide*

Supported W3C DOM Recommendations

All Oracle XML DB APIs for accessing and manipulating XML comply with standard XML processing requirements as approved by the W3C. The PL/SQL DOM supports Levels 1 and 2 from the W3C DOM specifications.

- In Oracle9*i* release 1 (9.0.1), Oracle XDK for PL/SQL implemented DOM Level 1.0 and parts of DOM Level 2.0.
- In Oracle9*i* release 2 (9.2) and Oracle Database 10*g* release 1 (10.1), the PL/SQL API for `XMLType` implements DOM Levels 1.0 and Level 2.0 Core, and is fully integrated in the database through extensions to the `XMLType` API.

The following briefly describes each level:

- **DOM Level 1.0 –** The first formal Level of the DOM specifications, completed in October 1998. Level 1.0 defines support for XML 1.0 and HTML.
- **DOM Level 2.0 –** Completed in November 2000, Level 2.0 extends Level 1.0 with support for XML 1.0 with namespaces and adds support for Cascading Style Sheets (CSS) and events (user-interface events and tree manipulation events), and enhances tree manipulations (tree ranges and traversal mechanisms). CSS are a simple mechanism for adding style (fonts, colors, spacing, and so on) to Web documents.

Difference Between DOM and SAX

The generic APIs for XML can be classified in two main categories:

- *Tree-based.* DOM is the primary generic tree-based API for XML.
- Event-based. SAX (Simple API for XML) is the primary generic event-based programming interface between an XML parser and an XML application.

DOM works by creating objects. These objects have child objects and properties, and the child objects have child objects and properties, and so on. Objects are referenced either by moving down the object hierarchy or by explicitly giving an HTML element an ID attribute. For example:

```
<img src="employee_jdoe.gif" ID="0123jdoe">
```

Examples of structural manipulations are:

- Reordering elements
- Adding or deleting elements
- Adding or deleting attributes
- Renaming elements

PL/SQL DOM API for XMLType (DBMS_XMLDOM): Features

Oracle XML DB extends the Oracle Database XML development platform beyond SQL support for storage and retrieval of XML data. It lets you operate on `XMLType` instances using DOM in PL/SQL, Java, and C.

The *default* action for the PL/SQL DOM API for `XMLType` (`DBMS_XMLDOM`) is to do the following:

- Produce a parse tree that can be accessed by DOM APIs.
- Validate, if a DTD is found; otherwise, do not validate.
- Raise an application error if parsing fails.

DTD validation occurs when the object document is manifested. If lazy manifestation is employed, then the document is validated when it is used.

The PL/SQL DOM API exploits a C-based representation of XML in the server and operates on XML schema-based XML instances. The PL/SQL, Java, and C DOM APIs for `XMLType` comply with the W3C DOM Recommendations to define and implement structured storage of XML in relational or object-relational columns and as in-memory instances of `XMLType`. See "Using PL/SQL DOM API for XMLType: Preparing XML Data" on page 12-6, for a description of W3C DOM Recommendations.

XML Schema Support

The PL/SQL DOM API for `XMLType` supports XML schema. Oracle XML DB uses annotations within an XML schema as metadata to determine the structure of an XML document and the mapping of the document to a database schema.

> **Note:** For backward compatibility and flexibility, the PL/SQL DOM supports both XML schema-based documents and non-schema-based documents.

After an XML schema is registered with Oracle XML DB, the PL/SQL DOM API for `XMLType` builds an in-memory tree representation of an associated XML document as a hierarchy of node objects, each with its own specialized interfaces. Most node object types can have child node types, which in turn implement additional, more specialized interfaces. Nodes of some node types can have child nodes of various types, while nodes of other node types must be leaf nodes, which do not have child nodes.

Enhanced Performance

Oracle XML DB uses DOM to provide a standard way to translate data between XML and multiple back-end data sources. This eliminates the need to use separate XML translation techniques for the different data sources in your environment. Applications needing to exchange XML data can use a single native XML database to cache XML documents. Oracle XML DB can thus speed up application performance by acting as an intermediate cache between your Web applications and your back-end data sources, whether they are in relational databases or file systems.

See Also: Chapter 14, "Java DOM API for XMLType"

Designing End-to-End Applications Using Oracle XDK and Oracle XML DB

When you build applications based on Oracle XML DB, you do not need the additional components in Oracle XDK. However, you can use Oracle XDK components with Oracle XML DB to deploy a full suite of XML-enabled applications that run end-to-end. You can use features in Oracle XDK for:

- Simple API for XML (SAX) interface processing. SAX is an XML standard interface provided by XML parsers and used by procedural and event-based applications.
- DOM interface processing, for structural and recursive object-based processing.

Oracle XDK contain the basic building blocks for creating applications that run on a client, in a browser or a plug-in. Such applications typically read, manipulate, transform and view XML documents. To provide a broad variety of deployment options, Oracle XDK is available for Java, C, and C++. Oracle XDK is fully supported and comes with a commercial redistribution license.

Oracle XDK for Java consists of these components:

- **XML Parsers –** Creates and parses XML using industry standard DOM and SAX interfaces. Supports Java, C, C++, and JAXP.
- **XSL Processor –** Transforms or renders XML into other text-based formats such as HTML. Supports Java, C, and C++.
- **XML Schema Processor –** Uses XML simple and complex data types. Supports Java, C, and C++.
- **XML Class Generator, Oracle JAXB Class Generator –** Automatically generate C++ and Java classes, respectively, from DTDs and XML schemas, to send XML data from Web forms or applications. Class generators accept an input file and create a set of output classes that have corresponding functionality. For the XML Class Generator, the input file is a DTD, and the output is a series of classes that can be used to create XML documents conforming with the DTD.
- **XML SQL Utility –** Generates XML documents, DTDs, and XML schemas from SQL queries. Supports Java.
- **TransX Utility –** Loads data encapsulated in XML into the database. Has additional functionality useful for installations.

- **XSQL Servlet –** Combines XML, SQL, and XSLT in the server to deliver dynamic Web content.
- **XML Pipeline Processor –** Invokes Java processes through XML control files.
- **XSLT VM and Compiler –** Provides a high-performance C-based XSLT transformation engine that uses compiled style sheets.
- **XML Java Beans –** Parses, transforms, compares, retrieves, and compresses XML documents using Java components.

See Also: *Oracle XML Developer's Kit Programmer's Guide*

Using PL/SQL DOM API for XMLType: Preparing XML Data

To prepare data for using PL/SQL DOM APIs in Oracle XML DB:

1. Create a standard XML schema.
2. Annotate the XML schema with definitions for the SQL objects you use.
3. Register the XML schema, to generate the necessary database mappings.

You can then do any of the following:

- Use `XMLType` views to wrap existing relational or object-relational data in XML formats, making it available to your applications in XML form. See "Wrapping Existing Data into XML with XMLType Views" on page 12-7.
- Insert XML data into `XMLType` columns.
- Use Oracle XML DB PL/SQL and Java DOM APIs to manipulate XML data stored in `XMLType` columns and tables.

Defining an XML Schema Mapping to SQL Object Types

An XML schema must be registered before it can be referenced by an XML document. When you register an XML schema, elements and attributes it declares are mapped to attributes of corresponding SQL object types within the database.

After XML schema registration, XML documents that conform to the XML schema and reference it can be managed by Oracle XML DB. Tables and columns for storing the conforming documents can be created for root elements defined by the XML schema.

See Also: Chapter 6, "XML Schema Storage and Query: Basic"

An XML schema is registered by using PL/SQL package `DBMS_XMLSCHEMA` and by specifying the schema document and its *schema-location URL*. This URL is a name that uniquely identifies the registered schema within the database; it need not correspond to any real location—in particular, it need not indicate where the schema document is located.

The *target namespace* of the schema is another URL used in the XML schema. It specifies a namespace for the XML-schema elements and types. An XML document should specify both the namespace of the root element and the schema-location URL identifying the schema that defines this element.

When documents are inserted into Oracle XML DB using path-based protocols such as HTTP(S) and FTP, the XML schema to which the document conforms is *registered implicitly*, provided its name and location are specified and it has not yet been registered.

See Also: *Oracle Database PL/SQL Packages and Types Reference* descriptions of the individual DBMS_XMLSCHEMA methods

DOM Fidelity for XML Schema Mapping

Elements and attributes declared within the XML schema get mapped to separate attributes of the corresponding SQL object type. Other information encoded in an XML document, such as comments, processing instructions, namespace declarations and prefix definitions, and whitespace, is not represented directly.

To store this additional information, binary attribute SYS_XDBPD$ is present in all generated SQL object types. This database attribute stores all information in the original XML document that is not stored using the other database attributes. Retaining this accessory information ensures *DOM fidelity* for XML documents stored in Oracle XML DB: an XML document retrieved from the database is identical to the original document that was stored.

Note: In this book, the SYS_XDBPD$ attribute has been omitted from most examples, for simplicity. However, the attribute is always present in SQL object types generated by schema registration.

Wrapping Existing Data into XML with XMLType Views

To make existing relational and object-relational data available to your XML applications, you can create XMLType views, wrapping the data in an XML format. You can then access this XML data using the PL/SQL DOM API.

After you register an XML schema containing annotations that represent the mapping between XML types and SQL object types, you can create an XMLType view that conforms to the XML schema.

See Also: Chapter 19, "XMLType Views"

DBMS_XMLDOM Methods Supported

All DBMS_XMLDOM methods are supported by Oracle XML DB, with the *exception* of the following:

- writeExternalDTDToFile()
- writeExternalDTDToBuffer()
- writeExternalDTDToClob()

See Also: *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual DBMS_XMLDOM methods

PL/SQL DOM API for XMLType: Node Types

In the DOM specification, the term "**document**" is used to describe a container for many different kinds of information or data, which the DOM objectifies. The DOM specifies the way elements within an XML document container are used to create an object-based tree structure and to define and expose interfaces to manage and use the objects stored in XML documents. Additionally, the DOM supports storage of documents in diverse systems.

When a request such as `getNodeType(myNode)` is given, it returns `myNodeType`, which is the node type supported by the parent node. These constants represent the different types that a node can adopt:

- `ELEMENT_NODE`
- `ATTRIBUTE_NODE`
- `TEXT_NODE`
- `CDATA_SECTION_NODE`
- `ENTITY_REFERENCE_NODE`
- `ENTITY_NODE`
- `PROCESSING_INSTRUCTION_NODE`
- `COMMENT_NODE`
- `DOCUMENT_NODE`
- `DOCUMENT_TYPE_NODE`
- `DOCUMENT_FRAGMENT_NODE`
- `NOTATION_NODE`

Table 12–1 shows the node types for XML and HTML and the allowed corresponding children node types.

Table 12–1 XML and HTML DOM Node Types and Their Child Node Types

Node Type	Children Node Types
`Document`	`Element` (maximum of one), `ProcessingInstruction`, `Comment`, `DocumentType` (maximum of one)
`DocumentFragment`	`Element`, `ProcessingInstruction`, `Comment`, `Text`, `CDATASection`, `EntityReference`
`DocumentType`	No children
`EntityReference`	`Element`, `ProcessingInstruction`, `Comment`, `Text`, `CDATASection`, `EntityReference`
`Element`	`Element`, `Text`, `Comment`, `ProcessingInstruction`, `CDATASection`, `EntityReference`
`Attr`	`Text`, `EntityReference`
`ProcessingInstruction`	No children
`Comment`	No children
`Text`	No children
`CDATASection`	No children
`Entity`	`Element`, `ProcessingInstruction`, `Comment`, `Text`, `CDATASection`, `EntityReference`
`Notation`	No children

Oracle XML DB DOM API for `XMLType` also specifies these interfaces:

- **A NodeList interface** to handle ordered lists of Nodes, for example:
  - The children of a Node

  - Elements returned by method `getElementsByTagName` of the element interface

- **A NamedNodeMap interface** to handle unordered sets of nodes, referenced by their name attribute, such as the attributes of an element.

Working with XML Schema-Based Data

Oracle Database has several extensions for character-set conversion and input and output to and from a file system. PL/SQL API for `XMLType` is optimized to operate on XML schema-based XML instances. Function `newDOMDocument` constructs a DOM document handle, given an `XMLType` value.

A typical usage scenario would be for a PL/SQL application to:

1. Fetch or construct an `XMLType` instance
2. Construct a `DOMDocument` node over the `XMLType` instance
3. Use the DOM API to access and manipulate the XML data

Note: For `DOMDocument`, node types represent handles to XML fragments but do not represent the data itself.

For example, if you copy a node value, `DOMDocument` clones the handle to the same underlying data. Any data modified by one of the handles is visible when accessed by the other handle. The `XMLType` value from which the `DOMDocument` handle is constructed is the data, and reflects the results of all DOM operations on it.

DOM NodeList and NamedNodeMap Objects

`NodeList` and `NamedNodeMap` objects in the DOM are active; that is, changes to the underlying document structure are reflected in all relevant `NodeList` and `NamedNodeMap` objects.

For example, if a DOM user gets a `NodeList` object containing the children of an element, and then subsequently adds more children to that element (or removes children, or modifies them), then those changes are automatically propagated in the `NodeList`, without additional action from the user. Likewise, changes to a node in the tree are propagated throughout all references to that node in `NodeList` and `NamedNodeMap` objects.

The interfaces: `Text`, `Comment`, and `CDATASection`, all inherit from the `CharacterData` interface.

Using PL/SQL DOM API for XMLType (DBMS_XMLDOM)

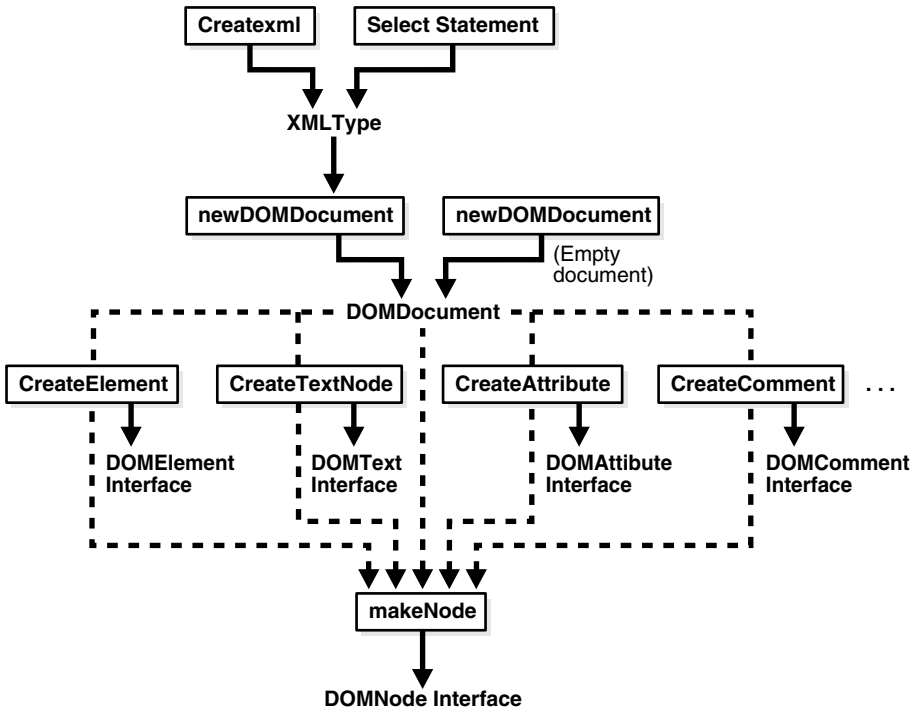
Figure 12–1 illustrates the use of PL/SQL DOM API for `XMLType` (`DBMS_XMLDOM`).

You can create a DOM document (`DOMDocument`) from an existing `XMLType` or as an empty document.

1. The `newDOMDocument` procedure processes the `XMLType` instance or empty document. This creates a `DOMDocument` instance.
2. You can use DOM API methods such as `createElement`, `createText`, `createAttribute`, and `createComment` to traverse and extend the DOM tree.

3. The results of methods such as `DOMElement` and `DOMText` can also be passed to `makeNode` to obtain the `DOMNode` interface.

Figure 12–1 Using PL/SQL DOM API for XMLType



PL/SQL DOM API for XMLType – Examples

This section presents examples of using the PL/SQL DOM API for `XMLType`.

Remember to call procedure `freeDocument` for *each* `DOMDocument` instance, when you are through with the instance. This procedure frees the document and all of its nodes. You can still access `XMLType` instances on which `DOMDocument` instances were built, even after the `DOMDocument` instances have been freed.

Example 12–1 Creating and Manipulating a DOM Document

This example creates a hierarchical, in-memory representation of an XML document – a DOM document. It uses a *handle* to this DOM document to manipulate it: print it, change part of it, and print it again after the change. Manipulating the DOM document by its handle also indirectly affects the XML data represented by the document, so that querying that data after the change shows the changed result.

The in-memory document is created from an `XMLType` variable using PL/SQL function `newDOMDocument`. The handle to this document is created using function `makeNode`. The document is written to a `VARCHAR2` buffer using function `writeToBuffer`, and the buffer is printed using `DBMS_OUTPUT.put_line`.

After manipulating the document using various `DBMS_XMLDOM` procedures, the (changed) data in the `XMLType` variable is inserted into a table and queried, showing the change. It is only when the data is inserted into a database table that it becomes persistent; until then, it exists in memory only. This persistence is demonstrated by the fact that the database query is made after the in-memory document (`DOMDocument` instance) has been freed.

```
CREATE TABLE person OF XMLType;

DECLARE
  var       XMLType;
  doc       DBMS_XMLDOM.DOMDocument;
  ndoc      DBMS_XMLDOM.DOMNode;
  docelem   DBMS_XMLDOM.DOMElement;
  node      DBMS_XMLDOM.DOMNode;
  childnode DBMS_XMLDOM.DOMNode;
  nodelist  DBMS_XMLDOM.DOMNodelist;
  buf       VARCHAR2(2000);
BEGIN
  var := XMLType('<PERSON><NAME>ramesh</NAME></PERSON>');

  -- Create DOMDocument handle
  doc     := DBMS_XMLDOM.newDOMDocument(var);
  ndoc    := DBMS_XMLDOM.makeNode(doc);

  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
  DBMS_OUTPUT.put_line('Before:'||buf);

  docelem := DBMS_XMLDOM.getDocumentElement(doc);

  -- Access element
  nodelist := DBMS_XMLDOM.getElementsByTagName(docelem, 'NAME');
  node := DBMS_XMLDOM.item(nodelist, 0);
  childnode := DBMS_XMLDOM.getFirstChild(node);

  -- Manipulate element
  DBMS_XMLDOM.setNodeValue(childnode, 'raj');
  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
  DBMS_OUTPUT.put_line('After:'||buf);
  DBMS_XMLDOM.freeDocument(doc);
  INSERT INTO person VALUES (var);
END;
/
```

This produces the following output:

```
Before:<PERSON>
  <NAME>ramesh</NAME>
</PERSON>

After:<PERSON>
  <NAME>raj</NAME>
</PERSON>
```

This query confirms that the data has changed:

```
SELECT * FROM person;
SYS_NC_ROWINFO$
---------------
<PERSON>
  <NAME>raj</NAME>
</PERSON>

1 row selected.
```

Example 12–2 Creating an Element Node and Obtaining Information About It

This example creates an empty DOM document, and then adds an element node (<ELEM>) to the document. DBMS_XMLDOM API node procedures are used to obtain the name (<ELEM>), value (NULL), and type (1 = element node) of the element node.

```
DECLARE
  doc   DBMS_XMLDOM.DOMDocument;
  elem  DBMS_XMLDOM.DOMElement;
  nelem DBMS_XMLDOM.DOMNode;
BEGIN
  doc := DBMS_XMLDOM.newDOMDocument;
  elem := DBMS_XMLDOM.createElement(doc, 'ELEM');
  nelem := DBMS_XMLDOM.makeNode(elem);
  DBMS_OUTPUT.put_line('Node name = ' || DBMS_XMLDOM.getNodeName(nelem));
  DBMS_OUTPUT.put_line('Node value = '|| DBMS_XMLDOM.getNodeValue(nelem));
  DBMS_OUTPUT.put_line('Node type = ' || DBMS_XMLDOM.getNodeType(nelem));
  DBMS_XMLDOM.freeDocument(doc);
END;
/
```

This produces the following output:

```
Node name = ELEM
Node value =
Node type = 1
```

Large Node Handling Using DBMS_XMLDOM

Prior to Oracle Database 11g Release 1 (11.1), each text node or attribute value processed by Oracle XML DB was limited in size to 64 K bytes. Starting with release 11.1, this restriction no longer applies.

To overcome this size limitation and allow nodes to contain graphics files, PDF files, and multibyte character encodings, the following abstract streams are available. These abstract PL/SQL streams are analogous to the corresponding Java streams. Each input stream has an associated writer, or data producer, and each output stream has an associated reader, or data consumer.

1. **Binary Input Stream:** This provides the data consumer with read-only access to source data, as a sequential (non-array) linear space of bytes. The consumer has iterative read access to underlying source data (whatever representation) in binary format, that is, read access to source data in unconverted, "raw" format. The consumer sees a sequence of bytes as they exist in the node. There is no specification of the format or representation of the source data. In particular, there is no associated character set.
2. **Binary Output Stream:** This provides the data producer with write-only access to target data as a sequential (non-array) linear space of bytes. The producer has iterative write access to target data in binary format, that is, write access to target data in pure binary format with no data semantic at all. The producer passes a sequence of bytes and the target data is replaced by these bytes. No data conversion occurs.
3. **Character Input Stream:** This provides the data consumer iterative read-only access to source data as a sequential (non-array) linear space of characters, independent of the representation and format of the source data. Conversion of the source data may or may not occur.
4. **Character Output Stream:** This provides the data producer with iterative write-only access to target data as a sequential (non-array) linear space of

characters. The producer passes a sequence of characters and the target data is replaced by this sequence of characters. Conversion of the passed data may or may not occur.

Each of the input streams has the following abstract methods: open, read, and close. Each of the output streams has the following abstract methods: open, write, flush, and close. For output streams, you must close the stream before any nodes are physically written.

There are four general node access models, for reading and writing. Each access model has both binary and character versions. Binary and character stream methods defined on data type `DOMNode` realize these access models. Each access model is described in a separate section, with an explanation of the PL/SQL functions and procedures in package `DBMS_XMLDOM` that operate on large nodes.

- Get-Push Model
- Get-Pull Model
- Set-Pull Model
- Set-Push Model

For all except the get-push and set-pull access models (whether binary or character), Oracle supplies a concrete stream that you can use (implicitly). For get-push and set-pull, you must define a subtype of the abstract stream type that Oracle provides, and you must implement its access methods (open, close, and so on). For get-push and set-pull, you then instantiate your stream type and supply your stream as an argument to the access method. So, for example, you would use `my_node.getNodeValueAsCharacterStream(my-stream)` for get-push, but just `my_node.getNodeValueAsCharacterStream()` for get-pull. The latter requires no explicit stream argument, because the concrete stream supplied by Oracle is used.

Note: When you access a character-data stream, the access method you use determines the apparent character set of the nodes accessed. If you use Java to access the stream, then the character set seen by your Java program is UCS2 (or an application-specified character set). If you use PL/SQL to access the stream, then the character set seen by your PL/SQL program is the database-session character set (or an application-specified character set). In all cases, however, the XML data is stored in the database in the database character set.

In the following descriptions, C1 is the character set of the node as stored in the database, and C2 is the character set of the node as seen by your program.

See Also:

- "Handling Large Nodes Using Java" on page 14-17 for information on using Java with large nodes
- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle Database XML Java API Reference* for information about Java functions for handling large nodes
- *Oracle Database XML C API Reference* for information about C functions for handling large nodes

Get-Push Model

To read a node value in this model, the application creates a binary output stream or character output stream and passes this to Oracle XML DB. In this case, the source data is the node value. Oracle XML DB will populate the output stream by pushing node data into the stream. If the stream is a character output stream, then the character set, C2, will be the session character set and node data is converted, if necessary, from C1 to C2. Additionally, the data type of the node may be any supported by Oracle XML DB and, if the node data type is not character data then the node data is first converted to character data in C2. If a binary output stream, the data type of the node must be `RAW` or `BLOB`.

The procedures of the `DBMS_XMLDOM` package to be used for this case are:

```
PROCEDURE getNodeValueAsBinaryStream (n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_BinaryOutputStream);
```

The application passes an implementation of `SYS.utl_BinaryOutputStream` into which Oracle XML DB will write the contents of the node. The data type of the node must be `RAW` or `CLOB`; if not an exception is raised.

```
PROCEDURE getNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_CharacterOutputStream);
```

The node data is converted, as necessary, to the session character set and then "pushed" into the `SYS.utl_CharacterOutputStream`.

The following example fragments illustrate reading the node value as binary data and driving the write methods in a user-defined subtype of `SYS.utl_BinaryOutPutStream`, which is called `MyBinaryOutputStream`:

Example 12–3 Creating a User-Defined Subtype of SYS.util_BinaryOutputStream()

```
CREATE TYPE MyBinaryOutputStream UNDER SYS.utl_BinaryOutputStream (
    CONSTRUCTOR FUNCTION MyBinaryOutputStream ()
    RETURN SELF AS RESULT,
    MEMBER FUNCTION  write (bytes IN RAW) RETURN INTEGER,
    MEMBER PROCEDURE write (bytes IN RAW, offset IN INTEGER, length IN OUT
           INTEGER),
    MEMBER FUNCTION flush () RETURN BOOLEAN,
    MEMBER FUNCTION close () RETURN BOOLEAN);
);

-- Here, you write the code to implement these methods
...
```

Example 12–4 Retrieving Node Value with a User-Defined Stream

```
DECLARE
  ostream     MyBinaryOutputStream = MyBinaryOutputStream ();
  node        DBMS_XMLDOM.domnode;
  ...
BEGIN
  ...
  -- This drives the write methods in MyBinaryOutputStream,
  -- flushes the data, and closes the stream after the value has been
  -- completely written.
  DBMS_XMLDOM.getNodeValueAsBinaryStream (node, ostream);
  ...
END;
```

Get-Pull Model

To read the value of a node in this model, Oracle XML DB creates a binary input stream or character input stream and returns this to the caller. The character set, C2, of the character input stream is the current session character set. Oracle XML DB will populate the input stream as the caller pulls the node data from the stream so Oracle XML DB is again the producer of the data. If the stream is a character input stream, then the node data type may be any supported by Oracle XML DB and node data, if character, is converted, if necessary, from C1 to C2. If the node data is non-character, it is converted to character in C2. If a binary input stream, the data type of the node must be `RAW` or `BLOB`.

The functions of the `DBMS_XMLDOM` package to be used for this case are `getNodeValueAsBinaryStream` and `getNodeValueAsCharacterStream`.

```
FUNCTION getNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_BinaryInputStream;
```

This function returns an instance of the new PL/SQL `SYS.utl_BinaryInputStream` that can be read using defined methods as described in the section "Set-Pull Model" on page 12-16. The node data type must be `RAW` or `BLOB`; otherwise, an exception is raised.

```
FUNCTION getNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_CharacterInputStream;
```

This function returns an instance of the new PL/SQL `SYS.utl_CharacterInputStream` that can be read using defined methods. If the node data is character it is converted to the current session character set. If the node data is not character data, it is first converted to character data.

Example 12–5 illustrates reading a node value as binary data in 50-byte increments:

Example 12–5 Get-Pull of Binary Data

```
DECLARE
  istream      SYS.utl_BinaryInputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       raw(50);
  numBytes     pls_integer;
  ...
BEGIN
  ...
  istream := DBMS_XMLDOM.getNodeValueAsBinaryStream (node);
  -- Read stream in 50-byte chunks
  LOOP
    numBytes := 50;
    istream.read ( buffer, numBytes);
    if numBytes <= 0 then
       exit;
    end if;
-- Process next 50 bytes of node value in buffer
END LOOP
...
END;
```

Example 12–6 illustrates reading a node value as character data in 50-character increments:

Example 12–6 Get-Pull of Character Data

```
DECLARE
  istream      SYS.utl_CharacterInputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       varchar2(50);
  numChars     pls_integer;
  ...
BEGIN
  ...
  istream := DBMS_XMLDOM.getNodeValueAsCharacterStream (node);
-- Read stream in 50-character chunks
LOOP
   numChars := 50;
   istream.read ( buffer, numChars);
   IF numChars <= 0 then
      exit;
   END IF;
-- Process next 50 characters of node value in buffer
END LOOP
...
END;
```

Set-Pull Model

To write a node value in this mode, the application creates a binary input stream or character input stream and passes this to Oracle XML DB. The character set of the character input stream, C2, is the session character set. Oracle XML DB will pull the data from the input stream and populate the node. If the stream is a character input stream, then the data type of the node may be any supported by Oracle XML DB. If the data type of the node is not character, the stream data is first converted to the node data type. If the node data type is character, then no conversion occurs; the node data remains in character set C2. If the stream is a `binary input stream`, then the data type of the node must be `RAW` or `BLOB` and no conversion occurs.

The procedures of the `DBMS_XMLDOM` package to be used for this case are `setNodeValueAsBinaryStream` and `setNodeValueAsCharacterStream`.

```
PROCEDURE setNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_BinaryInputStream);
```

The application passes in an implementation of `SYS.utl_BinaryInputStream` from which Oracle XML DB reads data to populate the node. The data type of the node must be `RAW` or `BLOB`; if not an exception is raised.

```
PROCEDURE setNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode,
          value IN SYS.utl_CharacterInputStream);
```

The application passes in an implementation of `SYS.utl_CharacterInputStream` from which Oracle XML DB reads to populate the node. The data type of the node may be any valid type supported by Oracle XML DB. If it is a non-character data type, the character data read from the stream is converted to the data type of the node. If the data type of the node is either character or `CLOB`, then no conversion occurs and the character set of the node becomes the character set of the PL/SQL session.

Example 12–7 illustrates setting the node value to binary data produced by the read methods defined in a user-defined subtype of `SYS.utl_BinaryInputStream`, which is called `MyBinaryInputStream`:

Example 12–7 Set-Pull of Binary Data

```
CREATE TYPE MyBinaryInputStream UNDER SYS.utl_BinaryInputStream (
    CONSTRUCTOR FUNCTION MyBinaryInputStream ()
    RETURN SELF AS RESULT,
  MEMBER FUNCTION read () RETURN RAW,
  MEMBER PROCEDURE read (bytes IN OUT RAW, numbytes IN OUT INTEGER),
  MEMBER PROCEDURE read (bytes IN OUT RAW, offset IN INTEGER, length IN OUT
         INTEGER),
  MEMBER FUNCTION close () RETURN BOOLEAN);
```

You can use an object of type `MyBinaryInputStream` to set the value of a node as follows:

```
DECLARE
  istream     MyBinaryInputStream = MyBinaryInputStream ();
  node        DBMS_XMLDOM.domnode;
  ...
BEGIN
  ...
  -- This drives the read methods in MyBinaryInputStream
  DBMS_XMLDOM.setNodeValueAsBinaryStream (node, istream);
  ...
END;
```

Set-Push Model

To write a new node value in this mode, Oracle XML DB creates a binary output stream or character output stream and returns this to the caller. The character set of the character output stream, C2, is the current session character set. The caller pushes data into the output stream and Oracle XML DB then writes this to the Oracle XML DB Node. If the stream is a character output stream, then the data type of the node may be any type supported by Oracle XML DB. In this case, the character data is converted to the node data type. If the node data type is character, then the character set, C1, is changed to C2. No data conversion occurs. If the stream is a binary input stream, and the data type of the node must be `RAW` or `BLOB`. In this case, the stream is read without data conversion.

The procedures of the `DBMS_XMLDOM` package to be used for this case are `setNodeValueAsBinaryStream` and `setNodeValueAsCharacterStream`.

```
FUNCTION setNodeValueAsBinaryStream(n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_BinaryOutputStream;
```

This function returns an instance of `SYS.utl_BinaryOutputStream` into which the caller can write the node value. The data type of the node must be `RAW` or `BLOB`; if not, an exception is raised.

```
FUNCTION setNodeValueAsCharacterStream (n IN DBMS_XMLDOM.domnode)
         RETURN SYS.utl_CharacterOutputStream;
```

This function returns an instance of the PL/SQL `SYS.utl_CharacterOutputStream` type into which the caller can write the node value. The data type of the node can be any valid Oracle XML DB data type. If the type is not character or CLOB, the character data written to the stream is converted to the node data type. If the data type of the node is character or CLOB, then the character data written to the stream is converted from PL/SQL session character set to the character set of the node

Example 12–8 illustrates setting the value of a node to binary data by writing 50-byte segments into the `SYS.utl_BinaryOutputStream`:

Example 12–8 Set-Push of Binary Data

```
DECLARE
  ostream      SYS.utl_BinaryOutputStream;
  node         DBMS_XMLDOM.domnode;
  buffer       raw(500);
  segment      raw(50);
  numBytes     pls_integer;
  offset       pls_integer;
  ...
BEGIN
  ...
  ostream := DBMS_XMLDOM.setNodeValueAsBinaryStream (node);
  offset := 0;
  length := 500;
  -- Write to stream in 50-byte chunks
  LOOP
    numBytes := 50;
    -- Get next 50 bytes of buffer
    ostream.write ( segment, offset, numBytes);
    length := length - numBytes;
    IF length  <= 0 then
       exit;
    END IF;
  END LOOP
  ostream.close();
  ...
END;
```

Determining Binary Stream or Character Stream

To determine whether to use a character stream or a binary stream to access the node value use the following method which is also included as part of the `DBMS_XMLDOM` package:

```
FUNCTION useBinaryStream (n IN DBMS_XMLDOM.domnode) RETURN BOOLEAN;
```

This function returns `TRUE` if the data type of the node is `RAW` or `BLOB`, so that the node value may be read or written using either a `SYS.utl_BinaryInputStream` or a `SYS.utl_BinaryOutputStream`. If a value of `FALSE` is returned, the node value can be accessed only using a `SYS.utl_CharacterInputStream` or a `SYS.utl_CharacterOutputStream`.

PL/SQL Parser API for XMLType (DBMS_XMLPARSER)

XML documents are made up of storage units, called *entities*, that contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data and some of which form markup. Markup encodes a description of the document storage layout and logical structure. XML provides a mechanism for imposing constraints on the storage layout and logical structure.

A software module called an XML parser or processor reads XML documents and provides access to their content and structure. An XML parser usually does its work on behalf of another module, typically the application.

PL/SQL Parser API for XMLType: Features

The PL/SQL Parser API for `XMLType` (`DBMS_XMLPARSER`) builds a result tree that can be accessed by PL/SQL APIs. If parsing fails, it raises an error.

See *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual methods of the PL/SQL Parser API for `XMLType` (`DBMS_XMLPARSER`).

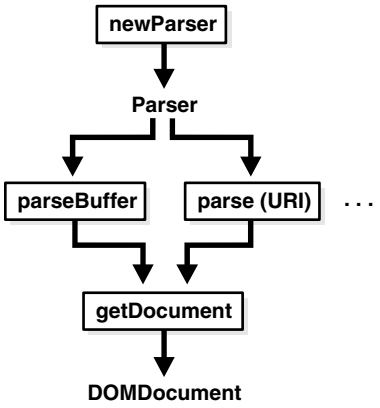
Method `DBMS_XMLPARSER.setErrorLog()` is not supported.

Using PL/SQL Parser API for XMLType (DBMS_XMLPARSER)

Figure 12–2 illustrates how to use the PL/SQL Parser for `XMLType` (`DBMS_XMLPARSER`). These are the steps:

1. Construct a parser instance using method.
2. Parse XML documents using methods such as `parseBuffer(),parseClob()`, and `parse(URI)`. An error is raised if the input is not a valid XML document.
3. Call `getDocument` on the parser to obtain a `DOMDocument` interface.

Figure 12–2 Using PL/SQL Parser API for XMLType



Example 12–9 Parsing an XML Document

This example parses a simple XML document. It creates an XML parser (instance of `DBMS_XMLPARSER.parser`) and uses it to parse the XML document (text) in variable `indoc`. Parsing creates a DOM document, which is retrieved from the parser using `DBMS_XMLPARSER.getDocument`. A DOM node is created that contains the entire document, and the node is printed. After freeing (destroying) the DOM document, the parser instance is freed using `DBMS_XMLPARSER.freeParser`.

```
DECLARE
  indoc    VARCHAR2(2000);
  indomdoc DBMS_XMLDOM.DOMDocument;
  innode   DBMS_XMLDOM.DOMNode;
  myparser DBMS_XMLPARSER.parser;
  buf      VARCHAR2(2000);
BEGIN
  indoc := '<emp><name>De Selby</name></emp>';
  myParser := DBMS_XMLPARSER.newParser;
  DBMS_XMLPARSER.parseBuffer(myParser, indoc);
  indomdoc := DBMS_XMLPARSER.getDocument(myParser);
  innode := DBMS_XMLDOM.makeNode(indomdoc);
  DBMS_XMLDOM.writeToBuffer(innode, buf);
  DBMS_OUTPUT.put_line(buf);
  DBMS_XMLDOM.freeDocument(indomdoc);
  DBMS_XMLPARSER.freeParser(myParser);
END;
/
```

This produces the following output:

```
<emp><name>De Selby</name></emp>
```

PL/SQL XSLT Processor for XMLType (DBMS_XSLPROCESSOR)

The W3C XSL Recommendation describes rules for transforming a source tree into a result tree. A transformation expressed in Extensible Stylesheet Language Transformation (XSLT) language is called an **XSL style sheet**. The transformation specified is achieved by associating patterns with templates defined in the XSLT style sheet. A template is instantiated to create part of the result tree.

Enabling Transformations and Conversions with XSLT

The Oracle XML DB PL/SQL DOM API for `XMLType` also supports XSLT. This enables transformation from one XML document to another, or conversion into HTML, PDF, or other formats. XSLT is also widely used to convert XML to HTML for browser display.

The embedded XSLT processor follows Extensible Stylesheet Language (XSL) statements and traverses the DOM tree structure for XML data residing in `XMLType`. Oracle XML DB applications do not require a separate parser as did the prior release XML Parser for PL/SQL. However, applications requiring external processing can still use the XML Parser for PL/SQL first to expose the document structure.

PL/SQL package `DBMS_XSLPROCESSOR` provides a convenient and efficient way of applying a single style sheet to multiple documents. The performance of this package is better than that of SQL function `transform` and `XMLType` method `transform()`, because the style sheet is parsed only once.

Note: The XML Parser for PL/SQL in Oracle XDK parses an XML document (or a standalone DTD) so that the XML document can be processed by an application, typically running on the client. PL/SQL APIs for `XMLType` are used for applications that run on the server and are natively integrated in the database. Benefits include performance improvements and enhanced access and manipulation options.

See Also: Chapter 10, "Transforming and Validating XMLType Data"

PL/SQL XSLT Processor for XMLType: Features

PL/SQL XSLT Processor for `XMLType` (`DBMS_XSLPROCESSOR`) is the Oracle XML DB implementation of the XSL processor. This follows the W3C XSLT final recommendation (REC-xslt-19991116). It includes the required action of an XSL processor in terms of how it must read XSLT style sheets and the transformations it must achieve.

The types and methods of the PL/SQL XSLT Processor API are made available by the PL/SQL package, `DBMS_XSLPROCESSOR`. The methods in this package use two PL/SQL data types specific to the XSL Processor implementation: `PROCESSOR` and `STYLESHEET`.

All `DBMS_XSLPROCESSOR` methods are supported by Oracle XML DB, with the *exception* of method `setErrorLog()`.

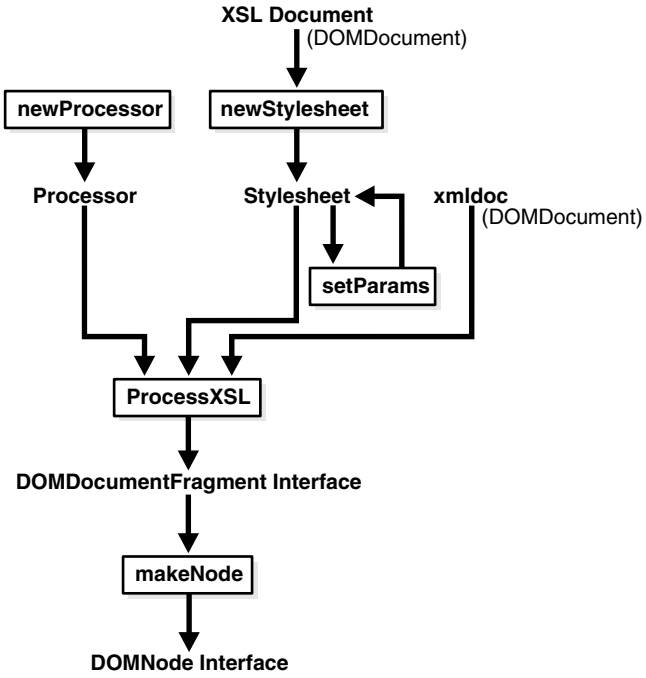
See Also: *Oracle Database PL/SQL Packages and Types Reference* for descriptions of the individual `DBMS_XSLPROCESSOR` methods

Using PL/SQL XSLT Processor API for XMLType (DBMS_XSLPROCESSOR)

Figure 12–3 illustrates how to use XSLT Processor for `XMLType` (`DBMS_XSLPROCESSOR`). These are the steps:

1. Construct an XSLT processor using `newProcessor`.
2. Use `newStylesheet` to build a `STYLESHEET` object from a DOM document.
3. Optionally, you can set parameters for the `STYLESHEET` object using `setParams`.
4. Use `processXSL` to transform a DOM document using the processor and `STYLESHEET` object.
5. Use the PL/SQL DOM API for `XMLType` to manipulate the result of XSLT processing.

Figure 12–3 Using PL/SQL XSLT Processor for XMLType



Example 12–10 Transforming an XML Document Using an XSL Style Sheet

This example transforms an XML document using procedure `processXSL`. It uses the same parser instance to create two different DOM documents: the XML text to transform and the XSLT style sheet. An XSL processor instance is created, which applies the style sheet to the source XML to produce a new DOM fragment. A DOM node (`outnode`) is created from this fragment, and the node content is printed. The output DOM fragment, parser, and XSLT processor instances are freed using procedures `freeDocFrag`, `freeParser`, and `freeProcessor`, respectively.

```
DECLARE
  indoc      VARCHAR2(2000);
  xsldoc     VARCHAR2(2000);
  myParser   DBMS_XMLPARSER.parser;
  indomdoc   DBMS_XMLDOM.DOMDocument;
```

```
  xsltdomdoc DBMS_XMLDOM.DOMDocument;
  xsl        DBMS_XSLPROCESSOR.stylesheet;
  outdomdocf DBMS_XMLDOM.DOMDocumentFragment;
  outnode    DBMS_XMLDOM.DOMNode;
  proc       DBMS_XSLPROCESSOR.processor;
  buf        VARCHAR2(2000);
BEGIN
  indoc := '<emp><empno>1</empno>
              <fname>robert</fname>
              <lname>smith</lname>
              <sal>1000</sal>
              <job>engineer</job>
            </emp>';
  xsldoc := '<?xml version="1.0"?>
             <xsl:stylesheet version="1.0"
                             xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
               <xsl:output encoding="utf-8"/>
               <!-- alphabetizes an xml tree -->
               <xsl:template match="*">
                 <xsl:copy>
                   <xsl:apply-templates select="*|text()">
                     <xsl:sort select="name(.)" data-type="text"
                               order="ascending"/>
                   </xsl:apply-templates>
                 </xsl:copy>
               </xsl:template>
               <xsl:template match="text()">
                 <xsl:value-of select="normalize-space(.)"/>
               </xsl:template>
             </xsl:stylesheet>';
  myParser := DBMS_XMLPARSER.newParser;
  DBMS_XMLPARSER.parseBuffer(myParser, indoc);
  indomdoc   := DBMS_XMLPARSER.getDocument(myParser);
  DBMS_XMLPARSER.parseBuffer(myParser, xsldoc);
  xsltdomdoc := DBMS_XMLPARSER.getDocument(myParser);
  xsl        := DBMS_XSLPROCESSOR.newStyleSheet(xsltdomdoc, '');
  proc       := DBMS_XSLPROCESSOR.newProcessor;
  --apply stylesheet to DOM document
  outdomdocf := DBMS_XSLPROCESSOR.processXSL(proc, xsl, indomdoc);
  outnode    := DBMS_XMLDOM.makeNode(outdomdocf);
  -- PL/SQL DOM API for XMLType can be used here
  DBMS_XMLDOM.writeToBuffer(outnode, buf);
  DBMS_OUTPUT.put_line(buf);
  DBMS_XMLDOM.freeDocument(indomdoc);
  DBMS_XMLDOM.freeDocument(xsltdomdoc);
  DBMS_XMLDOM.freeDocFrag(outdomdocf);
  DBMS_XMLPARSER.freeParser(myParser);
  DBMS_XSLPROCESSOR.freeProcessor(proc);
END;
/
```

This produces the following output:

```
<emp>
<empno>1</empno>
<fname>robert</fname>
<job>engineer</job>
<lname>smith</lname>
<sal>1000</sal>
</emp>
```

PL/SQL Translation API for XMLType (DBMS_XMLTRANSLATIONS)

When you store security objects in the Oracle XML DB Repository, you store them as `XMLType` instances. The security objects also contain some strings that need to be translated, so that you can search for or display them in various languages. The translations for these strings are also stored in the Oracle XML DB Repository, along with the original strings, because they must be associated with the original document. You can retrieve and operate on these strings, depending on your language settings.

Oracle XML DB provides translation support through the `DBMS_XMLTRANSLATIONS` package, which provides an interface to perform translations so that strings can be searched or displayed in various languages.

> **See Also:** Chapter 6, "XML Schema Storage and Query: Basic" for an overview of XML translations

DBMS_XMLTRANSLATIONS Methods

The `DBMS_XMLTRANSLATIONS` package provides the following methods:

- `updateTranslation`: Updates the translation in a particular language at the specified `XPATH`. If the translation in that language is not present, then it is inserted.
- `setSourceLang`: Sets the source language to a particular language at the specified `XPATH`.
- `translateXML`: Returns the document in the specified language.
- `getBaseDocument`: Returns the base document with all the translations.
- `extractXLiff`: Extracts the translations in `XLIFF` format from either an `XMLTYPE` instance or a resource in Oracle XML DB Repository.
- `mergeXLiff`: Merges the translations in `XLIFF` format into either an `XMLTYPE` or a resource in Oracle XML DB Repository.
- `disableTranslation`: Disables translations in the current session so that query or retrieval will take place on the base document ignoring session language values.
- `enableTranslation`: Enables translations in the current session.

> **See Also:** *Oracle Database PL/SQL Packages and Type References* for a description of the individual `DBMS_XMLTRANSLATIONS` methods.

13

Package DBMS_XMLSTORE

This chapter introduces you to the PL/SQL package DBMS_XMLSTORE. This package is used to insert, update, and delete data from XML documents in object-relational tables.

This chapter contains these topics:

Overview of PL/SQL Package DBMS_XMLSTORE

The DBMS_XMLSTORE package enables DML operations to be performed on relational tables using XML. It takes a canonical XML mapping similar to that produced by package DBMS_XMLGEN; converts it to object-relational constructs; and inserts, updates or deletes the value from relational tables.

The functionality of the DBMS_XMLSTORE package is similar to that of the DBMS_XMLSAVE package, which is part of the Oracle XML SQL Utility (XSU). There are, however, several key differences:

- DBMS_XMLSTORE is written in C and compiled into the kernel, so it provides higher performance.
- DBMS_XMLSTORE uses SAX to parse the input XML document, so it has higher scalability and lower memory requirements. DBMS_XMLSTORE lets you input XMLType data, in addition to CLOB and VARCHAR.
- PL/SQL functions insertXML, updateXML, and deleteXML, which are also present in package DBMS_XMLSAVE, have been enhanced in package DBMS_XMLSTORE to take XMLType instances in addition to CLOB values and strings. This provides for better integration with Oracle XML DB functionality.

Using Package DBMS_XMLSTORE

To use PL/SQL package DBMS_XMLSTORE, follow these steps:

1. Create a context handle by calling function DBMS_XMLSTORE.**newContext** and supplying it with the table name to use for the DML operations. For case sensitivity, double-quote the string that is passed to the function.

By default, XML documents are expected to identify rows with the <ROW> tag. This is the same default used by package DBMS_XMLGEN when generating XML. This may be overridden by calling function setRowTag.

2. *For Inserts:* You can set the list of columns to insert calling procedure DBMS_XMLSTORE.**setUpdateColumn** for each column. This is highly recommended, since it will improve performance. The default behavior is to insert values for all of the columns whose corresponding elements are present in the XML document.
3. *For Updates:* You must specify one or more (pseudo-) key columns using function DBMS_XMLSTORE.**setKeyColumn**. These are used to specify which *rows* are to be updated. In SQL, you would do that using a WHERE clause in an UPDATE statement, specifying a combination of columns that uniquely identify the rows to be updated. The columns that you use with setKeyColumn need *not* be keys of the table—as long as they uniquely specify a row, they can be used.

   For example, in table employees, column employee_id uniquely identifies rows (it is a key of the table). If the XML document that you use to update the table contains element <EMPLOYEE_ID>2176</EMPLOYEE_ID>, then the rows where employee_id equals 2176 are updated.

   The list of *update* columns can also be specified, using DBMS_XMLSTORE.setUpdateColumn. This is recommended, for better performance. The default behavior is to update *all* of the columns in the row(s) identified by setKeyColumn whose corresponding elements are present in the XML document.
4. *For Deletions:* As for updates, you specify (pseudo-) key columns to identify the row(s) to delete.
5. Provide a document to PL/SQL function insertXML, updateXML, or deleteXML.
6. This last step may be repeated multiple times, with several XML documents.
7. Close the context with function DBMS_XMLSTORE.**closeContext**.

Inserting with DBMS_XMLSTORE

To insert an XML document into a table or view, you supply the table or view name and the document. DBMS_XMLSTORE parses the document and then creates an INSERT statement into which it binds all the values. By default, DBMS_XMLSTORE inserts values into all the columns represented by elements in the XML document.

Example 13–1 Inserting Data with Specified Columns

This example uses DBM_XMLSTORE to insert the information for two new employees into the employees table. The information is provided in the form of XML data.

```
SELECT employee_id AS EMP_ID, salary, hire_date, job_id, email, last_name
  FROM employees WHERE department_id = 30;

EMP_ID     SALARY HIRE_DATE JOB_ID     EMAIL       LAST_NAME
------ ---------- --------- ---------- ----------- ----------
   114      11000 07-DEC-94 PU_MAN     DRAPHEAL     Raphaely
   115       3100 18-MAY-95 PU_CLERK   AKHOO            Khoo
   116       2900 24-DEC-97 PU_CLERK   SBAIDA          Baida
   117       2800 24-JUL-97 PU_CLERK   STOBIAS        Tobias
   118       2600 15-NOV-98 PU_CLERK   GHIMURO        Himuro
   119       2500 10-AUG-99 PU_CLERK   KCOLMENA   Colmenares

6 rows selected.
```

```
DECLARE
  insCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW num="1">
         <EMPLOYEE_ID>920</EMPLOYEE_ID>
         <SALARY>1800</SALARY>
         <DEPARTMENT_ID>30</DEPARTMENT_ID>
         <HIRE_DATE>17-DEC-2002</HIRE_DATE>
         <LAST_NAME>Strauss</LAST_NAME>
         <EMAIL>JSTRAUSS</EMAIL>
         <JOB_ID>ST_CLERK</JOB_ID>
       </ROW>
       <ROW>
         <EMPLOYEE_ID>921</EMPLOYEE_ID>
         <SALARY>2000</SALARY>
         <DEPARTMENT_ID>30</DEPARTMENT_ID>
         <HIRE_DATE>31-DEC-2004</HIRE_DATE>
         <LAST_NAME>Jones</LAST_NAME>
         <EMAIL>EJONES</EMAIL>
         <JOB_ID>ST_CLERK</JOB_ID>
       </ROW>
     </ROWSET>';
BEGIN
  insCtx := DBMS_XMLSTORE.newContext('HR.EMPLOYEES'); -- Get saved context
  DBMS_XMLSTORE.clearUpdateColumnList(insCtx); -- Clear the update settings

  -- Set the columns to be updated as a list of values
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'EMPLOYEE_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'SALARY');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'HIRE_DATE');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'DEPARTMENT_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'JOB_ID');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'EMAIL');
  DBMS_XMLSTORE.setUpdateColumn(insCtx, 'LAST_NAME');

  -- Insert the doc.
  rows := DBMS_XMLSTORE.insertXML(insCtx, xmlDoc);
  DBMS_OUTPUT.put_line(rows || ' rows inserted.');

  -- Close the context
  DBMS_XMLSTORE.closeContext(insCtx);
END;
/

2 rows inserted.

PL/SQL procedure successfully completed.

SELECT employee_id AS EMP_ID, salary, hire_date, job_id, email, last_name
  FROM employees WHERE department_id = 30;

EMP_ID     SALARY HIRE_DATE JOB_ID     EMAIL       LAST_NAME
------ ---------- --------- ---------- ---------- ----------
   114      11000 07-DEC-94 PU_MAN     DRAPHEAL     Raphaely
   115       3100 18-MAY-95 PU_CLERK   AKHOO            Khoo
   116       2900 24-DEC-97 PU_CLERK   SBAIDA          Baida
   117       2800 24-JUL-97 PU_CLERK   STOBIAS        Tobias
```

```
   118       2600 15-NOV-98 PU_CLERK   GHIMURO        Himuro
   119       2500 10-AUG-99 PU_CLERK   KCOLMENA   Colmenares
   920       1800 17-DEC-02 ST_CLERK   STRAUSS       Strauss
   921       2000 31-DEC-04 ST_CLERK   EJONES          Jones

8 rows selected.
```

Updating with DBMS_XMLSTORE

To update (modify) existing data using package `DBMS_XMLSTORE`, you must specify which rows to update. In SQL, you would do that using a `WHERE` clause in an `UPDATE` statement. With `DBMS_XMLSTORE`, you do it by calling procedure `setKeyColumn` once for *each* of the columns that are used collectively to identify the row.

You can think of this set of columns as acting like a set of key columns: *together, they specify a unique row* to be updated. However, the columns that you use (with `setKeyColumn`) need *not* be keys of the table—as long as they uniquely specify a row, they can be used with calls to `setKeyColumn`.

Example 13–2 Updating Data With Key Columns

This example uses `DBM_XMLSTORE` to update information. Assuming that the first name for employee number 188 is incorrectly recorded as Kelly, this example corrects that first name to Pat. Since column `employee_id` is a primary key for table `employees`, a single call to `setKeyColumn` specifying column `employee_id` is sufficient to identify a unique row for updating.

```
SELECT employee_id, first_name FROM employees WHERE employee_id = 188;

EMPLOYEE_ID FIRST_NAME
----------- ----------
        188 Kelly

1 row selected.

DECLARE
  updCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW>
         <EMPLOYEE_ID>188</EMPLOYEE_ID>
         <FIRST_NAME>Pat</FIRST_NAME>
       </ROW>
     </ROWSET>';
BEGIN
   updCtx := DBMS_XMLSTORE.newContext('HR.EMPLOYEES'); -- get the context
   DBMS_XMLSTORE.clearUpdateColumnList(updCtx);        -- clear update settings

   -- Specify that column employee_id is a "key" to identify the row to update.
   DBMS_XMLSTORE.setKeyColumn(updCtx, 'EMPLOYEE_ID');
   rows := DBMS_XMLSTORE.updateXML(updCtx, xmlDoc);    -- update the table
   DBMS_XMLSTORE.closeContext(updCtx);                 -- close the context
END;
/

SELECT employee_id, first_name FROM employees WHERE employee_id = 188;

EMPLOYEE_ID FIRST_NAME
----------- ----------
```

```
       188 Pat

1 row selected.
```

This UPDATE statement is equivalent to the use of DBM_XMLSTORE in this example:

```
UPDATE hr.employees SET first_name = 'Pat' WHERE employee_id = 188;
```

Deleting with DBMS_XMLSTORE

Deletions are treated similarly to updates: you specify the key or pseudo-key columns that identify the rows to delete.

Example 13–3 DBMS_XMLSTORE.DELETEXML Example

```
SELECT employee_id FROM employees WHERE employee_id = 188;

EMPLOYEE_ID
-----------
       188

1 row selected.

DECLARE
  delCtx DBMS_XMLSTORE.ctxType;
  rows NUMBER;
  xmlDoc CLOB :=
    '<ROWSET>
       <ROW>
         <EMPLOYEE_ID>188</EMPLOYEE_ID>
         <DEPARTMENT_ID>50</DEPARTMENT_ID>
       </ROW>
     </ROWSET>';
BEGIN
  delCtx  := DBMS_XMLSTORE.newContext('HR.EMPLOYEES');
  DBMS_XMLSTORE.setKeyColumn(delCtx, 'EMPLOYEE_ID');
  rows := DBMS_XMLSTORE.deleteXML(delCtx, xmlDoc);
  DBMS_XMLSTORE.closeContext(delCtx);
END;
/

SELECT employee_id FROM employees WHERE employee_id = 188;

no rows selected.
```

14

Java DOM API for XMLType

This chapter describes how to use `XMLType` in Java, including fetching `XMLType` data through Java Database Connectivity (JDBC).

This chapter contains these topics:

- Overview of Java DOM API for XMLType
- Java DOM API for XMLType
- Loading a Large XML Document into the Database with JDBC
- Java DOM API for XMLType Features
- Java DOM API for XMLType Classes
- Handling Large Nodes Using Java
- Using the Java DOM API and JDBC With Binary XML

Overview of Java DOM API for XMLType

Oracle XML DB supports the Java Document Object Model (DOM) Application Program Interface (API) for `XMLType`. This is a generic API for client and server, for both XML schema-based and non-schema-based documents. It is implemented using Java package `oracle.xml.parser.v2`. DOM is an in-memory tree-based object representation of XML documents that enables programmatic access to their elements and attributes. The DOM object and interface are part of a W3C recommendation. DOM views the parsed document as a tree of objects.

To access `XMLType` data using JDBC, use the class `oracle.xdb.XMLType`.

For XML documents that do not conform to any XML schema, use the Java DOM API for `XMLType`, because it can handle *any* valid XML document.

See Also: *Oracle Database XML Java API Reference*

Java DOM API for XMLType

Java DOM API for `XMLType` handles all kinds of valid XML documents, irrespective of how they are stored in Oracle XML DB. It presents to the application a uniform view of the XML document, whether it is XML schema-based or non-schema-based and whatever the underlying storage model. Java DOM API works on both client and server.

As discussed in Chapter 12, "PL/SQL APIs for XMLType", the Oracle XML DB DOM APIs are compliant with the W3C DOM Level 1.0 and Level 2.0 Core Recommendation.

The Java DOM API for `XMLType` can be used to construct an `XMLType` instance from data encoded in different character sets. It also provides method `getBLOBVal()` to retrieve the XML contents in the requested character set.

You can use the Java DOM API for `XMLType` to access XML documents stored in Oracle XML DB Repository from Java applications. Naming conforms to the Java binding for DOM as specified by the W3C DOM Recommendation. The repository can contain both XML schema-based and non-schema-based documents.

Using JDBC to Access XMLType Data

This is a SQL-based approach for Java applications to access any data in Oracle Database, including XML documents in Oracle XML DB. Use Java class `oracle.xdb.XMLType`, method `createXML()`.

How Java Applications Use JDBC to Access XML Documents in Oracle XML DB

JDBC users can query an `XMLType` table to obtain a JDBC `XMLType` interface that supports all methods supported by SQL data type `XMLType`. The Java (JDBC) API for `XMLType` interface can implement the DOM document interface.

Example 14–1 XMLType Java: Using JDBC to Query an XMLType Table

The following is an example that illustrates using JDBC to query an `XMLType` table:

```
import oracle.xdb.XMLType;
            ...
   OraclePreparedStatement stmt = (OraclePreparedStatement)
 conn.prepareStatement("select e.poDoc from po_xml_tab e");
       ResultSet rset = stmt.executeQuery();
       OracleResultSet orset = (OracleResultSet) rset;

while(orset.next())
        {
       // get the XMLType
       XMLType poxml = XMLType.createXML(orset.getOPAQUE(1));
       // get the XMLDocument as a string...
Document podoc = (Document)poxml.getDOM();
        }
```

Example 14–2 XMLType Java: Selecting XMLType Data

You can select the `XMLType` data in JDBC in one of two ways:

- Use method `getCLOBVal()`, `getStringVal()` or `getBLOBVal(csid)` in SQL, and obtain the result as an `oracle.sql.CLOB`, `java.lang.String` or `oracle.sql.BLOB` in Java. The following Java code snippet shows how to do this:

```
DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

 Connection conn =
    DriverManager.getConnection("jdbc:oracle:oci8:@", "QUINE", "CURRY");

 OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
          "select e.poDoc.getCLOBVal() poDoc, "+
                  "e.poDoc.getStringVal() poString "+
          " from po_xml_tab e");

ResultSet rset = stmt.executeQuery();
```

```
OracleResultSet orset = (OracleResultSet) rset;

while(orset.next())
        {
// the first argument is a CLOB
oracle.sql.CLOB clb = orset.getCLOB(1);

// the second argument is a string..
String poString = orset.getString(2);

// now use the CLOB inside the program
        }
```

- Call method `getOPAQUE()` in the `PreparedStatement` to obtain the whole `XMLType` instance, and use the `XMLType` constructor to construct an `oracle.xdb.XMLType` class out of it. Then you can use the Java functions on the `XMLType` class to access the data.

```
import oracle.xdb.XMLType;
...

 OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
          "select e.poDoc from po_xml_tab e");

ResultSet rset = stmt.executeQuery();
OracleResultSet orset = (OracleResultSet) rset;

// get the XMLType
XMLType poxml = XMLType.createXML(orset.getOPAQUE(1));

// get the XML as a string...
String poString = poxml.getStringVal();
```

Example 14–3 XMLType Java: Directly Returning XMLType Data

This example shows the use of method `getObject()` to directly get the `XMLType` from the `ResultSet`. This code snippet is the easiest way to get the `XMLType` from the `ResultSet`.

```
import oracle.xdb.XMLType;
...
PreparedStatement stmt =  conn.prepareStatement(
          "select e.poDoc from po_xml_tab e");
ResultSet rset = stmt.executeQuery();
while(rset.next())
{
// get the XMLType
XMLType poxml = (XMLType)rset.getObject(1);

// get the XML as a string...
String poString = poxml.getStringVal();
 }
```

Example 14–4 XMLType Java: Returning XMLType Data

This example illustrates how to bind an `OUT` variable of `XMLType` to a SQL statement. The output parameter is registered as data type `XMLType`.

```
public void doCall (String[] args)
```

```
  throws Exception
  {

//  CREATE OR REPLACE FUNCTION getPurchaseOrder(reference VARCHAR2)
//  RETURN XMLTYPE
//  AS
//    xml XMLTYPE;
//  BEGIN
//    SELECT OBJECT_VALUE INTO xml
//      FROM purchaseorder
//      WHERE extractValue(OBJECT_VALUE,'/PurchaseOrder/Reference') = reference;
//      RETURN xml;
//  END;

    String SQLTEXT = "{? = call getPurchaseOrder('BLAKE-20021009123333601PDT')}";
    CallableStatement sqlStatement = null;
    XMLType xml = null;
    super.doSomething(args);
    createConnection();
    try
    {
      System.out.println("SQL := " + SQLTEXT);
      sqlStatement = getConnection().prepareCall(SQLTEXT);
      sqlStatement.registerOutParameter (1, OracleTypes.OPAQUE,"SYS.XMLTYPE");
      sqlStatement.execute();
      xml = (XMLType) sqlStatement.getObject(1);
      System.out.println(xml.getStringVal());
    }
    catch (SQLException SQLe)
    {
      if (sqlStatement != null)
      {
        sqlStatement.close();
        throw SQLe;
      }
    }
```

Using JDBC to Manipulate XML Documents Stored in a Database

You can also update, insert, and delete `XMLType` data using Java Database Connectivity (JDBC).

> **Note:** `XMLType` methods `extract()`, `transform()`, and `existsNode()` work only with the *thick* JDBC driver.
>
> Not all `oracle.xdb.XMLType` functions are supported by the thin JDBC driver. If you do not use `oracle.xdb.XMLType` classes and the OCI driver, you could lose performance benefits associated with the intelligent handling of XML.

Example 14–5 XMLType Java: Updating, Inserting, or Deleting XMLType Data

You can update, insert, or delete `XMLType` data in two ways:

- Bind a `CLOB` instance or a string to an `INSERT`, `UPDATE`, or `DELETE` statement, and use the `XMLType` constructor inside SQL to construct the XML instance:

```
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
```

```
            "update po_xml_tab set poDoc = XMLType(?) ");

    // the second argument is a string..
    String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";

    // now bind the string..
    stmt.setString(1,poString);
    stmt.execute();
```

- Use `setObject()` or `setOPAQUE()` in the `PreparedStatement` to set the entire `XMLType` instance:

```
import oracle.xdb.XMLType;
...
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
        "update po_xml_tab set poDoc = ? ");

// the second argument is a string
String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";
XMLType poXML = XMLType.createXML(conn, poString);

// now bind the string..
stmt.setObject(1,poXML);
stmt.execute();
```

Example 14–6 XMLType Java: Getting Metadata on XMLType

When selecting `XMLType` values, JDBC describes the column as an `OPAQUE` type. You can select the column type name and compare it with `XMLTYPE` to check if you are dealing with an `XMLType` instance:

```
import oracle.sql.*;
import oracle.jdbc.*;
...
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
        "select poDoc from po_xml_tab");

OracleResultSet rset = (OracleResultSet)stmt.exuecuteQuery();

// Now, we can get the resultset metadata
OracleResultSetMetaData mdata =
        (OracleResultSetMetaData)rset.getMetaData();

// Describe the column = the column type comes out as OPAQUE
// and column type name comes out as XMLTYPE
if (mdata.getColumnType(1) == OracleTypes.OPAQUE &&
    mdata.getColumnTypeName(1).compareTo("SYS.XMLTYPE") == 0)
{
   // we know it is an XMLtype
}
```

Example 14–7 XMLType Java: Updating an Element in an XMLType Column

This example updates the `discount` element inside `PurchaseOrder` stored in an `XMLType` column. It uses Java Database Connectivity (JDBC) and the `oracle.xdb.XMLType` class. This example also shows you how to insert, update, or delete `XMLType`s using Java (JDBC). It uses the parser to update an in-memory DOM tree and write the updated XML value to the column.

```
-- create po_xml_hist table to store old PurchaseOrders
CREATE TABLE po_xml_hist (
 xpo XMLType
);

/*
   DESCRIPTION
    Example for oracle.xdb.XMLType

   NOTES
   Have classes12.zip, xmlparserv2.jar, and xdb.jar in CLASSPATH

*/

import java.sql.*;
import java.io.*;

import oracle.xml.parser.v2.*;
import org.xml.sax.*;
import org.w3c.dom.*;

import oracle.jdbc.driver.*;
import oracle.sql.*;

import oracle.xdb.XMLType;

public class tkxmtpje
{

  static String conStr = "jdbc:oracle:oci8:@";
  static String user = "QUINE";
  static String pass = "CURRY";
  static String qryStr =
        "SELECT x.poDoc from po_xml_tab x "+
        "WHERE  x.poDoc.extract('/PO/PONO/text()').getNumberVal()=200";

 static String updateXML(String xmlTypeStr)
  {
     System.out.println("\n================================");
     System.out.println("xmlType.getStringVal():");
     System.out.println(xmlTypeStr);
     System.out.println("================================");
     String outXML = null;
     try{
        DOMParser parser  = new DOMParser();
        parser.setValidationMode(false);
        parser.setPreserveWhitespace (true);

        parser.parse(new StringReader(xmlTypeStr));
        System.out.println("xmlType.getStringVal(): xml String is well-formed");

        XMLDocument doc = parser.getDocument();

        NodeList nl = doc.getElementsByTagName("DISCOUNT");

        for(int i=0;i<nl.getLength();i++){
           XMLElement discount = (XMLElement)nl.item(i);
           XMLNode textNode = (XMLNode)discount.getFirstChild();
           textNode.setNodeValue("10");
        }
```

```
      StringWriter sw = new StringWriter();
      doc.print(new PrintWriter(sw));

      outXML = sw.toString();

     //print modified xml
      System.out.println("\n==============================");
      System.out.println("Updated PurchaseOrder:");
      System.out.println(outXML);
      System.out.println("==============================");
     }
   catch (Exception e)
   {
     e.printStackTrace(System.out);
   }
   return outXML;
 }

public static void main(String args[]) throws Exception
 {
   try{

       System.out.println("qryStr="+ qryStr);

       DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

       Connection conn =
         DriverManager.getConnection("jdbc:oracle:oci8:@", user, pass);

       Statement s = conn.createStatement();
       OraclePreparedStatement stmt;

       ResultSet rset = s.executeQuery(qryStr);
       OracleResultSet orset = (OracleResultSet) rset;

       while(orset.next()){

       //retrieve PurchaseOrder xml document from database
        XMLType xt = XMLType.createXML(orset.getOPAQUE(1));

        //store this PurchaseOrder in po_xml_hist table
        stmt = (OraclePreparedStatement)conn.prepareStatement(
                  "insert into po_xml_hist values(?)");

        stmt.setObject(1,xt);  // bind the XMLType instance
        stmt.execute();

        //update "DISCOUNT" element
        String newXML = updateXML(xt.getStringVal());

        // create a new instance of an XMLtype from the updated value
        xt = XMLType.createXML(conn,newXML);

       // update PurchaseOrder xml document in database
        stmt = (OraclePreparedStatement)conn.prepareStatement(
          "update po_xml_tab x set x.poDoc =? where "+
            "x.poDoc.extract('/PO/PONO/text()').getNumberVal()=200");

        stmt.setObject(1,xt);  // bind the XMLType instance
```

```
          stmt.execute();

          conn.commit();
          System.out.println("PurchaseOrder 200 Updated!");

         }

        //delete PurchaseOrder 1001
         s.execute("delete from po_xml x"+
            "where x.xpo.extract"+
               "('/PurchaseOrder/PONO/text()').getNumberVal()=1001");
         System.out.println("PurchaseOrder 1001 deleted!");
    }
    catch(Exception e)
    {
      e.printStackTrace(System.out);
    }
  }
}

----------------------
-- list PurchaseOrders
----------------------

SELECT x.xpo.getCLOBVal()
FROM po_xml x;
```

Here is the resulting updated purchase order in XML:

```
<?xml version = "1.0"?>
<PurchaseOrder>
  <PONO>200</PONO>
  <CUSTOMER>
   <CUSTNO>2</CUSTNO>
   <CUSTNAME>John Nike</CUSTNAME>
   <ADDRESS>
    <STREET>323 College Drive</STREET>
    <CITY>Edison</CITY>
    <STATE>NJ</STATE>
    <ZIP>08820</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>609-555-1212</VARCHAR2>
    <VARCHAR2>201-555-1212</VARCHAR2>
   </PHONELIST>
  </CUSTOMER>
  <ORDERDATE>20-APR-97</ORDERDATE>
  <SHIPDATE>20-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1004">
     <PRICE>6750</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>1</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
    <ITEM StockNo="1011">
     <PRICE>4500.23</PRICE>
     <TAXRATE>2</TAXRATE>
```

```
    </ITEM>
    <QUANTITY>2</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR>
   <STREET>55 Madison Ave</STREET>
   <CITY>Madison</CITY>
   <STATE>WI</STATE>
   <ZIP>53715</ZIP>
  </SHIPTOADDR>
</PurchaseOrder>
```

Example 14–8 Manipulating an XMLType Column

This example performs the following:

- Selects an `XMLType` instance from an `XMLType` table
- Extracts portions of the `XMLType` instance, based on an XPath expression
- Checks for the existence of elements
- Transforms the `XMLType` instance to another XML format based on XSL
- Checks the validity of the `XMLType` document against an XML schema

```
import java.sql.*;
import java.io.*;
import java.net.*;
import java.util.*;

import oracle.xml.parser.v2.*;
import oracle.xml.parser.schema.*;
import org.xml.sax.*;
import org.w3c.dom.*;

import oracle.xml.sql.dataset.*;
import oracle.xml.sql.query.*;
import oracle.xml.sql.docgen.*;
import oracle.xml.sql.*;

import oracle.jdbc.driver.*;
import oracle.sql.*;

import oracle.xdb.XMLType;

public class tkxmtpk1
{

  static String conStr = "jdbc:oracle:oci8:@";
  static String user = "tpjc";
  static String pass = "tpjc";
  static String qryStr = "select x.resume from t1 x where id<3";
  static String xslStr =
                "<?xml version='1.0'?> " +
                "<xsl:stylesheet version='1.0' xmlns:xsl='http://www.w3.org/1
999/XSL/Transform'> " +
                "<xsl:template match='ROOT'> " +
                "<xsl:apply-templates/> " +
                "</xsl:template> " +
                "<xsl:template match='NAME'> " +
                "<html> " +
```

```
                "  <body> " +
                "      This is Test " +
                "  </body> " +
                "</html> " +
                "</xsl:template> " +
                "</xsl:stylesheet>";

  static void parseArg(String args[])
  {
    conStr = (args.length >= 1 ? args[0]:conStr);
    user = (args.length >= 2 ? args[1].substring(0, args[1].indexOf("/")):user);
    pass = (args.length >= 2 ? args[1].substring(args[1].indexOf("/")+1):pass);
    qryStr = (args.length >= 3 ? args[2]:qryStr);
  }
  /**
   * Print the byte array contents
   */
  static void showValue(byte[] bytes) throws SQLException
  {
    if (bytes == null)
      System.out.println("null");
    else if (bytes.length == 0)
      System.out.println("empty");
    else
    {
      for(int i=0; i<bytes.length; i++)
        System.out.print((bytes[i]&0xff)+" ");
      System.out.println();
    }
  }

public static void main(String args[]) throws Exception
{
 tkxmjnd1 util = new tkxmjnd1();

 try{

     if(args != null)
         parseArg(args);

     //      System.out.println("conStr=" + conStr);
     System.out.println("user/pass=" + user + "/" +pass );
     System.out.println("qryStr="+ qryStr);

     DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());

     Connection conn = DriverManager.getConnection(conStr, user, pass);
     Statement s = conn.createStatement();

     ResultSet rset = s.executeQuery(qryStr);
     OracleResultSet orset = (OracleResultSet) rset;
     OPAQUE xml;

     while(orset.next()){
      xml = orset.getOPAQUE(1);
      oracle.xdb.XMLType xt = oracle.xdb.XMLType.createXML(xml);

      System.out.println("Testing getDOM() ...");
      Document doc = xt.getDOM();
      util.printDocument(doc);
```

```
 System.out.println("Testing getBytesValue() ...");
 showValue(xt.getBytesValue());

 System.out.println("Testing existsNode() ...");
 try {
   System.out.println("existsNode(/)" + xt.existsNode("/", null));
 }
 catch (SQLException e) {
   System.out.println("Thin driver Expected exception: " + e);
 }

 System.out.println("Testing extract() ...");
 try {
   XMLType xt1 = xt.extract("/RESUME", null);
   System.out.println("extract RESUME: " + xt1.getStringVal());
   System.out.println("should be Fragment: " + xt1.isFragment());
 }
 catch (SQLException e) {
   System.out.println("Thin driver Expected exception: " + e);
 }

 System.out.println("Testing isFragment() ...");
 try {
   System.out.println("isFragment = " + xt.isFragment());       }
     catch (SQLException e)
{
   System.out.println("Thin driver Expected exception: " + e);
 }

System.out.println("Testing isSchemaValid() ...");
 try {
System.out.println("isSchemaValid(): " + xt.isSchemaValid(null,"RES UME"));
 }
 catch (SQLException e) {
   System.out.println("Thin driver Expected exception: " + e);
 }

 System.out.println("Testing transform() ...");
 System.out.println("XSLDOC: \n" + xslStr + "\n");
 try {
 /*  XMLType xslDoc = XMLType.createXML(conn, xslStr);
 System.out.println("XSLDOC Generated");
 System.out.println("After transformation:\n" + (xt.transform(xslDoc,
       null)).getStringVal()); */
 System.out.println("After transformation:\n" + (xt.transform(null,
       null)).getStringVal());
     }
 catch (SQLException e) {
   System.out.println("Thin driver Expected exception: " + e);
 }

 System.out.println("Testing createXML(conn, doc) ...");
 try {
   XMLType xt1 = XMLType.createXML(conn, doc);
   System.out.println(xt1.getStringVal());
 }
catch (SQLException e) {
   System.out.println("Got exception: " + e);
 }
```

```
    }
}
catch(Exception e)
{
  e.printStackTrace(System.out);
}
}
}
```

Loading a Large XML Document into the Database with JDBC

If a large XML document (greater than 4000 characters, typically) is inserted into an `XMLType` table or column using a `String` object in JDBC, this run-time error occurs:

```
"java.sql.SQLException: Data size bigger than max size for this type"
```

This error can be avoided by using a Java `CLOB` object to hold the large XML document. Example 14–9 demonstrates this technique, loading a large document into an `XMLType` column; the same approach can be used for `XMLType` tables. The `CLOB` object is created using class `oracle.sql.CLOB` on the client side. This class is the Oracle JDBC driver implementation of the standard JDBC interface `java.sql.Clob`.

Example 14–9 Loading a Large XML Document

In this example, `XMLType` method `insertXML()` inserts a large XML document into the `purchaseOrder` `XMLType` column of table `poTable`. It uses a `CLOB` object containing the XML document to do this. The `CLOB` object is bound to a JDBC prepared statement, which inserts the data into the `XMLType` column.

Prerequisites for running this example are as follows:

- Oracle Database, version 9.2.0.1 or later.
- `Classes12.zip` or `Classes12.jar`, available in `ORACLE_HOME\jdbc\lib`, should be included in the `CLASSPATH` environment variable.
- The target database table. Execute the following SQL before running the example:

  ```
  CREATE TABLE poTable (purchaseOrder XMLType);
  ```

The formal parameters of `XMLType` method `insertXML()` are as follows:

- *`xmlData`* – XML data to be inserted into the `XMLType` column
- *`conn`* – database connection object (Oracle Connection Object)

```
...
import oracle.sql.CLOB;
import java.sql.Connection;
import java.sql.SQLException;
import java.sql.PreparedStatement;
...

private void insertXML(String xmlData, Connection conn) {
  CLOB clob = null;
  String query;
    // Initialize statement Object
  PreparedStatement pstmt = null;
  try{
    query = "INSERT INTO potable (purchaseOrder) VALUES (XMLType(?)) ";
    // Get the statement Object
    pstmt = conn.prepareStatement(query);
```

```
    // xmlData is the string that contains the XML Data.
    // Get the CLOB object using the getCLOB method.
    clob = getCLOB(xmlData, conn);
    // Bind this CLOB with the prepared Statement
    pstmt.setObject(1, clob);
    // Execute the Prepared Statement
    if (pstmt.executeUpdate () == 1) {
    System.out.println ("Successfully inserted a Purchase Order");
    }
  } catch(SQLException sqlexp){
    sqlexp.printStackTrace();
  } catch(Exception exp){
    exp.printStackTrace();
  }
}
```

Method `insertXML()` calls method `getCLOB()` to create and return the `CLOB` object that holds the XML data. The formal parameters of `getCLOB()` are as follows:

- *`xmlData`* – XML data to be inserted into the `XMLType` column
- *`conn`* – database connection object (Oracle Connection Object)

```
...
import oracle.sql.CLOB;
import java.sql.Connection;
import java.sql.SQLException;
import java.io.Writer;
...

private CLOB getCLOB(String xmlData, Connection conn) throws SQLException{
  CLOB tempClob = null;
  try{
    // If the temporary CLOB has not yet been created, create one
    tempClob = CLOB.createTemporary(conn, true, CLOB.DURATION_SESSION);

    // Open the temporary CLOB in readwrite mode, to enable writing
    tempClob.open(CLOB.MODE_READWRITE);
    // Get the output stream to write
    Writer tempClobWriter = tempClob.getCharacterOutputStream();
    // Write the data into the temporary CLOB
    tempClobWriter.write(xmlData);

    // Flush and close the stream
    tempClobWriter.flush();
    tempClobWriter.close();

    // Close the temporary CLOB
    tempClob.close();
  } catch(SQLException sqlexp){
    tempClob.freeTemporary();
    sqlexp.printStackTrace();
  } catch(Exception exp){
    tempClob.freeTemporary();
    exp.printStackTrace();
  }
  return tempClob;
}
```

See Also: *Oracle Database SecureFiles and Large Objects Developer's Guide*

Java DOM API for XMLType Features

When you use the Java DOM API to retrieve XML data from Oracle XML DB:

- If the connection is *thin*, you get an **XML**`Document` instance
- If the connection is *thick* or *kprb*, you get an **XDB**`Document` instance with method `getDOM()` and an **XML**`Document` instance with method `getDocument()`. Method `getDOM()` and class `XDBDocument` are deprecated.

Both `XMLDocument` and `XDBDocument` (which is deprecated) are instances of the W3C Document Object Model (DOM) interface. From this document interface you can access the document elements and perform all the operations specified in the W3C DOM Recommendation. The DOM works on:

- Any type of XML document, schema-based or non-schema-based
- Any type of underlying storage used by the document:
  - Character Large Object (CLOB)
  - Binary Large Object (BLOB)
  - object-relational

The Java DOM API for `XMLType` supports deep and shallow searching in the document to retrieve children and properties of XML objects such as name, namespace, and so on. Conforming to the DOM 2.0 recommendation, Java DOM API for `XMLType` is namespace aware.

The Java API for `XMLType` also lets applications create XML documents programmatically, even on the fly (dynamically). Such documents can conform to a registered XML schema or not.

Creating XML Schema-Based Documents

To create XML schema-based documents, Java DOM API for `XMLType` uses an extension to specify which XML schema URL to use. For XML schema-based documents, it also verifies that the DOM being created conforms to the specified XML schema, that is, that the appropriate children are being inserted under the appropriate documents.

Note: The Java DOM API for `XMLType` does *not* perform type and constraint checks.

Once the DOM object has been created, it can be saved to Oracle XML DB Repository using the Oracle XML DB resource API for Java. The XML document is stored in the appropriate format:

- As a BLOB instance for non-schema-based documents.
- In the format specified by the XML schema for XML schema-based documents.

Example 14–10 Creating a DOM Object with the Java DOM API

The following example shows how you can use Java DOM API for `XMLType` to create a DOM object and store it in the format specified by the XML schema. Note that the validation against the XML schema is not shown here.

```
import oracle.xdb.XMLType;
...
OraclePreparedStatement stmt =
    (OraclePreparedStatement) conn.prepareStatement(
        "update po_xml_XMLTypetab set poDoc = ? ");

// the second argument is a string
String poString = "<PO><PONO>200</PONO><PNAME>PO_2</PNAME></PO>";
XMLType poXML = XMLType.createXML(conn, poString);
Document poDOM = (Document)poXML.getDOM();

Element rootElem = poDOM.createElement("PO");
poDOM.insertBefore(poDOM, rootElem, null);

// now bind the string..
stmt.setObject(1,poXML);
stmt.execute();
```

JDBC or SQLJ

An `XMLType` instance is represented in Java by `oracle.xdb.XMLType`. When an instance of `XMLType` is fetched using JDBC, it is automatically manifested as an object of the provided `XMLType` class. Similarly, objects of this class can be bound as values to Data Manipulation Language (DML) statements where an `XMLType` is expected. The same action is supported in SQLJ clients.

Java DOM API for XMLType Classes

Oracle XML DB supports the W3C DOM Level 2 Recommendation. In addition to the W3C Recommendation, Oracle XML DB DOM API also provides Oracle-specific extensions, to facilitate your application interfacing with Oracle XDK for Java. A list of the Oracle extensions is found at:

`http://www.oracle.com/technology/tech/xml/`

`XMLDocument` is a class that represents the DOM for the instantiated XML document. You can retrieve the `XMLType` value from the XML document using the constructor `XMLType` constructor that takes a `Document` argument:

```
XMLType createXML(Connection conn, Document domdoc)
```

Table 14–1 lists the Java DOM API for `XMLType` classes and the W3C DOM interfaces they implement. The Java DOM API classes are all in package `oracle.xml.parser.v2`.

Table 14–1 Java DOM API for XMLType: Classes

Java DOM API for XMLType Class	W3C DOM Interface Recommendation Class
`XMLDocument`	`org.w3c.dom.Document`
`XMLCDATA`	`org.w3c.dom.CDataSection`
`XMLComment`	`org.w3c.dom.Comment`
`XMLPI`	`org.w3c.dom.ProcessingInstruction`

Table 14–1 (Cont.) Java DOM API for XMLType: Classes

Java DOM API for XMLType Class	W3C DOM Interface Recommendation Class
XMLText	org.w3c.dom.Text
XMLEntity	org.w3c.dom.Entity
DTD	org.w3c.dom.DocumentType
XMLNotation	org.w3c.dom.Notation
XMLNodeList	org.w3c.dom.NodeList
XMLAttr	org.w3c.dom.Attribute
XMLDomImplementation	org.w3c.dom.DOMImplementation
XMLElement	org.w3c.dom.Element
XMLAttrList	org.w3c.dom.NamedNodeMap
XMLNode	org.w3c.dom.Node

Java Methods That Are Deprecated or Not Supported

The following are methods documented in release 2 (9.2.0.1) but not currently supported:

- XDBDocument.getElementByID
- XDBDocument.importNode
- XDBNode.normalize
- XDBNode.isSupported
- XDBDomImplementation.hasFeature

In addition, in releases prior to Oracle Database 11*g* release 1, a different API, in package oracle.xdb.dom, was used for the Java DOM. Please refer to the documentation for such releases for more information on that deprecated API. The following classes in oracle.xdb.dom have been *deprecated*; use the oracle.xml.parser.v2 classes instead.

- XDBAttribute – use XMLAttr
- XDBBinaryDocument
- XDBCData – use XMLCDATA
- XDBComment – use XMLComment
- XDBDocFragment – use XMLDocumentFragment
- XDBDocument – use XMLDocument
- XDBDocumentType – use DTD
- XDBDOMException – use XMLDomException
- XDBDomImplementation – use XMLDomImplementation
- XDBElement – use XMLElement
- XDBEntity – use XMLEntity
- XDBEntityReference – use XMLEntityReference
- XDBNamedNodeMap – use XMLAttrList
- XDBNode – use XMLNode

- XDBNodeList – use XMLNodeList
- XDBNotation – use XMLNotation
- XDBProcInst – use XMLPI
- XDBText – use XMLText

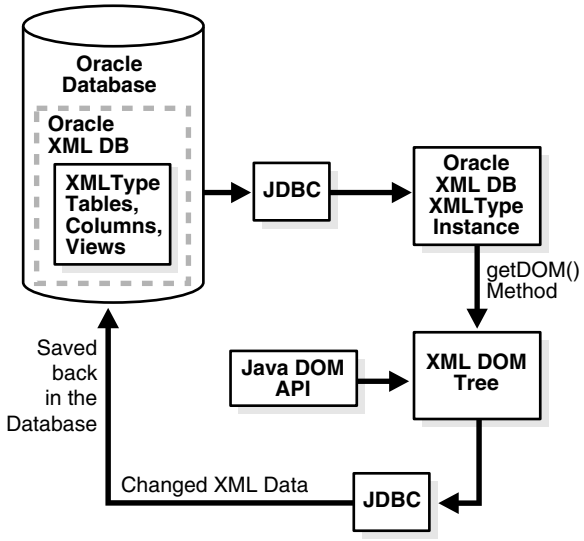
Using Java DOM API for XMLType

Figure 14–1 illustrates how to use the Java DOM API for XMLType.[1] These are the steps:

1. Retrieve the XML data from the XMLType table or XMLType column in the table. When you fetch XML data, Oracle creates an instance of an XMLType. You can then use method getDocument() to retrieve a Document instance. You can then manipulate elements in the DOM tree using Java DOM API for XMLType.
2. Use the Java DOM API for XMLType to manipulate elements of the DOM tree. The XMLType instance holds the modified data, but the data is sent back using a JDBC update.

The XMLType and XMLDocument instances should be closed using method close() in the respective classes. This releases any underlying memory that is held.

Figure 14–1 Using Java DOM API for XMLType



Handling Large Nodes Using Java

Prior to Oracle Database 11*g* release 1, there were restrictions on the size of nodes to less than 64 KB, because the Java methods to set and get a node value supported only arguments of type java.lang.String. The maximum size of a string is dependent on the implementation of the Java VM, but it is bounded. Prior to release 11.1, the Java DOM APIs to manage a node value, contained within class oracle.xdb.dom.XDBNode.java, were these:

```
public String getNodeValue ();
public void setNodeValue (String value);
```

[1] This assumes that your XML data is pre-registered with an XML schema, and that it is stored in an XMLType column.

The Java DOM APIs to manage an attribute, contained within class `oracle.xdb.dom.XDBAttribute.java`, were these:

```
public String getValue ();
public void setValue (String value);
```

Package `oracle.xdb.dom` is deprecated, starting with Oracle Database 11*g* release 1. Java classes `XDBNode` and `XDBAttribute` in that package are replaced by classes `XMLNode` and `XMLAttr`, respectively, in package `oracle.xml.parser.v2`. In addition, these DOM APIs were extended in release 11.1 to support text and binary node values of arbitrary size.

Note: The large-node feature works only with a thick or kprb connection; it does not work with a thin connection.

See Also:

- "Large Node Handling Using DBMS_XMLDOM" on page 12-12 for information on using PL/SQL with large nodes
- "Java Methods That Are Deprecated or Not Supported" on page 14-16 for more about deprecated classes `XDBNode` and `XDBAttribute`

Stream Extensions to Java DOM

All `Java String`, `Reader`, and `Writer` data are represented in `UCS2`. This may not be the same as the database character set. Additionally, node character data is tagged with a character set id, set at the time the node value is populated.

The following methods of `oracle.xml.parser.v2.XMLNode.java` allow access to nodes of size greater than 64 KB. These APIs will throw exceptions if you try to get or set a node which is not a leaf node (attribute, `PI`, `CDATA`, and so on). Also, be sure to use `close()` which actually writes the value and frees resources used to maintain the state for streaming access to nodes.

Get-Pull Model

For a binary input stream:

```
public java.io.InputStream getNodeValueAsBinaryStream ()
       throws java.io.IOException, DOMException;
```

This method returns an instance of `java.io.InputStream` that can be read using the defined methods for this class. The data type of the node must be `RAW` or `BLOB`. If not, an `IOException` is thrown. The following example fragment illustrates reading the value of a node in binary 50-byte segments:

```
...
oracle.xml.parser.v2.XMLNode node = null;
...

java.io.InputStream value = node.getNodeValueAsBinaryStream ();
// now read InputStream...
byte buffer [] = new byte [50];
int returnValue = 0;
while ((returnValue = value.read (buffer)) != -1)
{
```

```
   // process next 50 bytes of node
}
...
```

For a character input stream:

```
public java.io.Reader getNodeValueAsCharacterStream()
       throws java.io.IOException, DOMException;
```

This method returns an instance of `java.io.Reader` that can be read using the defined methods for this class. If the data type of the node is neither character nor `CLOB`, the node data is first converted to character. All node data is ultimately in character format and is converted to `UCS2`, if necessary. The following example fragment illustrates reading the node value in segments of 50 characters:

```
...
oracle.xml.parser.v2.XMLNode node = null;
...

java.io.Reader value = node.getNodeValueAsCharacterStream ();
// now read InputStream
char buffer [] = new char [50];
int returnValue = 0;
while ((returnValue = value.read (buffer)) != -1)
{
   // process next 50 characters of node
}
...
```

Get-Push Model

For a binary output stream:

```
public void getNodeValueAsBinaryStream (java.io.OutputStream pushValue)
       throws java.io.IOException,  DOMException;
```

The state of the `java.io.OutputStream` specified by `pushValue` must be open. The data type of the node must be `RAW` or `BLOB`. If not, an `IOException` is thrown. The node binary data is written to `pushValue` using the `write()` method of `OutputStream`, and the `close()` method is called when the node value has been completely written to the stream.

For a character output stream:

```
public void getNodeValueAsCharacterStream (java.io.Writer pushValue)
       throws java.io.IOException, DOMException;
```

The state of the `java.io.Writer` specified by `pushValue` must be open. If the data type of the node is neither character nor `CLOB`, then the data is first converted to character. The node data, always in character format, is converted, as necessary, to `UCS2` and then pushed into the `java.io.Writer`.

Set-Pull Model

For a binary input stream:

```
public void setNodeValueAsBinaryStream (java.io.InputStream pullValue)
       throws java.io.IOException, DOMException;
```

The state of the `java.io.InputStream` specified by `pullValue` must be open. The data type of the node must be `RAW` or `BLOB`. If not, an `IOException` is thrown. The

binary data from pullValue is read in its entirety using the read() method of InputStream and replaces the node value.

```
import java.io.InputStream;
import oracle.xml.parser.*;
...
oracle.xml.parser.v2.XMLNode node = null;
...
byte [] buffer = new byte [500];
java.io.InputStream  istream; //user-defined input stream
node.setNodeValueAsBinaryStream (istream);
```

For a character input stream:

```
public void setNodeValueAsCharacterStream (java.io.Reader pullValue)
       throws java.io.IOException, DOMException;
```

The state of the java.io.Reader specified by pullValue must be open. If the data type of the node is neither character nor CLOB, the character data is converted from UCS2 to the node data type. If the data type of the node is character or CLOB, then the character data read from pullValue is converted from UCS2 to the character set of the node.

Set-Push Model

For a binary output stream:

```
public java.io.OutputStream setNodeValueAsBinaryStream ()
     throws java.io.IOException, DOMException;
```

This method returns an instance of java.io.OutputStream, into which the caller can write the node value. The data type of the node must be RAW or BLOB. Otherwise, an IOException is raised. The following example fragment illustrates setting the value of a node to binary data by writing to the implementation of java.io.OutputStream provided by Oracle XML DB or Oracle XDK.

For a character output stream:

```
public java.io.Writer setNodeValueAsCharacterStream ()
       throws java.io.IOException, DOMException;
```

This method returns an instance of java.io.Writer into which the caller can write the node value. The character data written is first converted from UCS2 to the node character set, if necessary. If the data type of the node is neither character nor CLOB, then the character data is converted to the node data type. Similarly, the following example fragment illustrates setting the value of a node to character data by writing to the implementation of java.io.Writer provided by Oracle XML DB or Oracle XDK.

```
import java.io.Writer;
import oracle.xml.parser.*;
...
oracle.xml.parser.v2.XMLNode node = null;
...
char [] buffer = new char [500];
java.io.Writer  writer = node.setNodeValueAsCharacterStream ();
for (int k = 0; k < 10; k++)
  {
    byte segment [] = new byte [50];
    // copy next subset of buffer into segment
    writer.write (segment);
```

```
  }
writer.flush ();
writer.close();
```

See Also:

- *Oracle Database XML Java API Reference*
- *Oracle Database XML C API Reference* for information about C functions for large nodes

Oracle XML DB creates a `writer` or `OutputStream` and passes it to the user who calls the `write()` method repeatedly until the complete node value has been written. The new node value is reflected only when the user calls the `close()` method.

Using the Java DOM API and JDBC With Binary XML

XML data can be stored in Oracle XML DB using `XMLType`, and one of the storage models for this abstract data type is binary XML. Binary XML is a compact, XML Schema-aware encoding of XML data. You can use it as a storage model for `XMLType` in the database, but you can also use it for XML data located outside the database. Client-side processing of XML data can involve data stored in Oracle XML DB or transient data that resides outside the database.

You can use the Java DOM API for XML to read or write XML data that is encoded as binary XML from or to Oracle XML DB. Doing so involves the usual read and write procedures.

Binary XML is XML Schema-aware and can use various encoding schemes, depending on your needs and your data. Because of this, in order to manipulate binary XML data, you must have both the data and this metadata about the relevant XML schemas and encodings.

For `XMLType` data stored in the database, this metadata is also stored in the database. However, depending on how your database and data are set up, the metadata might not be on the same server as the data it applies to. If this is the case, then, before you can read or write binary XML data from or to the database, you must carry out these steps:

1. Create a context instance for the metadata.
2. Associate this context with a data connection that you use to access binary XML data in the database. A data connection can be a dedicated connection or a connection pool. You use methods `getDedicatedConn()` and `getConnPool()` in class `java.sql.Connection` to obtain handles to these two types of connection, respectively.

Then, when your application needs to encode or decode binary XML data on the data connection, it will automatically the fetch the metadata needed to do that. The overall sequence of actions is thus as follows:

1. Create an XML data connection object, in class `java.sql.Connection`.
2. Create one or more metadata contexts, as needed, using method `BinXMLMetadataProviderFactory.createDBMetadataProvider()` in package `oracle.xml.binxml`. A metadata context is sometimes referred to as a metadata repository. You can create a metadata context from a dedicated connection or from a connection pool.

3. Associate the metadata context(s) with the binary XML data connection(s). Use method `DBBinXMLMetadataProvider.associateDataConnection()` in package `oracle.xml.binxml` to do this.
4. (Optional) If the XML data originated outside of the database, use method `oracle.xdb.XMLType.setFormatPref()` to specify that XML data to be sent to the database from now on will be in binary XML format. This applies to a DOM document (class `oracle.xdb.XMLType`). If you do not specify binary XML, the data will be stored as text (`CLOB`).
5. Use the usual Java methods to read and write XML data from and to the database. Whenever it is needed for encoding or decoding binary XML documents, the necessary metadata is fetched automatically using the metadata context.

   Use the Java DOM API for XML to operate on the XML data at the client level.

Example 14–11 illustrates this.

Example 14–11 Using the Java DOM API With Binary XML

```
import java.sql.*;
import oracle.jdbc.*;
import oracle.jdbc.pool.OracleDataSource;
import oracle.xdb.XMLType;
import oracle.xml.binxml.*;

class tdadxdbxdb11jav001 {
  public static void printBinXML() throws SQLException, BinXMLException
  {
    // Create datasource to connect to local database
    OracleDataSource ods = new OracleDataSource();
    ods.setURL("jdbc:oracle:kprb");
    System.out.println("Starting Binary XML Java Example");
    // Create data connection
    Connection conn = ods.getConnection();
    // Create binary XML metadata context, using connection pool
    DBBinXMLMetadataProvider repos =
      BinXMLMetadataProviderFactory.createDBMetadataProvider();
    repos.setConnectionPool(ods);
    // Associate metadata context with data connection
    repos.associateDataConnection(conn);
    // Query XML data stored in XMLType column as binary XML
    Statement stmt = conn.createStatement();
    ResultSet rset = stmt.executeQuery("SELECT doc FROM po_binxmltab");
    // Get the XMLType object
    while (rset.next())
    {
      XMLType xmlobj = (XMLType) rset.getObject(1);
      // Perform XMLType operation
      String xmlvalue = xmlobj.getStringVal();
      System.out.println(xmlvalue);
    }
    // Close result set, statement, and connection
    rset.close();
    stmt.close();
    conn.close();
    System.out.println("Completed Binary XML Java Example");
  }
}
```

See Also:

- "XMLType Storage Models" on page 1-15
- *Oracle XML Developer's Kit Programmer's Guide*

15

Using the C API for XML

This chapter provides a guideline for using the C API for XML with Oracle XML DB.

This chapter contains these topics:

- Overview of the C API for XML (Oracle XDK and Oracle XML DB)
- Using OCI and the C API for XML with Oracle XML DB
- XML Context Parameter for C DOM API Functions
- Initializing and Terminating an XML Context
- Using the C API for XML With Binary XML
- Using the Oracle XDK Pull Parser With Oracle XML DB
- Common XMLType Operations in C

Overview of the C API for XML (Oracle XDK and Oracle XML DB)

The C API for XML is used for both Oracle XDK (Oracle XML Developer's Kit) and Oracle XML DB. It is a C-based DOM[1] API for XML. It can be used for XML data that is inside or outside the database. This API also includes performance-improving extensions that you can use in Oracle XDK, for traditional XML storage, or in Oracle XML DB, for XML stored as an `XMLType` column in a table.

> **Note:** C DOM functions from releases prior to Oracle Database 10*g* Release 1 are supported only for backward compatibility; they will not be enhanced.

The C API for XML is implemented on `XMLType` in Oracle XML DB. In the W3C DOM Recommendation, the term "document" is used in a broad sense (URI, file system, memory buffer, standard input and output).

The C API for XML is a combined programming interface that includes all of the functionality needed by Oracle XDK and Oracle XML DB applications. It provides XSLT and XML Schema implementations. Although the DOM 2.0 Recommendation was followed closely, some naming changes were required for mapping from the objected-oriented DOM 2.0 Recommendation to the flat C namespace. For example, the method `getName()` was renamed to `getAttrName()`.

[1] DOM refers to compliance with the World Wide Web Consortium (W3C) DOM 2.0 Recommendation.

The C API for XML supersedes older Oracle APIs. In particular, the `oraxml` interface (top-level, DOM, SAX, and XSLT) and `oraxsd.h` (Schema) interfaces will be deprecated in a future release.

Using OCI and the C API for XML with Oracle XML DB

OCI applications typically operate on XML data stored in the server or created on the client. This section explains these two access methods in more detail.

Accessing XMLType Data Stored in the Database

Oracle XML DB provides support for storing and manipulating XML instances using abstract data type `XMLType`. These XML instances can be accessed and manipulated on the client side using the Oracle Call Interface (OCI) in conjunction with the C DOM API for XML. You can bind and define `XMLType` values using the C DOM structure `xmldocnode`. This structure can be used for binding, defining and operating on XML values in OCI statements. You can use OCI statements to select XML data from the server, which you can then use with C DOM API functions. Similarly, values can be bound back to SQL statements directly.

The main flow for an application program involves initializing the usual OCI handles, such as server handle and statement handle, and then initializing an XML context parameter. You can then either operate on XML instances in the database or create new instances on the client side. The initialized XML context can be used with all of the C DOM functions.

> **See Also:** "XML Context Parameter for C DOM API Functions" on page 15-2

Creating XMLType Instances on the Client

You can construct new `XMLType` instances on the client side using `XmlLoadDom()`, as follows:

1. Initialize the `xmlctx` as in Example 15–1.
2. Construct the XML data from a user buffer, local file, or URI. The return value, a (`xmldocnode*`), can be used in the rest of the common C API.
3. If required, you can cast (`xmldocnode *`) to (`void*`) and provide it directly as the bind value.

You can construct empty `XMLType` instances with `XMLCreateDocument()`. This is similar to using `OCIObjectNew()` for other types.

XML Context Parameter for C DOM API Functions

An *XML context* is a required parameter to all the C DOM API functions. This opaque context encapsulates information about the data encoding, the error message language, and so on. The contents of the context are different for Oracle XDK applications and Oracle XML DB. For Oracle XML DB, there are two OCI functions that initialize (`OCIXmlDbInitXmlCtx()`) and terminate (`OCIXmlDbFreeXmlCtx()`) an XML context.

OCIXmlDbInitXmlCtx() Syntax

The syntax of function `OCIXmlDbInitXmlCtx()` is as follows:

```
xmlctx *OCIXmlDbInitXMlCtx (OCIEnv        *envhp,
                            OCISvcHp      *svchp,
                            OCIError      *errhp,
                            ocixmldbparam *params,
                            ub4           num_params );
```

Table 15–1 describes the parameters.

Table 15–1 OCIXmlDbInitXMlCtx() Parameters

Parameter	Description
`envhp (IN)`	The OCI environment handle.
`svchp (IN)`	The OCI service handle.
`errhp (IN)`	The OCI error handle.
`params (IN)`	An array of optional values: ▪ OCI duration. Default value is `OCI_DURATION_SESSION`. ▪ Error handler, which is a user-registered callback: `void (*err_handler) (sword errcode, (CONST OraText *) errmsg);`
`num_params (IN)`	Number of parameters to be read from `params`.

OCIXmlDbFreeXmlCtx() Syntax

The syntax of function `OCIXmlDbFreeXmlCtx()` is as follows, where parameter `xctx (IN)` is the XML context to terminate.:

```
void OCIXmlDbFreeXmlCtx (xmlctx *xctx);
```

Initializing and Terminating an XML Context

Example 15–1 shows a C program that uses the C DOM API to construct an XML document and save it to Oracle Database in table `my_table`. It calls OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context. These OCI functions are defined in header file `ocixmldb.h`.

The C code in Example 15–1 assumes that the following SQL code has first been executed to create table `my_table` in database schema:

```
CONNECT CAPIUSER/CAPIUSER

CREATE TABLE my_table OF XMLType;
```

Example 15–4 queries table `my_table` to show the data that was inserted by Example 15–1.

Example 15–1 Using OCIXmlDbInitXmlCtx() and OCIXmlDbFreeXmlCtx()

This example shows how to use OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context. It constructs an XML document using the C DOM API and saves it to the database. The code uses helper functions `exec_bind_xml`, `init_oci_handles`, and `free_oci_handles`, which are not listed here. The complete listing of this example, including the helper functions, can be found in Appendix A, "Oracle-Supplied XML Schemas and Examples", "Initializing and Terminating an XML Context (OCI)" on page A-43.

```
#ifndef S_ORACLE
```

```
#include <s.h>
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>

typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
STATICF sword exec_bind_xml(OCISvcCtx *svchp,
                    OCIError *errhp,
                    OCIStmt *stmthp,
                    void *xml,
                    OCIType *xmltdo,
                    OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
STATICF sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
STATICF sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;

  oratext ins_stmt[] = "insert into my_table values (:1)";
  oratext tlpxml_test_sch[] = "<TOP/>";
  ctx->username = (oratext *)"CAPIUSER";
  ctx->password = (oratext *)"CAPIUSER";

  /* Initialize envhp, svchp, errhp, dur, stmthp */
```

```
init_oci_handles(ctx);

/* Get an xml context */
params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
params[0].value_ocixmldbparam = &ctx->dur;
xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

/* Start processing - first, check that this DOM supports XML 1.0 */
printf("\n\nSupports XML 1.0? : %s\n",
       XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
       "YES" : "NO");

/* Parse a document */
if (!(doc = XmlLoadDom(xctx, &err, "buffer", tlpxml_test_sch,
                       "buffer_length", sizeof(tlpxml_test_sch)-1,
                       "validate", TRUE, NULL)))
{
  printf("Parse failed, code %d\n", err);
}
else
{
  /* Get the document element */
  top = (xmlnode *)XmlDomGetDocElem(xctx, doc);

  /* Print out the top element */
  printf("\n\nOriginal top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document-note that the changes are reflected here */
  printf("\n\nOriginal document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Create some elements and add them to the document */
  quux = (xmlnode *) XmlDomCreateElem(xctx ,doc, (oratext *) "QUUX");
  foo = (xmlnode *) XmlDomCreateElem(xctx, doc, (oratext *) "FOO");
  foo_data = (xmlnode *) XmlDomCreateText(xctx, doc, (oratext *) "data");
  foo_data = XmlDomAppendChild(xctx, (xmlnode *) foo, (xmlnode *) foo_data);
  foo = XmlDomAppendChild(xctx, quux, foo);
  quux = XmlDomAppendChild(xctx, top, quux);

  /* Print out the top element */
  printf("\n\nNow the top element is :\n");
  XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

  /* Print out the document. Note that the changes are reflected here */
  printf("\n\nNow the document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

  /* Insert the document into my_table */
  status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp,
                         (const text *) "SYS", (ub4) strlen((char *)"SYS"),
                         (const text *) "XMLTYPE",
                         (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  if (status == OCI_SUCCESS)
  {
    exec_bind_xml(ctx->svchp, ctx->errhp, ctx->stmthp, (void *)doc, xmltdo,
                  ins_stmt);
  }
```

```
  }
  /* Free xml ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}
```

The output from compiling and running this C program is as follows:

```
Supports XML 1.0? : YES

Original top element is :
<TOP/>

Original document is :
<TOP/>

Now the top element is :
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>

Now the document is :
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>
```

This is the result of querying the constructed document in `my_table`:

```
SELECT * FROM my_table;

SYS_NC_ROWINFO$
---------------
<TOP>
  <QUUX>
    <FOO>data</FOO>
  </QUUX>
</TOP>

1 row selected.
```

Using the C API for XML With Binary XML

XML data can be stored in Oracle XML DB using `XMLType`, and one of the storage models for this abstract data type is binary XML. Binary XML is a compact, XML Schema-aware encoding of XML data. You can use it as a storage model for `XMLType` in the database, but you can also use it for XML data located outside the database. As explained in "Using OCI and the C API for XML with Oracle XML DB" on page 15-2, client-side processing of XML data can involve data stored in Oracle XML DB or transient data that resides outside the database.

You can use the C API for XML to read or write XML data that is encoded as binary XML from or to Oracle XML DB. Doing so involves the usual read and write procedures.

Binary XML is XML Schema-aware and can use various encoding schemes, depending on your needs and your data. Because of this, in order to manipulate binary XML data, you must have both the data and this metadata about the relevant XML schemas and encodings.

For `XMLType` data stored in the database, this metadata is also stored in the database. However, depending on how your database and data are set up, the metadata might not be on the same server as the data it applies to. If this is the case, then, before you can read or write binary XML data from or to the database, you must carry out these steps:

1. Create a context instance for the metadata.
2. Associate this context with a data connection that you use to access binary XML data in the database. A data connection can be a dedicated connection (`OCISvcCtx`) or a connection pool (`OCICPool`).

Then, when your application needs to encode or decode binary XML data on the data connection, it will automatically fetch the metadata needed to do that. The overall sequence of actions is thus as follows:

1. Create the usual OCI handles for environment (`OCIEnv`), connection (`OCISvcCtx`), and error context (`OCIError`).
2. Create one or more metadata contexts, as needed. A metadata context is sometimes referred to as a metadata repository, and `OCIBinXMLReposCtx` is the OCI context data structure.

   You use `OCIBinXMLCreateReposCtxFromConn` to create a metadata context from a dedicated connection and `OCIBinXMLCreateReposCtxFromCPool` to create a context from a connection pool.
3. Associate the metadata context(s) with the binary XML data connection(s). You use `OCIBinXmlSetReposCtxForConn` to do this.
4. (Optional) If the XML data originated outside of the database, use `setPicklePreference` to specify that XML data to be sent to the database from now on will be in binary XML format. This applies to a DOM document (`xmldomdoc`). If you do not specify binary XML, the data will be stored as text (`CLOB`).
5. Use OCI libraries to read and write XML data from and to the database. Whenever it is needed for encoding or decoding binary XML documents, the necessary metadata is fetched automatically using the metadata context.

   Use the C DOM API for XML to operate on the XML data at the client level.

Example 15–2 illustrates this.

Example 15–2 Using the C API for XML With Binary XML

```
. . .
/* Private types and constants */
#define SCHEMA        (OraText *)"SYS"
#define TYPE          (OraText *)"XMLTYPE"
#define USER          (OraText *)"oe"
#define USER_LEN      (ub2)(strlen((char *)USER))
#define PWD           (OraText *)"oe"
#define PWD_LEN       (ub2)(strlen((char *)PWD))
#define NUM_PARAMS    1
STATICF void checkerr(OCIError *errhp, sword status);
STATICF sword create_env(OraText *user, ub2 user_len, OraText *pwd, ub2 pwd_len,
                         OCIEnv **envhp, OCISvcCtx **svchp, OCIError **errhp);
```

```
STATICF sword run_example(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp,
                          OCIDuration dur);
STATICF void cleanup(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp);

int main (int argc, char *argv[])
{
  OCIEnv     *envhp;
  OCISvcCtx  *svchp;
  OCIError   *errhp;
  printf("*** Starting Binary XML Example program\n");
  if (create_env(USER, USER_LEN, PWD, PWD_LEN, &envhp, &svchp, &errhp))
    {
      printf("FAILED: create_env()\n");
      cleanup(envhp, svchp, errhp);
      return OCI_ERROR;
    }
  if (run_example(envhp, svchp, errhp, OCI_DURATION_SESSION))
    {
      printf("FAILED: run_example()\n");
      cleanup(envhp, svchp, errhp);
      return OCI_ERROR;
    }
  cleanup(envhp, svchp, errhp);
  printf ("*** Completed Binary XML example\n");
  return OCI_SUCCESS;
}

STATICF sword create_env(OraText *user, ub2 user_len,
                         OraText *pwd,  ub2 pwd_len,
                         OCIEnv **envhp, OCISvcCtx **svchp, OCIError **errhp)
{
  sword       status;
  OCIServer  *srvhp;
  OCISession *usrp;
  OCICPool   *poolhp;
  OraText    *poolname;
  ub4         poolnamelen;
  OraText    *database =(OraText *)"";
  OCIBinXmlReposCtx *rctx;
  /* Create and initialize environment. Allocate error handle. */
  . . .
  if ((status = OCIConnectionPoolCreate((dvoid *)*envhp, (dvoid*)*errhp,
                                        (dvoid *)poolhp, &poolname,
                                        (sb4 *)&poolnamelen,
                                        (OraText *)0,
                                        (sb4) 0, 1, 10, 1,
                                        (OraText *)USER,
                                        (sb4) USER_LEN,
                                        (OraText *)PWD,
                                        (sb4) PWD_LEN,
                                        OCI_DEFAULT)) != OCI_SUCCESS)
    {
      printf ("OCIConnectionPoolCreate - Fail %d\n", status);
      return OCI_ERROR;
    }
  status = OCILogon2((OCIEnv *)*envhp, *errhp, svchp, (OraText *)USER,
                     (ub4)USER_LEN, (const oratext *)PWD, (ub4)PWD_LEN,
                     (const oratext *)poolname, poolnamelen, OCI_CPOOL);
  if (status)
    {
```

```
      printf ("OCILogon2 - Fail %d\n", status);
      return OCI_ERROR;
    }
  OCIBinXmlCreateReposCtxFromCPool(*envhp, poolhp, *errhp, &rctx);
  OCIBinXmlSetReposCtxForConn(*svchp, rctx);
  return OCI_SUCCESS;
}

STATICF sword run_example(OCIEnv *envhp, OCISvcCtx *svchp, OCIError *errhp,
                          OCIDuration dur)
{
  OCIType   *xmltdo = (OCIType *)0;
  OCIStmt   *stmthp;
  OCIDefine *defnp;
  xmldocnode *xmldoc = (xmldocnode *)0;
  ub4        xmlsize = 0;
  text      *selstmt = (text *)"SELECT doc FROM po_binxmltab";
  sword      status;
  struct xmlctx *xctx = (xmlctx *) 0;
  ocixmldbparam params[NUM_PARAMS];
  xmlerr xerr = (xmlerr) 0;
  /* Obtain type definition for XMLType. Allocate statement handle.
     Prepare SELECT statement. Define variable for XMLType. Execute statement. */
  . . .
  /* Construct xmlctx for using XML C API */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, NUM_PARAMS);
  /* Print result to local string */
  XmlSaveDom(xctx, &xerr, (xmlnode *)xmldoc, "stdio", stdout, NULL);
  /* Free instances */
  . . .
}
```

See Also:

- "XMLType Storage Models" on page 1-15
- *Oracle XML Developer's Kit Programmer's Guide*

Using the Oracle XDK Pull Parser With Oracle XML DB

You can use the Oracle XDK pull parser with `XMLType` instances in Oracle XML DB. When you use this parser, your application drives the parsing process; that is, parsing is done on demand. Your application accesses an XML document through a sequence of events, with start tags, end tags, and comments, just as in SAX parsing. However, unlike the case of SAX parsing, where parsing events are handled by callbacks, in pull parsing your application calls methods to ask for (pull) events only when it needs them. This gives the application more control over XML processing. In particular, filtering is more flexible with the pull parser than with the SAX parser.

You can also use the Oracle XDK pull parser to perform stream-based XML Schema validation.

Example 15–3 shows how to use the Oracle XML DB pull parser with an `XMLType` instance. To use the pull parser, you will also need static library `libxml10.a` on Unix and Linux systems or `oraxml10.dll` on Microsoft Windows systems. You will also need header file `xmlev.h`.

See Also:

- *Oracle XML Developer's Kit Programmer's Guide* for information about the Oracle XDK pull parser
- *Oracle XML Developer's Kit Programmer's Guide* for information on using the pull parser for stream-based validation

Example 15–3 Using the Oracle XML DB Pull Parser

```
#define MAXBUFLEN 64*1024
void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  ocixmldbparam params[1];
  sword status = 0;
  xmlctx *xctx;
  OCIDefine *defnp = (OCIDefine *) 0;
  oratext sel_stmt[] = "SELECT x.getClobVal() FROM PURCHASEORDER x where rownum = 1";
  OCILobLocator *clob;
  ub4 amtp, nbytes;
  ub1 bufp[MAXBUFLEN];
  ctx->username = (oratext *)"OE";
  ctx->password = (oratext *)"OE";

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_handles(ctx);

  /* Get an xml context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &ctx->dur;
  xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

  /* Start processing */
  printf("\n\nSupports XML 1.0? : %s\n",
         XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
         "YES" : "NO");

  /* Allocate the lob descriptor */
  status = OCIDescriptorAlloc((dvoid *) ctx->envhp, (dvoid **) &clob,
                      (ub4)OCI_DTYPE_LOB, (size_t) 0, (dvoid **) 0);
  if (status)
  {
    printf("OCIDescriptorAlloc Failed\n");
    goto error;
  }
  status = OCIStmtPrepare(ctx->stmthp, ctx->errhp,
                (CONST OraText *)sel_stmt, (ub4) strlen((char *)sel_stmt),
                (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT);
  if (status)
  {
    printf("OCIStmtPrepare Failed\n");
    goto error;
  }
  status = OCIDefineByPos(ctx->stmthp, &defnp, ctx->errhp, (ub4) 1,
                (dvoid *) &clob, (sb4) -1, (ub2 ) SQLT_CLOB,
                (dvoid *) 0, (ub2 *)0,
                (ub2 *)0, (ub4) OCI_DEFAULT);
  if (status)
```

```
  {
    printf("OCIDefineByPos Failed\n");
    goto error;
  }
  status = OCIStmtExecute(ctx->svchp, ctx->stmthp, ctx->errhp, (ub4) 1,
                          (ub4) 0, (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                          (ub4) OCI_DEFAULT);
  if (status)
  {
    printf("OCIStmtExecute Failed\n");
    goto error;
  }
  /* read the fetched value into a buffer */
  amtp = nbytes = MAXBUFLEN-1;
  status = OCILobRead(ctx->svchp, ctx->errhp, clob, &amtp,
                (ub4) 1, (dvoid *) bufp, (ub4) nbytes, (dvoid *)0,
                (sb4 (*)(dvoid *, CONST dvoid *, ub4, ub1)) 0,
                (ub2) 0, (ub1) SQLCS_IMPLICIT);
  if (status)
  {
    printf("OCILobRead Failed\n");
    goto error;
  }
  bufp[amtp] = '\0';
  if (amtp > 0)
  {
     printf("\n=> Query result of %s: \n%s\n", sel_stmt, bufp);
     /********** PULL PARSING *****************/
     status = pp_parse(xctx, bufp, amtp);
     if (status)
       printf("Pull Parsing failed\n");
  }
error:
  /* Free XML Ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}
#define ERRBUFLEN 256
sb4 pp_parse(xctx, buf, amt)
xmlctx  *xctx;
oratext *buf;
ub4     amt;
{
  xmlevctx *evctx;
  xmlerr   xerr = XMLERR_OK;
  oratext  message[ERRBUFLEN];
  oratext  *emsg = message;
  xmlerr   ecode;
  boolean  done, inattr = FALSE;
  xmlevtype event;

  /* Create an XML event context - Pull Parser Context */
  evctx = XmlEvCreatePPCtx(xctx, &xerr,
                           "expand_entities", FALSE,
                           "validate", TRUE,
                           "attr_events", TRUE,
                           "raw_buffer_len", 1024,
                           NULL);
```

```
 if (!evctx)
  {
    printf("FAILED: XmlEvCreatePPCtx: %d\n", xerr);
    return OCI_ERROR;
  }
  /* Load the document from input buffer */
  xerr = XmlEvLoadPPDoc(xctx, evctx, "buffer", buf, amt, "utf-8");
  if (xerr)
  {
    printf("FAILED: XmlEvLoadPPDoc: %d\n", xerr);
    return OCI_ERROR;
  }
  /* Process the events until END_DOCUMENT event or error */
  done = FALSE;
  while(!done)
  {
    event = XmlEvNext(evctx);
    switch(event)
    {
      case XML_EVENT_START_ELEMENT:
        printf("START ELEMENT: %s\n", XmlEvGetName0(evctx));
        break;
      case XML_EVENT_END_ELEMENT:
        printf("END ELEMENT: %s\n", XmlEvGetName0(evctx));
        break;
      case XML_EVENT_START_DOCUMENT:
        printf("START DOCUMENT\n");
        break;
      case XML_EVENT_END_DOCUMENT:
        printf("END DOCUMENT\n");
        done = TRUE;
        break;
      case XML_EVENT_START_ATTR:
        printf("START ATTRIBUTE: %s\n", XmlEvGetAttrName0(evctx, 0));
        inattr = TRUE;
        break;
      case XML_EVENT_END_ATTR:
        printf("END ATTRIBUTE: %s\n", XmlEvGetAttrName0(evctx, 0));
        inattr = FALSE;
        break;
      case XML_EVENT_CHARACTERS:
        if (inattr)
          printf("ATTR VALUE: %s\n", XmlEvGetText0(evctx));
        else
          printf("TEXT: %s\n", XmlEvGetText0(evctx));
        break;
      case XML_EVENT_ERROR:
      case XML_EVENT_FATAL_ERROR:
        done = TRUE;
        ecode = XmlEvGetError(evctx, &emsg);
        printf("ERROR: %d: %s\n", ecode, emsg);
        break;
    }
  }
  /* Destroy the event context */
  XmlEvDestroyPPCtx(xctx, evctx);
  return OCI_SUCCESS;
}
```

The output from compiling and running this C program is as follows:

```
=> Query result of SELECT x.getClobVal() FROM PURCHASEORDER x where rownum = 1:
```

```
<PurchaseOrder xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:noNamespaceSchemaLocation=
                 "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd">
  <Reference>AMCEWEN-20021009123336171PDT</Reference>
  <Actions>
    <Action>
      <User>KPARTNER</User>
    </Action>
  </Actions>
  <Reject/>
  <Requestor>Allan D. McEwen</Requestor>
  <User>AMCEWEN</User>
  <CostCenter>S30</CostCenter>
  <ShippingInstructions>
    <name>Allan D. McEwen</name>
    <address>Oracle Plaza
Twin Dolphin Drive
Redwood Shores
CA
94065
USA</address>
    <telephone>650 506 7700</telephone>
  </ShippingInstructions>
  <SpecialInstructions>Ground</SpecialInstructions>
  <LineItems>
    <LineItem ItemNumber="1">
      <Description>Salesman</Description>
      <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
    </LineItem>
    . . .
  </LineItems>
</PurchaseOrder>

START DOCUMENT
START ELEMENT: PurchaseOrder
START ATTRIBUTE: xmlns:xsi
ATTR VALUE: http://www.w3.org/2001/XMLSchema-instance
END ATTRIBUTE: xmlns:xsi
START ATTRIBUTE: xsi:noNamespaceSchemaLocation
ATTR VALUE: http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
END ATTRIBUTE: xsi:noNamespaceSchemaLocation
START ELEMENT: Reference
TEXT: AMCEWEN-20021009123336171PDT
END ELEMENT: Reference
START ELEMENT: Actions
START ELEMENT: Action
START ELEMENT: User
TEXT: KPARTNER
END ELEMENT: User
END ELEMENT: Action
END ELEMENT: Actions
START ELEMENT: Reject
END ELEMENT: Reject
START ELEMENT: Requestor
TEXT: Allan D. McEwen
END ELEMENT: Requestor
START ELEMENT: User
TEXT: AMCEWEN
END ELEMENT: User
START ELEMENT: CostCenter
```

```
TEXT: S30
END ELEMENT: CostCenter
START ELEMENT: ShippingInstructions
START ELEMENT: name
TEXT: Allan D. McEwen
END ELEMENT: name
START ELEMENT: address
TEXT: Oracle Plaza
Twin Dolphin Drive
Redwood Shores
CA
94065
USA
END ELEMENT: address
START ELEMENT: telephone
TEXT: 650 506 7700
END ELEMENT: telephone
END ELEMENT: ShippingInstructions
START ELEMENT: SpecialInstructions
TEXT: Ground
END ELEMENT: SpecialInstructions
START ELEMENT: LineItems
START ELEMENT: LineItem
START ATTRIBUTE: ItemNumber
ATTR VALUE: 1
END ATTRIBUTE: ItemNumber
START ELEMENT: Description
TEXT: Salesman
END ELEMENT: Description
START ELEMENT: Part
START ATTRIBUTE: Id
ATTR VALUE: 37429158920
END ATTRIBUTE: Id
START ATTRIBUTE: UnitPrice
ATTR VALUE: 39.95
END ATTRIBUTE: UnitPrice
START ATTRIBUTE: Quantity
ATTR VALUE: 2
END ATTRIBUTE: Quantity
END ELEMENT: Part
END ELEMENT: LineItem
. . .
END ELEMENT: LineItems
END ELEMENT: PurchaseOrder
END DOCUMENT
```

Common XMLType Operations in C

Table 15–2 provides the `XMLType` functional equivalent of common XML operations.

Table 15–2 Common XMLType Operations in C

Description	C API XMLType Function
Create empty `XMLType` instance	`XmlCreateDocument()`
Create from a source buffer	`XmlLoadDom()`
Extract an XPath expression	`XmlXPathEvalexpr()` and family
Transform using an XSLT style sheet	`XmlXslProcess()` and family

Table 15–2 (Cont.) Common XMLType Operations in C

Description	C API XMLType Function
Check if an XPath exists	`XmlXPathEvalexpr()` and family
Is document schema-based?	`XmlDomIsSchemaBased()`
Get schema information	`XmlDomGetSchema()`
Get document namespace	`XmlDomGetNodeURI()`
Validate using schema	`XmlSchemaValidate()`
Obtain DOM from XMLType	Cast `(void *)` to `(xmldocnode *)`
Obtain XMLType from DOM	Cast `(xmldocnode *)` to `(void *)`

See Also: *Oracle XML Developer's Kit Programmer's Guide* "XML Parser for C"

Example 15–4 Using the DOM to Count Ordered Parts

This example shows how to use the DOM to determine how many instances of a particular part have been ordered. The part in question has `Id 37429158722`. See Appendix A, "Oracle-Supplied XML Schemas and Examples", Example A–4 on page A-43 for the definitions of helper functions `exec_bind_xml`, `free_oci_handles`, and `init_oci_handles`.

```
#ifndef S_ORACLE
#include <s.h>
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>

typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
STATICF sword exec_bind_xml(OCISvcCtx *svchp,
                    OCIError *errhp,
                    OCIStmt *stmthp,
                    void *xml,
```

```
                    OCIType *xmltdo,
                    OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
STATICF sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
STATICF sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;
  ub4 xmlsize = 0;
  OCIDefine *defnp = (OCIDefine *) 0;
  oratext sel_stmt[] = "SELECT SYS_NC_ROWINFO$ FROM PURCHASEORDER";
  xmlnodelist *litems = (xmlnodelist *)0;
  xmlnode *item = (xmlnode *)item;
  xmlnode *part;
  xmlnamedmap *attrs;
  xmlnode *id;
  xmlnode *qty;
  oratext *idval;
  oratext *qtyval;
  ub4 total_qty;
  int i;
  int numdocs;

  ctx->username = (oratext *)"OE";
  ctx->password = (oratext *)"OE";

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_handles(ctx);

  /* Get an xml context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &ctx->dur;
  xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

  /* Start processing */
  printf("\n\nSupports XML 1.0? : %s\n",
         XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
         "YES" : "NO");

  /* Get the documents from the database using a select statement */
  status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp, (const text *) "SYS",
                         (ub4) strlen((char *)"SYS"), (const text *) "XMLTYPE",
                         (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
                         (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                         (OCIType **) &xmltdo);
  status = OCIStmtPrepare(ctx->stmthp, ctx->errhp,
                 (CONST OraText *)sel_stmt, (ub4) strlen((char *)sel_stmt),
                 (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT);
```

```
  status = OCIDefineByPos(ctx->stmthp, &defnp, ctx->errhp, (ub4) 1, (dvoid *) 0,
                 (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                 (ub2 *)0, (ub4) OCI_DEFAULT);
  status = OCIDefineObject(defnp, ctx->errhp, (OCIType *) xmltdo,
                  (dvoid **) &doc,
                  &xmlsize, (dvoid **) 0, (ub4 *) 0);
  status = OCIStmtExecute(ctx->svchp, ctx->stmthp, ctx->errhp, (ub4) 0, (ub4) 0,
                 (CONST OCISnapshot*) 0, (OCISnapshot*) 0, (ub4) OCI_DEFAULT);

  /* Initialize variables */
  total_qty = 0;
  numdocs = 0;

  /* Loop through all the documents */
  while ((status = OCIStmtFetch2(ctx->stmthp, ctx->errhp, (ub4) 1, (ub4) OCI_
FETCH_NEXT,
                                 (ub4)1, (ub4) OCI_DEFAULT)) == 0)
  {
    numdocs++;

    /* Get all the LineItem elements */
    litems = XmlDomGetDocElemsByTag(xctx, doc, (oratext *)"LineItem");
    i = 0;

    /* Loop through all LineItems */
    while (item = XmlDomGetNodeListItem(xctx, litems, i))
    {
      /* Get the part */
      part = XmlDomGetLastChild(xctx, item);

      /* Get the attributes */
      attrs = XmlDomGetAttrs(xctx, (xmlelemnode *)part);

      /* Get the id attribute and its value */
      id = XmlDomGetNamedItem(xctx, attrs, (oratext *)"Id");
      idval = XmlDomGetNodeValue(xctx, id);

      /* We are only interested in parts with id 37429158722 */
      if (idval && (strlen((char *)idval) == 11 )
          && !strncmp((char *)idval, (char *)"37429158722", 11))
      {
        /* Get the quantity attribute and its value.*/
        qty = XmlDomGetNamedItem(xctx, attrs, (oratext *)"Quantity");
        qtyval = XmlDomGetNodeValue(xctx, qty);

        /* Add the quantity to total_qty */
        total_qty += atoi((char *)qtyval);
      }
      i++;
    }
    XmlFreeDocument(xctx, doc);
    doc = (xmldocnode *)0;
  }
  printf("Total quantity needed for part 37429158722 = %d\n", total_qty);
  printf("Number of documents in table PURCHASEORDER = %d\n", numdocs);

  /* Free Xml Ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
```

```
  free_oci_handles(ctx);
}
```

The output from compiling and running this C program is as follows:

```
Supports XML 1.0? : YES
Total quantity needed for part 37429158722 = 42
Number of documents in table PURCHASEORDER = 132
```

16

Using Oracle Data Provider for .NET with Oracle XML DB

Oracle Data Provider for Microsoft .NET (ODP.NET) is an implementation of a data provider for Oracle Database. It uses Oracle native APIs to offer fast and reliable access to Oracle data and features from any .NET application. It also uses and inherits classes and interfaces available in the Microsoft .NET Framework Class Library. ODP.NET supports the following LOB data types natively with .NET: `BLOB`, `CLOB`, `NCLOB`, and `BFILE`.

This chapter describes how to use ODP.NET with Oracle XML DB. It contains these topics:

ODP.NET XML Support and Oracle XML DB

ODP.NET supports XML natively in the database, through Oracle XML DB. ODP.NET XML support includes the following features:

- Stores XML data natively in Oracle Database as `XMLType`.
- Accesses relational and object-relational data as XML data from Oracle Database to a Microsoft .NET environment, and processes the XML using Microsoft .NET framework.
- Saves changes to the database server using XML data.

For the .NET application developer, these features include the following:

- Enhancements to the `OracleCommand`, `OracleConnection`, and `OracleDataReader` classes. Provides the following XML-specific classes:
  - `OracleXmlType`
  - `OracleXmlStream`
  - `OracleXmlQueryProperties`
  - `OracleXmlSaveProperties`

ODP.NET Sample Code

Example 16–1 retrieves `XMLType` data from the database to .NET and outputs the results:

Example 16–1 Retrieve XMLType Data to .NET

```
//Create OracleCommand and query XMLType
OracleCommand xmlCmd = new OracleCommand();
poCmd.CommandText = "SELECT po FROM po_tab";
poCmd.Connection = conn;
// Execute OracleCommand and output XML results to an OracleDataReader
OracleDataReader poReader = poCmd.ExecuteReader();
// ODP.NET native XML data type object from Oracle XML DB
OracleXmlType poXml;
string str = ""; //read XML results
while (poReader.Read())
{
  // Return OracleXmlType object of the specified XmlType column
  poXml = poReader.GetOracleXmlType(0);
  // Concatenate output for all the records
  str = str + poXml.Value;
} //Output XML results to the screen
Console.WriteLine(str);
```

See Also: *Oracle Data Provider for .NET Developer's Guide* for complete information about Oracle .NET support for Oracle XML DB.

Part IV

Viewing Existing Data as XML

Part IV of this manual introduces you to ways you can view your existing data as XML. It contains the following chapters:

17

Generating XML Data from the Database

This chapter describes Oracle XML DB features for generating (constructing) XML data from relational data in the database. It describes the SQL/XML standard functions and Oracle Database-provided functions and packages for generating XML data from relational content.

This chapter contains these topics:

> **See Also:** Chapter 18, "Using XQuery with Oracle XML DB" for information about constructing XML data using SQL/XML functions `XMLQuery` and `XMLTable`

Overview of Generating XML Data From Oracle Database

This section provides an overview of the various ways you can generate XML data with Oracle Database.

Overview of Generating XML Using Standard SQL/XML Functions

You can generate XML data using any of the following standard SQL/XML functions supported by Oracle XML DB. This is described in "Generating XML Using SQL Functions" on page 17-2.

Overview of Generating XML Using Oracle Database SQL Functions

You can generate XML data using any of the following Oracle Database SQL functions:

- XMLSEQUENCE SQL Function on page 17-11 . Only the cursor version of this function generates XML.
- XMLCOLATTVAL SQL Function on page 17-22
- XMLCDATA SQL Function on page 17-24

- Generating XML Using SQL Function SYS_XMLGEN on page 17-49. This operates on rows, generating XML documents.
- Generating XML Using SQL Function SYS_XMLAGG on page 17-56. This operates on groups of rows, aggregating several XML documents into one.

Overview of Generating XML Using DBMS_XMLGEN

You can generate XML from SQL queries using PL/SQL package `DBMS_XMLGEN`. This is described in "Generating XML Using DBMS_XMLGEN" on page 17-24.

Overview of Generating XML with XSQL Pages Publishing Framework

You can generate XML using XSQL Pages Publishing Framework, also known as XSQL Servlet. This is described in Generating XML Using XSQL Pages Publishing Framework on page 17-57. XSQL Pages Publishing Framework is part of Oracle XML Developer's Kit for Java.

Overview of Generating XML Using XML SQL Utility (XSU)

You can use XML SQL Utility (XSU) to perform the following tasks on data in `XMLType` tables and columns:

- Transform data retrieved from object-relational database tables or views into XML.
- Extract data from an XML document, and using a canonical mapping, insert the data into appropriate columns or attributes of a table or a view.
- Extract data from an XML document and apply this data to updating or deleting values of the appropriate columns or attributes.

See Also:

- "Generating XML Using XML SQL Utility (XSU)" on page 17-60
- Chapter 3, "Using Oracle XML DB"
- Chapter 10, "Transforming and Validating XMLType Data"
- Chapter 12, "PL/SQL APIs for XMLType"
- Chapter 14, "Java DOM API for XMLType"

Overview of Generating XML Using DBURIType

You can use a `DBURIType` instance to construct XML documents that contain database data and whose structure reflects the database structure. This is described in Chapter 20, "Accessing Data Through URIs".

Generating XML Using SQL Functions

This section describes SQL functions that you can use to construct XML data. Many of these functions belong to the SQL/XML standard, a SQL standard for XML:

- XMLELEMENT and XMLATTRIBUTES SQL Functions on page 17-3
- XMLFOREST SQL Function on page 17-10
- XMLCONCAT SQL Function on page 17-15
- XMLAGG SQL Function on page 17-16

- XMLPI SQL Function on page 17-19
- XMLCOMMENT SQL Function on page 17-20
- XMLROOT SQL Function on page 17-20
- XMLSERIALIZE SQL Function on page 17-21
- XMLPARSE SQL Function on page 17-22

These XML-generation functions are also known as **XML publishing** functions.

The **SQL/XML standard** is ISO/IEC 9075–14:2005(E), Information technology – Database languages – SQL – Part 14: XML-Related Specifications (SQL/XML). As part of the SQL standard, it is aligned with SQL:2003. It is being developed under the auspices of these two standards bodies:

- ISO/IEC JTC1/SC32 ("International Organization for Standardization and International Electrotechnical Committee Joint Technical Committee 1, Information technology, Subcommittee 32, Data Management and Interchange").
- INCITS Technical Committee H2 ("INCITS" stands for "International Committee for Information Technology Standards"). INCITS is an Accredited Standards Development Organization operating under the policies and procedures of ANSI, the American National Standards Institute. Committee H2 is the committee responsible for SQL and SQL/MM.

This standardization process is ongoing. Please refer to `http://www.sqlx.org` for the latest information about `XMLQuery` and `XMLTable`.

Other XML-generating SQL functions presented in this section are Oracle Database-specific:

- XMLSEQUENCE SQL Function on page 17-11 . Only the cursor version of this function generates XML.
- XMLCOLATTVAL SQL Function on page 17-22
- XMLCDATA SQL Function on page 17-24
- Generating XML Using SQL Function SYS_XMLGEN on page 17-49. This operates on relational rows, generating XML documents.
- Generating XML Using SQL Function SYS_XMLAGG on page 17-56. This operates on groups of relational rows, aggregating several XML documents into one.

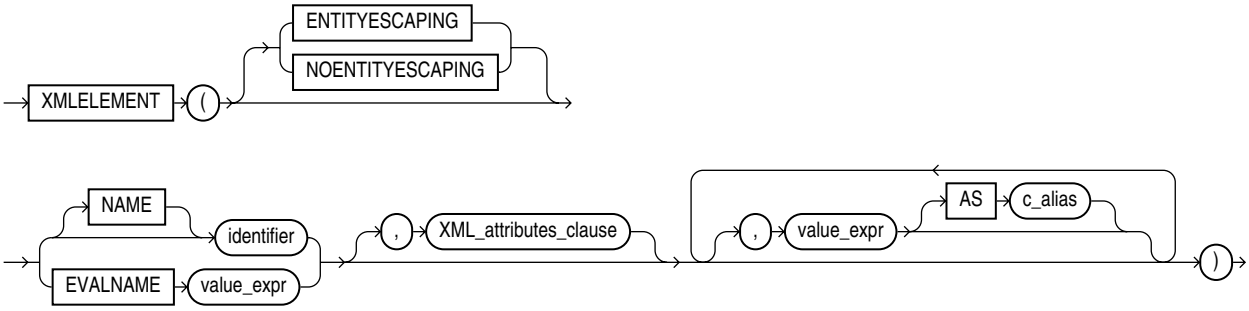
All of the XML-generation SQL functions convert scalars and user-defined data-type instances to their canonical XML format. In this canonical mapping, user-defined data-type attributes are mapped to XML elements.

> **See Also:** Chapter 18, "Using XQuery with Oracle XML DB" for information about constructing XML data using SQL/XML functions `XMLQuery` and `XMLTable`

XMLELEMENT and XMLATTRIBUTES SQL Functions

You use SQL/XML standard function `XMLElement` to construct XML elements from relational data. It takes as arguments an element name, an optional collection of attributes for the element, and zero or more additional arguments that make up the element content. It returns an `XMLType` instance.

Figure 17–1 XMLELEMENT Syntax



For an explanation of keywords `ENTITYESCAPING` and `NOENTITYESCAPING`, see "Escaping Characters in Generated XML Data" on page 17-5.

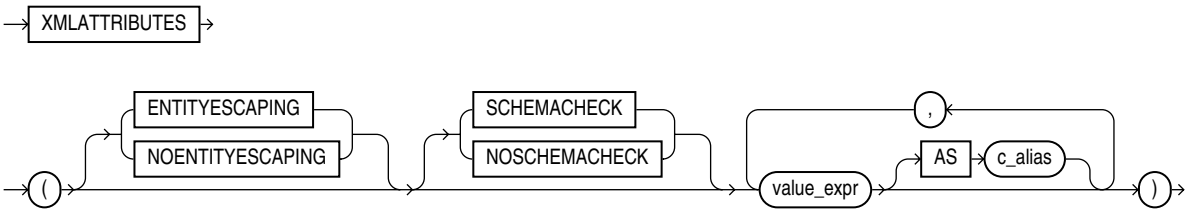
The first argument to function `XMLElement` defines an identifier that names the *root* XML element to be created. The root-element identifier argument can be defined using a literal identifier (*`identifier`*, in Figure 17–1) or by `EVALNAME` followed by an expression (*`value_expr`*) that evaluates to an identifier. However it is defined, the identifier cannot be `NULL`; if it is, then an error is raised.

The optional *`XML-attributes-clause`* argument of function `XMLElement` specifies the attributes of the root element to be generated. Figure 17–2 shows the syntax of this argument.

In addition to the optional *`XML-attributes-clause`* argument, function `XMLElement` accepts zero or more *`value_expr`* arguments that make up the *content* of the root element (child elements and text content). If an *`XML-attributes-clause`* argument is also present, these content arguments must follow the *`XML-attributes-clause`* argument. Each of the content-argument expressions is evaluated, and the result is converted to XML format. If a value argument evaluates to `NULL`, then no content is created for that argument.

The optional *`XML-attributes-clause`* argument uses SQL/XML standard function `XMLAttributes` to specify the *attributes* of the root element. Function `XMLAttributes` can be used *only* in a call to function `XMLElement`; it cannot be used on its own.

Figure 17–2 XMLAttributes Clause Syntax (XMLATTRIBUTES)



For an explanation of keywords `ENTITYESCAPING` and `NOENTITYESCAPING`, see "Escaping Characters in Generated XML Data" on page 17-5.

Keywords `SCHEMACHECK` and `NOSCHEMACHECK` determine whether or not a runtime check is made of the generated attributes, to see if any of them specify a schema location that corresponds to an XML schema that is registered with Oracle XML DB, and, if so, to try to generate XML schema-based XML data accordingly. The default behavior is that provided by `NOSCHEMACHECK`: no check is made. In releases prior to

11*g* Release 1 (11.1), the default behavior is to perform the check; keyword SCHEMACHECK can be used to obtain backward compatibility.

Note that a similar check is *always* made at *compile* time, regardless of the presence or absence of NOSCHEMACHECK. This means, in particular, that if you use a string literal to specify an XML schema location attribute value, then a (compile-time) check will be made, and, if appropriate, XML schema-based data will be generated accordingly.

Note: If a view is created to generate XML data, function XMLAttributes is used to add XML-schema location references, and the target XML schema has not yet been registered with Oracle XML DB, then the XML data generated will not be XML schema-based. If the XML schema is subsequently registered, then XML data generated thereafter will also *not* be XML-schema-based. To create XML schema-based data, you must recompile the view.

Argument *XML-attributes-clause* itself contains one or more *value_expr* expressions as arguments to function XMLAttributes. These are evaluated to obtain the values for the attributes of the root element. (Do not confuse these *value_expr* arguments to function XMLAttributes with the *value_expr* arguments to function XMLElement, which specify the content of the root element.) The optional AS *c_alias* clause for each *value_expr* specifies that the attribute name is *c_alias*, which can be either a string literal or EVALNAME followed by an expression that evaluates to a string literal.

If an attribute value expression evaluates to NULL, then no corresponding attribute is created. The data type of an attribute value expression cannot be an object type or a collection.

Escaping Characters in Generated XML Data

As specified by the SQL/XML standard, characters in explicit *identifiers* are *not* escaped in any way – it is up to you to ensure that valid XML names are used. This applies to all SQL/XML functions; in particular, it applies to the root-element identifier of XMLElement (*identifier*, in Figure 17–1) and to attribute identifier aliases named with AS clauses of XMLAttributes (see Figure 17–2).

However, other XML data that is generated is *escaped*, by default, to ensure that only valid XML NameChar characters are generated. As part of generating a valid XML element or attribute name from a SQL identifier, each character that is disallowed in an XML name is replaced with an underscore character (_), followed by the hexadecimal Unicode representation of the original character, followed by a second underscore character. For example, the colon character (:) is escaped by replacing it with _003A_, where 003A is the hexadecimal Unicode representation.

Escaping applies to characters in the evaluated *value_expr* arguments to *all* SQL/XML functions, including XMLElement and XMLAttributes. It applies also to the characters of an attribute identifier that is defined implicitly from an XMLAttributes attribute value expression that is *not* followed by an AS clause: the escaped form of the SQL column name is used as the name of the attribute.

In some cases, you might not need or want character escaping. If you know, for example, that the XML data being generated is well-formed, then you can save some processing time by inhibiting escaping. You can do that by specifying the keyword NOENTITYESCAPING for SQL functions XMLElement and XMLAttributes. Keyword ENTITYESCAPING imposes escaping, which is the default behavior.

Formatting of XML Dates and Timestamps

The XML Schema standard specifies that dates and timestamps in XML data be in standard formats. XML generation functions in Oracle XML DB produce XML dates and timestamps according to this standard.

In releases prior to Oracle Database 10g Release 2, the database settings for date and timestamp formats, not the XML Schema standard formats, were used for XML. You can reproduce this *previous* behavior by setting the database event 19119, level 0x8, as follows:

```
ALTER SESSION SET EVENTS '19119 TRACE NAME CONTEXT FOREVER, LEVEL 0x8';
```

If you otherwise need to produce a non-standard XML date or timestamp, use SQL function `to_char` – see Example 17–1.

> **See Also:**
>
> `http://www.w3.org/TR/2004/REC-xmlschema-2-20041028/datatypes.html#isoformats` for the XML Schema specification of XML date and timestamp formats

XMLElement Examples

This section provides examples that use SQL function `XMLElement`.

Example 17–1 XMLELEMENT: Formatting a Date

This example shows how to produce an XML date with a format different from the XML Schema standard format.

```
-- With standard XML date format:
SELECT XMLElement("Date", hire_date)
  FROM hr.employees
  WHERE employee_id = 203;

XMLELEMENT("DATE",HIRE_DATE)
----------------------------
<Date>1994-06-07</Date>

1 row selected.

-- With an alternative date format:
SELECT XMLElement("Date", to_char(hire_date))
  FROM hr.employees
  WHERE employee_id = 203;

XMLELEMENT("DATE",TO_CHAR(HIRE_DATE))
-------------------------------------
<Date>07-JUN-94</Date>

1 row selected.
```

Example 17–2 XMLELEMENT: Generating an Element for Each Employee

This example produces an `Emp` element for each employee, with the employee name as its content:

```
SELECT e.employee_id,
       XMLELEMENT ("Emp", e.first_name ||' '|| e.last_name) AS "RESULT"
   FROM hr.employees e
   WHERE employee_id > 200;
```

This query produces the following typical result:

```
EMPLOYEE_ID RESULT
----------- --------------------------------
        201 <Emp>Michael Hartstein</Emp>
        202 <Emp>Pat Fay</Emp>
        203 <Emp>Susan Mavris</Emp>
        204 <Emp>Hermann Baer</Emp>
        205 <Emp>Shelley Higgins</Emp>
        206 <Emp>William Gietz</Emp>

6 rows selected.
```

SQL function `XMLElement` can also be nested, to produce XML data with a nested structure.

Example 17–3 XMLELEMENT: Generating Nested XML

To produce an `Emp` element for each employee, with elements that provide the employee name and hire date, do the following:

```
SELECT XMLElement("Emp",
                  XMLElement("name", e.first_name ||' '|| e.last_name),
                  XMLElement("hiredate", e.hire_date)) AS "RESULT"
FROM hr.employees e
WHERE employee_id > 200 ;
```

This query produces the following typical XML result:

```
RESULT
--------------------------------------------------------------------------
<Emp><name>Michael Hartstein</name><hiredate>1996-02-17</hiredate></Emp>
<Emp><name>Pat Fay</name><hiredate>1997-08-17</hiredate></Emp>
<Emp><name>Susan Mavris</name><hiredate>1994-06-07</hiredate></Emp>
<Emp><name>Hermann Baer</name><hiredate>1994-06-07</hiredate></Emp>
<Emp><name>Shelley Higgins</name><hiredate>1994-06-07</hiredate></Emp>
<Emp><name>William Gietz</name><hiredate>1994-06-07</hiredate></Emp>

6 rows selected.
```

Example 17–4 XMLELEMENT: Generating Employee Elements with ID and Name Attributes

This example produces an `Emp` element for each employee, with an `id` and `name` attribute:

```
SELECT XMLElement("Emp", XMLAttributes(
                           e.employee_id as "ID",
                           e.first_name ||' ' || e.last_name AS "name"))
  AS "RESULT"
  FROM hr.employees e
  WHERE employee_id > 200;
```

This query produces the following typical XML result fragment:

```
RESULT
----------------------------------------------
<Emp ID="201" name="Michael Hartstein"></Emp>
<Emp ID="202" name="Pat Fay"></Emp>
<Emp ID="203" name="Susan Mavris"></Emp>
<Emp ID="204" name="Hermann Baer"></Emp>
<Emp ID="205" name="Shelley Higgins"></Emp>
```

```
<Emp ID="206" name="William Gietz"></Emp>

6 rows selected.
```

As mentioned in "Escaping Characters in Generated XML Data" on page 17-5, characters in the root-element name and the names of any attributes defined by `AS` clauses are *not* escaped. Characters in an identifier name are escaped only if the name is created from an evaluated expression (such as a column reference). The following query shows that the root-element name and the attribute name are *not* escaped. Invalid XML is produced because greater-than sign (>) and a comma (,) are not allowed in XML element and attribute names.

```
SELECT XMLElement("Emp->Special",
                  XMLAttributes(e.last_name || ', ' || e.first_name
                                AS "Last,First"))
   AS "RESULT"
   FROM hr.employees e
   WHERE employee_id = 201;
```

This query produces the following result, which is not well-formed XML:

```
RESULT
--------------------------------------------------------------------
<Emp->Special Last,First="Hartstein, Michael"></Emp->Special>

1 row selected.
```

A full description of character escaping is included in the SQL/XML standard.

Example 17–5 XMLELEMENT: Using Namespaces to Create a Schema-Based XML Document

This example illustrates the use of namespaces to create an XML schema-based document. Assuming that an XML schema "`http://www.oracle.com/Employee.xsd`" exists and has no target namespace, then the following query creates an `XMLType` instance conforming to that schema:

```
SELECT XMLElement("Employee",
                  XMLAttributes('http://www.w3.org/2001/XMLSchema' AS
                                  "xmlns:xsi",
                                'http://www.oracle.com/Employee.xsd' AS
                                  "xsi:nonamespaceSchemaLocation"),
                  XMLForest(employee_id, last_name, salary)) AS "RESULT"
   FROM hr.employees
   WHERE department_id = 10;
```

This creates the following XML document that conforms to XML schema `Employee.xsd`. (The result is shown here pretty-printed, for clarity.)

```
RESULT
--------------------------------------------------------------------------------
<Employee xmlns:xsi="http://www.w3.org/2001/XMLSchema"
          xsi:nonamespaceSchemaLocation="http://www.oracle.com/Employee.xsd">
   <EMPLOYEE_ID>200</EMPLOYEE_ID>
   <LAST_NAME>Whalen</LAST_NAME>
   <SALARY>4400</SALARY>
</Employee>

1 row selected.
```

Example 17–6 XMLELEMENT: Generating an Element from a User-Defined Data-Type Instance

Example 17–10 shows an XML document with employee information. You can generate a hierarchical XML document with the employee and department information as follows:

```
CREATE OR REPLACE TYPE emp_t AS OBJECT ("@EMPNO" NUMBER(4),
                                        ENAME VARCHAR2(10));
/
Type created.

CREATE OR REPLACE TYPE emplist_t AS TABLE OF emp_t;
/
Type created.

CREATE OR REPLACE TYPE dept_t AS OBJECT ("@DEPTNO" NUMBER(2),
                                         DNAME VARCHAR2(14),
                                         EMP_LIST emplist_t);
/
Type created.

SELECT XMLElement("Department",
                  dept_t(department_id,
                         department_name,
                         CAST(MULTISET(SELECT employee_id, last_name
                                       FROM hr.employees e
                                       WHERE e.department_id = d.department_id)
                              AS emplist_t)))
  AS deptxml
  FROM hr.departments d
  WHERE d.department_id = 10;
```

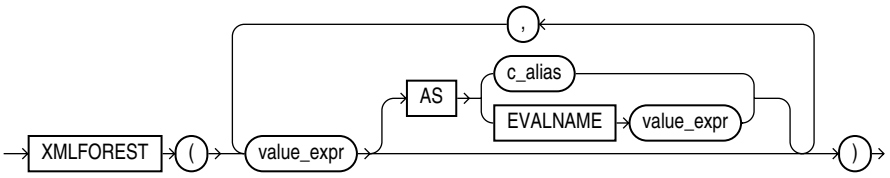
This produces an XML document which contains the `Department` element and the canonical mapping of type `dept_t`.

```
DEPTXML
-------------
<Department>
  <DEPT_T DEPTNO="10">
    <DNAME>ACCOUNTING</DNAME>
    <EMPLIST>
      <EMP_T EMPNO="7782">
        <ENAME>CLARK</ENAME>
      </EMP_T>
      <EMP_T EMPNO="7839">
        <ENAME>KING</ENAME>
      </EMP_T>
      <EMP_T EMPNO="7934">
        <ENAME>MILLER</ENAME>
      </EMP_T>
    </EMPLIST>
  </DEPT_T>
</Department>

1 row selected.
```

XMLFOREST SQL Function

You use SQL/XML standard function `XMLForest` to construct a forest of XML elements. Its arguments are expressions to be evaluated, with optional aliases. Figure 17–3 describes the `XMLForest` syntax.

Figure 17–3 XMLFOREST Syntax



Each of the value expressions (*value_expr* in Figure 17–3) is converted to XML format, and, optionally, identifier *c_alias* is used as the attribute identifier (*c_alias* can be a string literal or `EVALNAME` followed by an expression that evaluates to a string literal).

For an object type or collection, the `AS` clause is required. For other types, the `AS` clause is optional. For a given expression, if the `AS` clause is omitted, then characters in the evaluated value expression are *escaped* to form the name of the enclosing tag of the element. The escaping is as defined in "Escaping Characters in Generated XML Data" on page 17-5. If the value expression evaluates to `NULL`, then no element is created for that expression.

Example 17–7 XMLFOREST: Generating Elements with Attribute and Child Elements

This example generates an `Emp` element for each employee, with a `name` attribute and elements with the employee hire date and department as the content.

```
SELECT XMLElement("Emp",
                  XMLAttributes(e.first_name ||' '|| e.last_name AS "name"),
                  XMLForest(e.hire_date, e.department AS "department"))
AS "RESULT"
FROM employees e WHERE e.department_id = 20;
```

(The `WHERE` clause is used here to keep the example brief.) This query produces the following XML result:

```
RESULT
-------------------------------------
<Emp name="Michael Hartstein">
  <HIRE_DATE>1996-02-17</HIRE_DATE>
  <department>20</department>
</Emp>
<Emp name="Pat Fay">
  <HIRE_DATE>1997-08-17</HIRE_DATE>
  <department>20</department>
</Emp>

2 rows selected.
```

> **See Also:** Example 17–22, "XMLCOLATTVAL: Generating Elements with Attribute and Child Elements"

Example 17–8 XMLFOREST: Generating an Element from a User-Defined Data-Type Instance

You can also use SQL function `XMLForest` to generate hierarchical XML from user-defined data-type instances.

```
SELECT XMLForest(
  dept_t(department_id,
         department_name,
         CAST (MULTISET (SELECT employee_id, last_name
                         FROM hr.employees e
                         WHERE e.department_id = d.department_id)
               AS emplist_t))
         AS "Department")
  AS deptxml
  FROM hr.departments d
  WHERE department_id=10;
```

This produces an XML document with element `Department` containing attribute `DEPTNO` and child element `DNAME`.

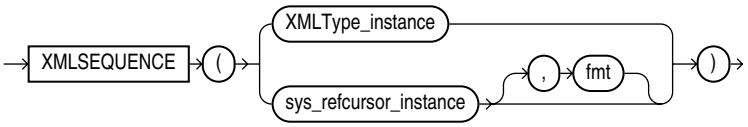
```
DEPTXML
--------------------------------
<Department DEPTNO="10">
  <DNAME>Administration</DNAME>
    <EMP_LIST>
      <EMP_T EMPNO="200">
        <ENAME>Whalen</ENAME>
      </EMP_T>
    </EMP_LIST>
</Department>

1 row selected.
```

You may want to compare this example with Example 17–6 and Example 17–27.

XMLSEQUENCE SQL Function

Oracle SQL function `XMLSequence` returns an `XMLSequenceType` value (a varray of `XMLType` instances). Because it returns a collection, this function can be used in the `FROM` clause of SQL queries. See Figure 17–4.

Figure 17–4 XMLSEQUENCE Syntax



Example 17–9 XMLSEQUENCE Returns Only Top-Level Element Nodes

Function `XMLSequence` returns only top-level element nodes. It will not break up attribute nodes or text nodes.

```
SELECT value(T).getstringval() Attribute_Value
  FROM table(XMLSequence(extract(XMLType('<A><B>V1</B><B>V2</B><B>V3</B></A>'),
                                 '/A/B'))) T;

ATTRIBUTE_VALUE
----------------------
```

```
<B>V1</B>
<B>V2</B>
<B>V3</B>

3 rows selected.
```

Function `XMLSequence` has two forms:

- The first form takes as input an `XMLType` instance, and returns a varray of top-level nodes. This form can be used to break up XML fragments into multiple rows.
- The second form takes as input a `REFCURSOR` instance and an optional instance of the `XMLFormat` object, and returns a varray of `XMLType` instances corresponding to each row of the cursor. This form can be used to construct `XMLType` instances from arbitrary SQL queries. This use of `XMLFormat` does *not* support XML schemas.

The first form is effectively *superseded* by standard SQL/XML function `XMLTable`, which provides for more readable SQL code. Prior to Oracle Database 10g Release 2, `XMLSequence` was used with SQL function `table` to do some of what can now be done better with standard function `XMLTable`.

> **See Also:** Chapter 18, "Using XQuery with Oracle XML DB" for more information about SQL/XML function `XMLTable`

Example 17–10 XMLSEQUENCE: Generating One XML Document from Another

Consider the following XMLType table containing an XML document with employee information:

```
CREATE TABLE emp_xml_tab OF XMLType;

Table created.

INSERT INTO emp_xml_tab VALUES( XMLType('<EMPLOYEES>
                                          <EMP>
                                            <EMPNO>112</EMPNO>
                                            <EMPNAME>Joe</EMPNAME>
                                            <SALARY>50000</SALARY>
                                          </EMP>
                                          <EMP>
                                            <EMPNO>217</EMPNO>
                                            <EMPNAME>Jane</EMPNAME>
                                            <SALARY>60000</SALARY>
                                          </EMP>
                                          <EMP>
                                            <EMPNO>412</EMPNO>
                                            <EMPNAME>Jack</EMPNAME>
                                            <SALARY>40000</SALARY>
                                          </EMP>
                                        </EMPLOYEES>'));

1 row created.

COMMIT;
```

To create a new XML document containing only employees who earn $50,000 or more, you can use the following query:

```
SELECT sys_XMLAgg(value(em), XMLFormat('EMPLOYEES'))
```

```
  FROM emp_xml_tab doc, table(XMLSequence(extract(value(doc),
                                          '/EMPLOYEES/EMP'))) em
  WHERE extractValue(value(em), '/EMP/SALARY') >= 50000;
```

These are the steps involved in this query:

1. Function `extract` returns a fragment of `EMP` elements.
2. Function `XMLSequence` gathers a collection of these top-level elements into `XMLType` instances and returns that.
3. Function `table` makes a table value from the collection. The table value is then used in the query `FROM` clause.

The query returns the following XML document:

```
SYS_XMLAGG(VALUE(EM),XMLFORMAT('EMPLOYEES'))
--------------------------------------------
<?xml version="1.0"?>
<EMPLOYEES>
  <EMP>
    <EMPNO>112</EMPNO>
    <EMPNAME>Joe</EMPNAME>
    <SALARY>50000</SALARY>
  </EMP>
  <EMP>
    <EMPNO>217</EMPNO>
    <EMPNAME>Jane</EMPNAME>
    <SALARY>60000</SALARY>
  </EMP>
</EMPLOYEES>

1 row selected.
```

Example 17–11 XMLSEQUENCE: Generate a Document for Each Row of a Cursor

In this example, SQL function `XMLSequence` is used to create an XML document for each row of a cursor expression, and it returns an `XMLSequenceType` value (a varray of `XMLType` instances).

```
SELECT value(em).getCLOBVal() AS "XMLTYPE"
  FROM table(XMLSequence(Cursor(SELECT *
                                FROM hr.employees
                                WHERE employee_id = 104))) em;
```

This query returns the following XML:

```
XMLTYPE
--------------------------------------------------
 <ROW>
  <EMPLOYEE_ID>104</EMPLOYEE_ID>
  <FIRST_NAME>Bruce</FIRST_NAME>
  <LAST_NAME>Ernst</LAST_NAME>
  <EMAIL>BERNST</EMAIL>
  <PHONE_NUMBER>590.423.4568</PHONE_NUMBER>
  <HIRE_DATE>21-MAY-91</HIRE_DATE>
  <JOB_ID>IT_PROG</JOB_ID>
  <SALARY>6000</SALARY>
  <MANAGER_ID>103</MANAGER_ID>
  <DEPARTMENT_ID>60</DEPARTMENT_ID>
 </ROW>

1 row selected.
```

The tag used for each row can be changed using the `XMLFormat` object.

Example 17–12 XMLSEQUENCE: Un-Nesting Collections in XML Documents into SQL Rows

Because SQL function `XMLSequence` is a table function, it can be used to un-nest the elements inside an XML document. For example, consider the following `XMLType` table `dept_xml_tab` containing XML documents:

```
CREATE TABLE dept_xml_tab OF XMLType;

Table created.

INSERT INTO dept_xml_tab
  VALUES(
    XMLType('<Department deptno="100">
               <DeptName>Sports</DeptName>
               <EmployeeList>
                 <Employee empno="200"><Ename>John</Ename><Salary>33333</Salary>
                 </Employee>
                 <Employee empno="300"><Ename>Jack</Ename><Salary>333444</Salary>
                 </Employee>
               </EmployeeList>
             </Department>'));

1 row created.

INSERT INTO dept_xml_tab
  VALUES (
    XMLType('<Department deptno="200">
               <DeptName>Sports</DeptName>
               <EmployeeList>
                 <Employee empno="400"><Ename>Marlin</Ename><Salary>20000</Salary>
                 </Employee>
               </EmployeeList>
             </Department>'));

1 row created.

COMMIT;
```

You can use SQL function `XMLSequence` to un-nest the `Employee` list items as top-level SQL rows:

```
SELECT extractValue(OBJECT_VALUE, '/Department/@deptno') AS deptno,
       extractValue(value(em), '/Employee/@empno') AS empno,
       extractValue(value(em), '/Employee/Ename') AS ename
  FROM dept_xml_tab,
       table(XMLSequence(extract(OBJECT_VALUE,
                                 '/Department/EmployeeList/Employee'))) em;
```

This returns the following:

```
DEPTNO       EMPNO          ENAME
--------------------------------
100           200           John
100           300           Jack
200           400           Marlin

3 rows selected
```

For each row in table dept_xml_tab, function table is applied. Here, function extract creates a new XMLType instance that contains a fragment of all employee elements. This is fed to SQL function XMLSequence, which creates a collection of all employees.

Function TABLE then explodes the collection elements into multiple rows which are correlated with the parent table dept_xml_tab. Thus you get a list of all the parent dept_xml_tab rows with the associated employees.

Function extractValue extracts out the scalar values for the department number, employee number, and name.

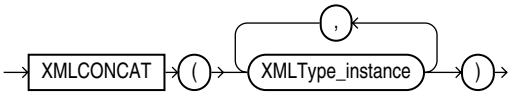
See Also: Chapter 4, "XMLType Operations"

XMLCONCAT SQL Function

You use SQL/XML standard function XMLConcat to construct an XML fragment by concatenating multiple XMLType instances. Figure 17–5 shows the XMLConcat syntax. Function XMLConcat has two forms:

- The first form takes an XMLSequenceType value (a varray of XMLType instances) and returns a single XMLType instance that is the concatenation of all of the elements of the varray. This form is useful to collapse lists of XMLType instances into a single instance.
- The second form takes an arbitrary number of XMLType instances and concatenates them together. If one of the values is NULL, then it is ignored in the result. If all the values are NULL, then the result is NULL. This form is used to concatenate arbitrary number of XMLType instances in the same row. Function XMLAgg can be used to concatenate XMLType instances across rows.

Figure 17–5 XMLCONCAT Syntax



Example 17–13 XMLCONCAT: Concatenating XMLType Instances from a Sequence

This example uses function XMLConcat to return a concatenation of XMLType instances from an XMLSequenceType value (a varray of XMLType instances).

```
SELECT XMLConcat(XMLSequenceType(
                  XMLType('<PartNo>1236</PartNo>'),
                  XMLType('<PartName>Widget</PartName>'),
                  XMLType('<PartPrice>29.99</PartPrice>'))).getCLOBVal()
  AS "RESULT"
  FROM DUAL;
```

This query returns a single XML fragment. (The result is shown here pretty-printed, for clarity.)

```
RESULT
---------------
<PartNo>1236</PartNo>
<PartName>Widget</PartName>
<PartPrice>29.99</PartPrice>

1 row selected.
```

Example 17–14 XMLCONCAT: Concatenating XML Elements

The following example creates an XML element for the first and the last names and then concatenates the result:

```
SELECT XMLConcat(XMLElement("first", e.first_name),
                 XMLElement("last", e.last_name))
  AS "RESULT"
  FROM employees e;
```

This query produces the following XML fragment:

```
RESULT
-----------------------------------------
<first>Den</first><last>Raphaely</last>
<first>Alexander</first><last>Khoo</last>
<first>Shelli</first><last>Baida</last>
<first>Sigal</first><last>Tobias</last>
<first>Guy</first><last>Himuro</last>
<first>Karen</first><last>Colmenares</last>

6 rows selected.
```

XMLAGG SQL Function

You use SQL/XML standard function `XMLAgg` to construct a forest of XML elements from a collection of XML elements—it is an aggregate function.

Figure 17–6 XMLAGG Syntax

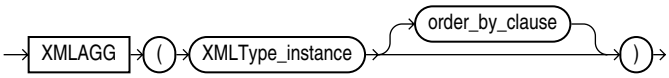


Figure 17–6 describes the `XMLAgg()` syntax, where the `order_by_clause` is the following:

```
ORDER BY [list of: expr [ASC|DESC] [NULLS {FIRST|LAST}]]
```

Numeric literals are *not* interpreted as column positions. For example, `ORDER BY 1` does not mean order by the first column. Instead, numeric literals are interpreted as any other literals.

As with SQL function `XMLConcat`, any arguments that are `NULL` are dropped from the result. Function `XMLAgg` is similar to function `sys_XMLAgg`, except that it returns a forest of nodes and does not take the `XMLFormat` parameter. Function `XMLAgg` can be used to concatenate `XMLType` instances across *multiple rows*. It also admits an optional `ORDER BY` clause, to order the XML values being aggregated.

Function `XMLAgg` produces one aggregated XML result for each group. If there is no group by specified in the query, then it returns a single aggregated XML result for all the rows of the query.

Example 17–15 XMLAGG: Generating Department Elements with a List of Employee Elements

This example produces a `Department` element containing `Employee` elements with employee job ID and last name as the contents of the elements. It also orders the employee XML elements in the department by their last name. (The result is shown here pretty-printed, for clarity.)

```
SELECT XMLElement("Department", XMLAgg(XMLElement("Employee",
                                                  e.job_id||' '||e.last_name)
                                       ORDER BY e.last_name))
  AS "Dept_list"
  FROM hr.employees e
  WHERE e.department_id = 30 OR e.department_id = 40;

Dept_list
------------------
<Department>
  <Employee>PU_CLERK Baida</Employee>
  <Employee>PU_CLERK Colmenares</Employee>
  <Employee>PU_CLERK Himuro</Employee>
  <Employee>PU_CLERK Khoo</Employee>
  <Employee>HR_REP Mavris</Employee>
  <Employee>PU_MAN Raphaely</Employee>
  <Employee>PU_CLERK Tobias</Employee>
</Department>

1 row selected.
```

The result is a *single* row, because `XMLAgg` aggregates the rows. You can use the `GROUP BY` clause to group the returned set of rows into multiple groups. (The result is shown here pretty-printed, for clarity.)

```
SELECT XMLElement("Department", XMLAttributes(department_id AS "deptno"),
                  XMLAgg(XMLElement("Employee", e.job_id||' '||e.last_name)))
   AS "Dept_list"
   FROM hr.employees e
   GROUP BY e.department_id;

Dept_list
------------------
<Department deptno="30">
  <Employee>PU_MAN Raphaely</Employee>
  <Employee>PU_CLERK Khoo</Employee>
  <Employee>PU_CLERK Baida</Employee>
  <Employee>PU_CLERK Himuro</Employee>
  <Employee>PU_CLERK Colmenares</Employee>
  <Employee>PU_CLERK Tobias</Employee>
</Department>

<Department deptno="40">
  <Employee>HR_REP Mavris</Employee>
</Department>

2 rows selected.
```

You can order the employees within each department by using the `ORDER BY` clause inside the `XMLAgg` expression.

> **Note:** Within the `ORDER BY` clause, Oracle Database does not interpret number literals as column positions, as it does in other uses of this clause.

Example 17–16 XMLAGG: Generating Nested Elements

Function `XMLAgg` can be used to reflect the hierarchical nature of some relationships that exist in tables. This example generates a department element for department 30.

Within this element is a child element for each employee of the department. Within each employee element is a `dependent` element for each dependent of that employee.

First, this query shows the employees of department 30.

```
SELECT last_name, employee_id FROM employees WHERE department_id = 30;

LAST_NAME                 EMPLOYEE_ID
------------------------- -----------
Raphaely                          114
Khoo                              115
Baida                             116
Tobias                            117
Himuro                            118
Colmenares                        119

6 rows selected.
```

A `dependents` table is created, to hold the dependents of each employee.

```
CREATE TABLE hr.dependents (id NUMBER(4) PRIMARY KEY,
                            employee_id NUMBER(4),
                            name VARCHAR2(10));
Table created.
INSERT INTO dependents VALUES (1, 114, 'MARK');
1 row created.
INSERT INTO dependents VALUES (2, 114, 'JACK');
1 row created.
INSERT INTO dependents VALUES (3, 115, 'JANE');
1 row created.
INSERT INTO dependents VALUES (4, 116, 'HELEN');
1 row created.
INSERT INTO dependents VALUES (5, 116, 'FRANK');
1 row created.
COMMIT;
Commit complete.
```

This query generates the XML data for department that contains the information about dependents. (The result is shown here pretty-printed, for clarity.)

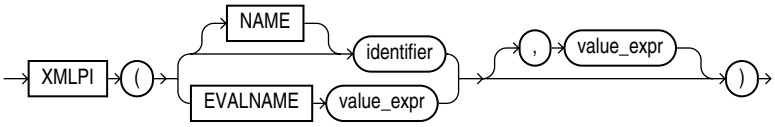
```
SELECT
  XMLElement(
    "Department",
    XMLAttributes(d.department_name AS "name"),
    (SELECT
       XMLAgg(XMLElement("emp",
                         XMLAttributes(e.last_name AS name),
                         (SELECT XMLAgg(XMLElement("dependent",
                                                   XMLAttributes(de.name AS "name")))
                            FROM dependents de
                            WHERE de.employee_id = e.employee_id)))
       FROM employees e
       WHERE e.department_id = d.department_id)) AS "dept_list"
  FROM departments d
  WHERE department_id = 30;

dept_list
--------------------------------------------------------------------------------
<Department name="Purchasing">
  <emp NAME="Raphaely">
    <dependent name="MARK"></dependent>
    <dependent name="JACK"></dependent>
```

```
  </emp><emp NAME="Khoo">
    <dependent name="JANE"></dependent>
  </emp>
  <emp NAME="Baida">
    <dependent name="HELEN"></dependent>
    <dependent name="FRANK"></dependent>
  </emp><emp NAME="Tobias"></emp>
  <emp NAME="Himuro"></emp>
  <emp NAME="Colmenares"></emp>
</Department>

1 row selected.
```

XMLPI SQL Function

You use SQL/XML standard function `XMLPI` to construct an XML processing instruction (PI). Figure 17–7 shows the syntax:

Figure 17–7 XMLPI Syntax



Argument *value_expr* is evaluated, and the string result is appended to the optional identifier (*identifier*), separated by a space. This concatenation is then enclosed between "<?" and "?>" to create the processing instruction. That is, if *string-result* is the result of evaluating *value_expr*, then the generated processing instruction is <?*identifier string-result*?>. If *string-result* is the empty string, '', then the function returns <?*identifier*?>.

As an alternative to using keyword `NAME` followed by a *literal* string *identifier*, you can use keyword `EVALNAME` followed by an expression that evaluates to a string to be used as the identifier.

An error is raised if the constructed XML is not a legal XML processing instruction. In particular:

- *identifier* must *not* be the word "xml" (uppercase, lowercase, or mixed case).
- *string-result* must *not* contain the character sequence "?>".

Function `XMLPI` returns an instance of `XMLType`. If *string-result* is `NULL`, then it returns `NULL`.

Example 17–17 Using XMLPI

```
SELECT XMLPI(NAME "OrderAnalysisComp", 'imported, reconfigured, disassembled')
  AS pi FROM DUAL;
```

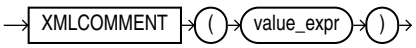
This results in the following output:

```
PI
------------------------------------------------------------
<?OrderAnalysisComp imported, reconfigured, disassembled?>

1 row selected.
```

XMLCOMMENT SQL Function

You use SQL/XML standard function `XMLComment` to construct an XML comment. Figure 17–8 shows the syntax:

Figure 17–8 XMLComment Syntax



Argument *value_expr* is evaluated to a string, and the result is used as the body of the generated XML comment; that is, the result is `<!--`*string-result*`-->`, where *string-result* is the string result of evaluating *value_expr*. If *string-result* is the empty string, then the comment is empty: `<!---->`.

An error is raised if the constructed XML is not a legal XML comment. In particular, *string-result* must *not* contain two consecutive hyphens (-): "--".

Function `XMLComment` returns an instance of `XMLType`. If *string-result* is `NULL`, then the function returns `NULL`.

Example 17–18 Using XMLCOMMENT

```
SELECT XMLComment('This is a comment') AS cmnt FROM DUAL;
```

This query results in the following output:

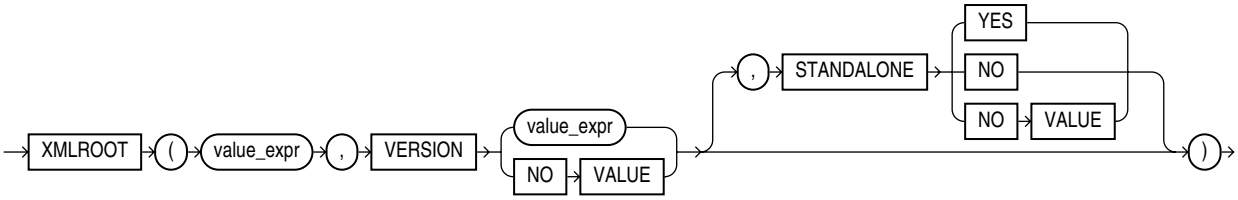
```
CMNT
--------------------------
<!--This is a comment-->
```

XMLROOT SQL Function

SQL function `XMLRoot` was at one time part of the SQL/XML standard, but it is deprecated as a standard function as of SQL/XML 2005. It remains available in Oracle XML DB, as an Oracle function.

You use `XMLRoot` to add a `VERSION` property, and optionally a `STANDALONE` property, to the root information item of an XML value. Typically, this is done to ensure data-model compliance. Figure 17–9 shows the syntax of `XMLRoot`:

Figure 17–9 XMLRoot Syntax



First argument *xml-expression* is evaluated, and the indicated properties (`VERSION`, `STANDALONE`) and their values are added to a new prolog for the resulting `XMLType` instance. If the evaluated *xml-expression* already contains a prolog, then an error is raised.

Second argument *string-valued-expression* (which follows keyword `VERSION`) is evaluated, and the resulting string is used as the value of the prolog `version` property. The value of the prolog `standalone` property (lowercase) is taken from the optional third argument `STANDALONE YES` or `NO` value. If `NOVALUE` is used for

VERSION, then "version=1.0" is used in the resulting prolog. If NOVALUE is used for STANDALONE, then the standalone property is omitted from the resulting prolog.

Function XMLRoot returns an instance of XMLType. If first argument *xml-expression* evaluates to NULL, then the function returns NULL.

Example 17–19 Using XMLRoot

```
SELECT XMLRoot(XMLType('<poid>143598</poid>'), VERSION '1.0', STANDALONE YES)
  AS xmlroot FROM DUAL;
```

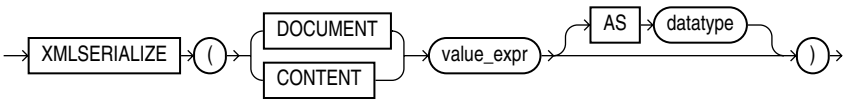
This results in the following output:

```
XMLROOT
--------------------------------------
<?xml version="1.0" standalone="yes"?>
<poid>143598</poid>

1 row selected.
```

XMLSERIALIZE SQL Function

You use SQL/XML standard function XMLSerialize to obtain a string or a LOB representation of XML data. Figure 17–10 shows the syntax:

Figure 17–10 XMLSerialize Syntax



Argument *value_expr* is evaluated, and the resulting XMLType instance is serialized to produce the content of the created string or LOB. If present[1], the specified *datatype* must be one of the following (the default data type is CLOB):

- VARCHAR2
- VARCHAR
- CLOB

If you specify DOCUMENT, then the result of evaluating *value_expr* must be a well-formed document; in particular, it must have a single root. If the result is not a well-formed document, then an error is raised. If you specify CONTENT, however, then the result of *value_expr* is *not* checked for being well-formed.

If the underlying CLOB value or string has encoding information, then an appropriate encoding="..." declaration is added to the prolog.

If *value_expr* evaluates to NULL or to the empty string (''), then function XMLSerialize returns NULL.

Example 17–20 Using XMLSERIALIZE

```
SELECT XMLSerialize(DOCUMENT XMLType('<poid>143598</poid>') AS CLOB)
  AS xmlserialize_doc FROM DUAL;
```

This results in the following output:

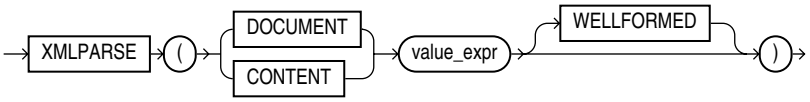
[1] The SQL/XML standard requires argument *data-type* to be present, but it is *optional* in the Oracle XML DB implementation of the standard, for ease of use.

```
XMLSERIALIZE_DOC
--------------------
<poid>143598</poid>
```

XMLPARSE SQL Function

You use SQL/XML standard function `XMLParse` to parse a string containing XML data and construct a corresponding `XMLType` instance. Figure 17–11 shows the syntax:

Figure 17–11 XMLParse Syntax



Argument *value_expr* is evaluated to produce the string that is parsed. If you specify `DOCUMENT`, then *value_expr* must correspond to a *singly rooted*, well-formed XML document. If you specify `CONTENT`, then *value_expr* need only correspond to a well-formed XML fragment; that is, it need not be singly rooted.

Keyword `WELLFORMED` is an Oracle XML DB extension to the SQL/XML standard. When you specify `WELLFORMED`, you are informing the parser that argument *value_expr* is well-formed, so Oracle XML DB does *not* check to ensure that it is well-formed.

Function `XMLParse` returns an instance of `XMLType`. If *value_expr* evaluates to `NULL`, then the function returns `NULL`.

Example 17–21 Using XMLPARSE

```
SELECT XMLParse(CONTENT
                '124 <purchaseOrder poNo="12435">
                       <customerName> Acme Enterprises</customerName>
                       <itemNo>32987457</itemNo>
                     </purchaseOrder>'
                WELLFORMED)
  AS po FROM DUAL d;
```

This results in the following output:

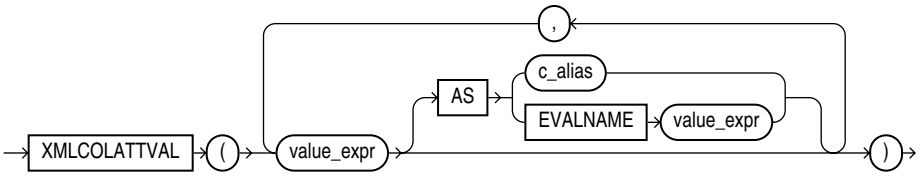
```
PO
------------------------------------------------
124 <purchaseOrder poNo="12435">
<customerName>Acme Enterprises</customerName>
<itemNo>32987457</itemNo>
</purchaseOrder>
```

> **See Also:** `http://www.w3.org/TR/REC-xml/`, *Extensible Markup Language (XML) 1.0*, for the definition of well-formed XML documents and fragments

XMLCOLATTVAL SQL Function

Oracle Database SQL function `XMLColAttVal` generates a forest of XML `column` elements containing the values of the arguments passed in. This function is an Oracle Database extension to the SQL/XML ANSI-ISO standard functions. Figure 17–12 shows the `XMLColAttVal` syntax.

Figure 17–12 XMLCOLATTVAL Syntax



The arguments are used as the values of the `name` attribute of the `column` element. The *`c_alias`* values are used as the attribute identifiers.

As an alternative to using keyword `AS` followed by a *literal* string *`c_alias`*, you can use `AS EVALNAME` followed by an expression that evaluates to a string to be used as the attribute identifier.

Because argument values *`value_expr`* are used only as attribute *values*, they need *not* be escaped in any way. This is in contrast to function `XMLForest`. It means that you can use `XMLColAttVal` to transport SQL columns and values without escaping.

Example 17–22 XMLCOLATTVAL: Generating Elements with Attribute and Child Elements

This example generates an `Emp` element for each employee, with a `name` attribute and elements with the employee hire date and department as the content.

```
SELECT XMLElement("Emp",
                  XMLAttributes(e.first_name ||' '||e.last_name AS "fullname" ),
                  XMLColAttVal(e.hire_date, e.department_id AS "department"))
  AS "RESULT"
  FROM hr.employees e
  WHERE e.department_id = 30;
```

This query produces the following XML result. (The result is shown here pretty-printed, for clarity.)

```
RESULT
------------------------------------------------------------
<Emp fullname="Den Raphaely">
  <column name = "HIRE_DATE">1994-12-07</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Alexander Khoo">
  <column name = "HIRE_DATE">1995-05-18</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Shelli Baida">
  <column name = "HIRE_DATE">1997-12-24</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Sigal Tobias">
  <column name = "HIRE_DATE">1997-07-24</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Guy Himuro">
  <column name = "HIRE_DATE">1998-11-15</column>
  <column name = "department">30</column>
</Emp>
<Emp fullname="Karen Colmenares">
  <column name = "HIRE_DATE">1999-08-10</column>
  <column name = "department">30</column>
```

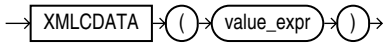
```
</Emp>

6 rows selected.
```

See Also: Example 17–7, "XMLFOREST: Generating Elements with Attribute and Child Elements"

XMLCDATA SQL Function

You use Oracle Database SQL function XMLCDATA to generate an XML CDATA section. Figure 17–13 shows the syntax:

Figure 17–13 XMLCDATA Syntax



Argument *value_expr* is evaluated to a string, and the result is used as the body of the generated XML CDATA section, <![CDATA[*string-result*]]>, where *string-result* is the result of evaluating *value_expr*. If *string-result* is the empty string, then the CDATA section is empty: <![CDATA[]]>.

An error is raised if the constructed XML is not a legal XML CDATA section. In particular, *string-result* must *not* contain two consecutive right brackets (]): "]]".

Function XMLCDATA returns an instance of XMLType. If *string-result* is NULL, then the function returns NULL.

Example 17–23 Using XMLCDATA

```
SELECT XMLElement("PurchaseOrder",
                  XMLElement("Address",
                             XMLCDATA('100 Pennsylvania Ave.'),
                             XMLElement("City", 'Washington, D.C.')))
  AS RESULT FROM DUAL;
```

This results in the following output. (The result is shown here pretty-printed, for clarity.)

```
RESULT
--------------------------
<PurchaseOrder>
  <Address>
    <![CDATA[100 Pennsylvania Ave.]]>
    <City>Washington, D.C.</City>
  </Address>
</PurchaseOrder>
```

Generating XML Using DBMS_XMLGEN

PL/SQL package DBMS_XMLGEN creates XML documents from SQL query results. It retrieves an XML document as a CLOB or XMLType value.

It provides a *fetch* interface, whereby you can specify the maximum number of rows to retrieve and the number of rows to skip. For example, the first fetch could retrieve a maximum of ten rows, skipping the first four. This is especially useful for pagination requirements in Web applications.

Package DBMS_XMLGEN also provides options for changing tag names for ROW, ROWSET, and so on. The parameters of the package can restrict the number of rows retrieved and the enclosing tag names.

See Also:

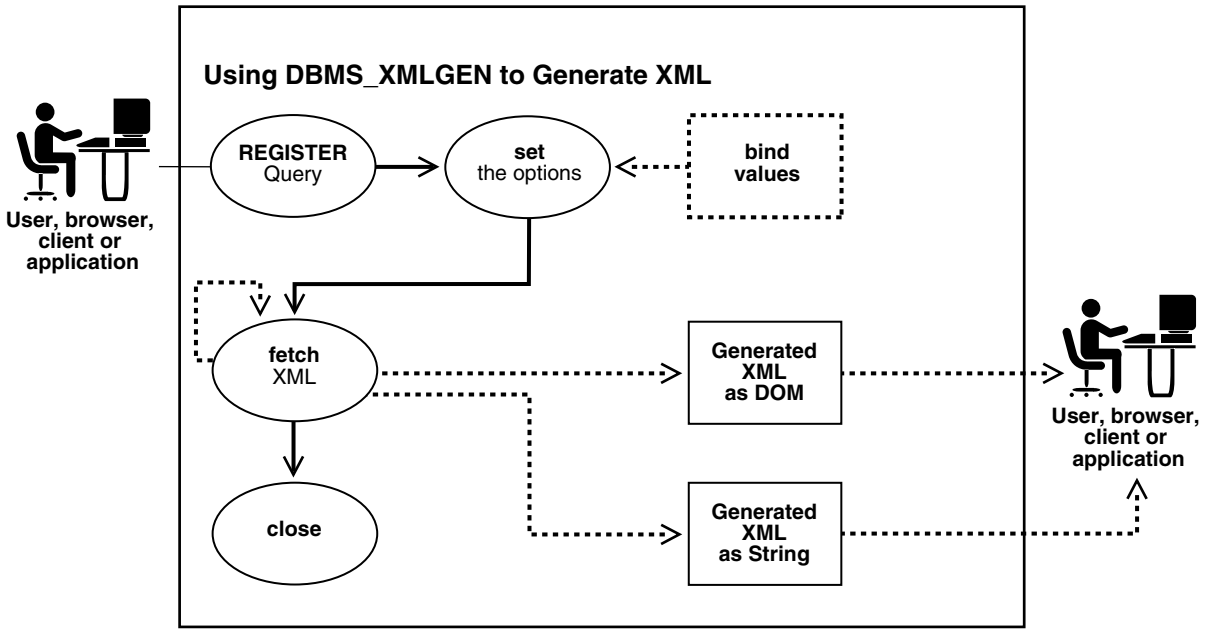
- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle XML Developer's Kit Programmer's Guide* (compare OracleXMLQuery with DBMS_XMLGEN)

Using DBMS_XMLGEN

Figure 17–14 illustrates how to use package DBMS_XMLGEN. The steps are as follows:

1. Get the context from the package by supplying a SQL query and calling PL/SQL function newContext.
2. Pass the context to all procedures or functions in the package to set the various options. For example, to set the ROW element name, use setRowTag(ctx), where ctx is the context got from the previous newContext call.
3. Get the XML result, using PL/SQL function getXML or getXMLType. By setting the maximum number of rows to be retrieved for each fetch using PL/SQL procedure setMaxRows, you can call either of these functions repeatedly, retrieving up to the maximum number of rows for each call. These functions return XML data (as a CLOB value and as an instance of XMLType, respectively), unless there are no rows retrieved; in that case, these functions return NULL. To determine how many rows were retrieved, use PL/SQL function getNumRowsProcessed.
4. You can reset the query to start again and repeat step 3.
5. Call PL/SQL procedure closeContext to free up any previously allocated resources.

Figure 17–14 Using DBMS_XMLGEN



In conjunction with a SQL query, method DBMS_XMLGEN.getXML() typically returns a result like the following, as a CLOB value:

```
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-87</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-89</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
</ROWSET>
```

The default mapping between relational data and XML data is as follows:

- Each row returned by the SQL query maps to an XML element with the default element name ROW.
- Each column returned by the SQL query maps to a child element of the ROW element.
- The entire result is wrapped in a ROWSET element.
- Binary data is transformed to its hexadecimal representation.

Element names ROW and ROWSET can be replaced with names you choose, using DBMS_XMLGEN procedures setRowTagName() and setRowSetTagName(), respectively.

The CLOB value returned by getXML() has the same encoding as the database character set. If the database character set is SHIFTJIS, then the XML document returned is also SHIFTJIS.

Functions and Procedures of Package DBMS_XMLGEN

Table 17–1 describes the functions and procedures of package DBMS_XMLGEN.

Table 17–1 DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description

`DBMS_XMLGEN` type definitions
`SUBTYPE ctxHandle IS NUMBER`
	The context handle used by all functions.
	Document Type Definition (DTD) or schema specifications:
	`NONE CONSTANT NUMBER:= 0;`
	`DTD CONSTANT NUMBER:= 1;`
	`SCHEMA CONSTANT NUMBER:= 2;`
	Can be used in function `getXML` to specify whether to generate a DTD or XML schema or neither (`NONE`). Only the `NONE` specification is supported.

FUNCTION PROTOTYPES `newContext()`	Given a query string, generate a new context handle to be used in subsequent functions.

FUNCTION
`newContext(`
`  queryString IN VARCHAR2)`
	Returns a new context
	Parameter: `queryString (IN)` - the query string, the result of which must be converted to XML
	Returns: Context handle. Call this function first to obtain a handle that you can use in the `getXML()` and other functions to get the XML back from the result.

FUNCTION
`newContext(`
`  queryString IN SYS_REFCURSOR)`
`  RETURN ctxHandle;`
	Creates a new context handle from a PL/SQL cursor variable. The context handle can be used for the rest of the functions.

FUNCTION
`newContextFromHierarchy(`
`  queryString IN VARCHAR2)`
`  RETURN ctxHandle;`
	Parameter: `queryString (IN)` - the query string, the result of which must be converted to XML. The query is a hierarchical query typically formed using a `CONNECT BY` clause, and the result must have the same property as the result set generated by a `CONNECT BY` query. The result set must have only two columns, the level number and an XML value. The level number is used to determine the hierarchical position of the XML value within the result XML document.
	Returns: Context handle. Call this function first to obtain a handle that you can use in the `getXML()` and other functions to get a hierarchical XML with recursive elements back from the result.

`setRowTag()`	Sets the name of the element separating all the rows. The default name is `ROW`.

PROCEDURE
`setRowTag(ctx IN ctxHandle,`
`  rowTag IN VARCHAR2);`
	Parameters:
	`ctx(IN)` - the context handle obtained from the newContext call.
	`rowTag(IN)` - the name of the `ROW` element. A `NULL` value for `rowTag` indicates that you do not want the `ROW` element to be present.
	Call this procedure to set the name of the `ROW` element, if you do not want the default `ROW` name to show up. You can also set `rowTag` to `NULL` to suppress the `ROW` element itself.
	However, since getXML returns complete XML documents, not XML fragments, there must be a (single) root element. Therefore, an error is raised if both the `rowTag` value and the `rowSetTag` value (see `setRowSetTag`, next) are `NULL` and there is more than one column or row in the output.

`setRowSetTag()`	Sets the name of the document root element. The default name is `ROWSET`

Table 17–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
PROCEDURE `setRowSetTag(ctx IN ctxHandle, rowSetTag IN VARCHAR2);`	*Parameters:* `ctx(IN)` – the context handle obtained from the `newContext` call. `rowSetTag(IN)` – the name of the document root element to be used in the output. A `NULL` value for `rowSetTag` indicates that you do *not* want the `ROWSET` element to be present. Call this procedure to set the name of the document root element, if you do not want the default name `ROWSET` to be used. You can set `rowSetTag` to `NULL` to suppress printing of the document root element. However, since function `getXML` returns complete XML documents, not XML fragments, there must be a (single) root element. Therefore, an error is raised if both the `rowTag` value and the `rowSetTag` value (see `setRowTag`, previous) are `NULL` and there is more than one column or row in the output, or if the `rowSetTag` value is `NULL` and there is more than one row in the output.
`getXML()`	Gets the XML document by fetching the maximum number of rows specified. It appends the XML document to the `CLOB` passed in.
PROCEDURE `getXML(ctx IN ctxHandle, clobval IN OUT NCOPY clob, dtdOrSchema IN number:= NONE);`	*Parameters:* `ctx(IN)` - The context handle obtained from the newContext() call, `clobval(IN/OUT)` - the `CLOB` to which the XML document is to be appended, `dtdOrSchema(IN)` - whether you should generate the DTD or Schema. This parameter is NOT supported. Use this version of the getXML function, to avoid any extra `CLOB` copies and if you want to reuse the same `CLOB` for subsequent calls. This `getXML()` call is more efficient than the next flavor, though this involves that you create the LOB locator. When generating the XML, the number of rows indicated by the `setSkipRows` call are skipped, then the maximum number of rows as specified by the `setMaxRows` call (or the entire result if not specified) is fetched and converted to XML. Use the `getNumRowsProcessed` function to check if any rows were retrieved or not.
`getXML()`	Generates the XML document and returns it as a `CLOB`.
FUNCTION `getXML(ctx IN ctxHandle, dtdOrSchema IN number:= NONE) RETURN clob;`	*Parameters:* `ctx(IN)` - The context handle obtained from the `newContext()` call, `dtdOrSchema(IN)` - whether we should generate the DTD or Schema. This parameter is *not* supported. *Returns:* A temporary `CLOB` containing the document. Free the temporary `CLOB` obtained from this function using the `DBMS_LOB.freeTemporary` call.

Table 17–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description

FUNCTION
`getXMLType(`
`  ctx IN ctxHandle,`
`  dtdOrSchema IN number:= NONE)`
`  RETURN XMLType;`
	Parameters:
	`ctx(IN)` - The context handle obtained from the `newContext()` call,
	`dtdOrSchema(IN)` - whether we should generate the DTD or Schema. This parameter is *not* supported.
	Returns: An `XMLType` instance containing the document.

FUNCTION
`getXML(`
`  sqlQuery IN VARCHAR2,`
`  dtdOrSchema IN NUMBER := NONE)`
`  RETURN CLOB;`
	Converts the query results from the passed in SQL query string to XML format, and returns the XML as a `CLOB`.

FUNCTION
`getXMLType(`
`  sqlQuery IN VARCHAR2,`
`  dtdOrSchema IN NUMBER := NONE)`
`  RETURN XMLType;`
	Converts the query results from the passed in SQL query string to XML format, and returns the XML as a `CLOB`.

`getNumRowsProcessed()`	Gets the number of SQL rows processed when generating XML data using function `getXML`. This count does not include the number of rows *skipped* before generating XML data.

FUNCTION
`getNumRowsProcessed(ctx IN ctxHandle)`
`  RETURN number;`
	Parameter: `queryString(IN)`- the query string, the result of which needs to be converted to XML
	Returns: The number of SQL rows that were processed in the last call to `getXML`.
	You can call this to find out if the end of the result set has been reached. This does not include the number of rows *skipped* before generating XML data. Use this function to determine the terminating condition if you are calling `getXML` in a loop. Note that `getXML` would always generate an XML document even if there are no rows present.

`setMaxRows()`	Sets the maximum number of rows to fetch from the SQL query result for every invocation of the `getXML` call. It is an error to call this function on a context handle created by `newContextFromHierary()` function

PROCEDURE
`setMaxRows(ctx IN ctxHandle,`
`  maxRows IN NUMBER);`
	Parameters:
	`ctx(IN)` - the context handle corresponding to the query executed,
	`maxRows(IN)` - the maximum number of rows to get for each call to `getXML`.
	The `maxRows` parameter can be used when generating paginated results using this utility. For instance when generating a page of XML or HTML data, you can restrict the number of rows converted to XML and then in subsequent calls, you can get the next set of rows and so on. This also can provide for faster response times. It is an error to call this procedure on a context handle created by `newContextFromHierary()` function

`setSkipRows()`	Skips a given number of rows before generating the XML output for every call to the `getXML()` routine. It is an error to call this function on a context handle created by function `newContextFormHierarchy()`.

Table 17–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
PROCEDURE `setSkipRows(ctx IN ctxHandle, skipRows IN NUMBER);`	*Parameters:* `ctx(IN)` - the context handle corresponding to the query executed, `skipRows(IN)` - the number of rows to skip for each call to `getXML`. The `skipRows` parameter can be used when generating paginated results for stateless Web pages using this utility. For instance when generating the first page of XML or HTML data, you can set `skipRows` to zero. For the next set, you can set the `skipRows` to the number of rows that you got in the first case. It is an error to call this function on a context handle created by `newContextFromHierarchy()` function.
`setConvertSpecialChars()`	Sets whether special characters in the XML data need to be converted into their escaped XML equivalent or not. For example, the < sign is converted to `<`. The default is to perform escape conversions.
PROCEDURE `setConvertSpecialChars( ctx IN ctxHandle, conv IN BOOLEAN);`	*Parameters:* `ctx(IN)` - the context handle to use, `conv(IN)` - true indicates that conversion is needed. You can use this function to speed up the XML processing whenever you are sure that the input data cannot contain any special characters such as **<**, **>**, **"**, **'**, and so on, which must be preceded by an escape character. It is expensive to scan the character data to replace the special characters, particularly if it involves a lot of data. So, in cases when the data is XML-safe, this function can be called to improve performance.
`useItemTagsForColl()`	Sets the name of the collection elements. The default name for collection elements it the type name itself. You can override that to use the name of the column with the `_ITEM` tag appended to it using this function.
PROCEDURE `useItemTagsForColl(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle. If you have a collection of `NUMBER`, say, the default tag name for the collection elements is `NUMBER`. You can override this action and generate the collection column name with the `_ITEM` tag appended to it, by calling this procedure.
`restartQuery()`	Restarts the query and generate the XML from the first row again.
PROCEDURE `restartQuery(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle corresponding to the current query. You can call this to start executing the query again, without having to create a new context.
`closeContext()`	Closes a given context and releases all resources associated with that context, including the SQL cursor and bind and define buffers, and so on.
PROCEDURE `closeContext(ctx IN ctxHandle);`	*Parameter:* `ctx(IN)` - the context handle to close. Closes all resources associated with this handle. After this you cannot use the handle for any other `DBMS_XMLGEN` function call.

Table 17–1 (Cont.) DBMS_XMLGEN Functions and Procedures

Function or Procedure	Description
Conversion Functions	

FUNCTION
`convert(`
`  xmlData IN varchar2,`
`  flag IN NUMBER := ENTITY_ENCODE)`
`  RETURN VARCHAR2;`
	Encodes or decodes the XML data string argument.
	■ Encoding refers to replacing entity references such as < to their escaped equivalent, such as `<`.
	■ Decoding refers to the reverse conversion.

FUNCTION
`convert(`
`  xmlData IN CLOB,`
`  flag IN NUMBER := ENTITY_ENCODE)`
`  RETURN CLOB;`
	Encodes or decodes the passed in XML CLOB data.
	■ Encoding refers to replacing entity references such as < to their escaped equivalent, such as `<`.
	■ Decoding refers to the reverse conversion.

NULL Handling
PROCEDURE
`setNullHandling(ctx IN ctxHandle,`
`  flag IN NUMBER);`
	The `setNullHandling` flag values are:
	■ `DROP_NULLS CONSTANT NUMBER := 0;` This is the default setting and leaves out the tag for `NULL` elements.
	■ `NULL_ATTR CONSTANT NUMBER := 1;` This sets `xsi:nil="true"`.
	■ `EMPTY_TAG CONSTANT NUMBER := 2;` This sets, for example, `<foo/>`.

PROCEDURE
`useNullAttributeIndicator(`
`  ctx IN ctxHandle,`
`  attrind IN BOOLEAN := TRUE);`
	`useNullAttributeIndicator` is a shortcut for `setNullHandling(ctx, NULL_ATTR)`.

PROCEDURE
`setBindValue(`
`  ctx IN ctxHandle,`
`  bindVariableName IN VARCHAR2,`
`  bindValue IN VARCHAR2);`
	Sets bind value for the bind variable appearing in the query string associated with the context handle. The query string with bind variables cannot be executed until all the bind variables are set values using `setBindValue()` call.

PROCEDURE `clearBindValue(ctx IN ctxHandle);`	Clears all the bind values for all the bind variables appearing in the query string associated with the context handle. Afterwards, all the bind variables have to rebind new values using `setBindValue()` call.

DBMS_XMLGEN Examples

Example 17–24 DBMS_XMLGEN: Generating Simple XML

This example creates an XML document by selecting employee data from an object-relational table and putting the resulting `CLOB` value into a table.

```
CREATE TABLE temp_clob_tab(result CLOB);

DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  qryCtx := DBMS_XMLGEN.newContext('SELECT * FROM hr.employees');
  -- Set the row header to be EMPLOYEE
  DBMS_XMLGEN.setRowTag(qryCtx, 'EMPLOYEE');
  -- Get the result
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
```

```
  --Close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/
```

This query example generates the following XML (only part of the result is shown):

```
SELECT * FROM temp_clob_tab WHERE ROWNUM = 1;

RESULT
------------------------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-87</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </EMPLOYEE>

...

1 row selected.
```

Example 17–25 DBMS_XMLGEN: Generating Simple XML with Pagination (Fetch)

Instead of generating all the XML data for all rows, you can use the *fetch* interface of `DBMS_XMLGEN` to retrieve a fixed number of rows each time. This speeds up response time and can help in scaling applications that need a Document Object Model (DOM) Application Program Interface (API) on the resulting XML, particularly if the number of rows is large.

The following example uses package `DBMS_XMLGEN` to retrieve results from table `hr.employees`:

```
-- Create a table to hold the results
CREATE TABLE temp_clob_tab(result clob);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  -- Get the query context;
  qryCtx := DBMS_XMLGEN.newContext('SELECT * FROM hr.employees');
  -- Set the maximum number of rows to be 2
  DBMS_XMLGEN.setMaxRows(qryCtx, 2);
  LOOP
    -- Get the result
    result := DBMS_XMLGEN.getXML(qryCtx);
    -- If no rows were processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;

    -- Do some processing with the lob data
    --   Here, we insert the results into a table.
    --   You can print the lob out, output it to a stream,
    --   put it in a queue, or do any other processing.
    INSERT INTO temp_clob_tab VALUES(result);
```

```
  END LOOP;
  --close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/

SELECT * FROM temp_clob_tab WHERE rownum <3;

RESULT
--------------------------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-87</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-89</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>102</EMPLOYEE_ID>
  <FIRST_NAME>Lex</FIRST_NAME>
  <LAST_NAME>De Haan</LAST_NAME>
  <EMAIL>LDEHAAN</EMAIL>
  <PHONE_NUMBER>515.123.4569</PHONE_NUMBER>
  <HIRE_DATE>13-JAN-93</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>103</EMPLOYEE_ID>
  <FIRST_NAME>Alexander</FIRST_NAME>
  <LAST_NAME>Hunold</LAST_NAME>
  <EMAIL>AHUNOLD</EMAIL>
  <PHONE_NUMBER>590.423.4567</PHONE_NUMBER>
  <HIRE_DATE>03-JAN-90</HIRE_DATE>
  <JOB_ID>IT_PROG</JOB_ID>
  <SALARY>9000</SALARY>
```

```
  <MANAGER_ID>102</MANAGER_ID>
  <DEPARTMENT_ID>60</DEPARTMENT_ID>
 </ROW>
</ROWSET>

2 rows selected.
```

Example 17–26 DBMS_XMLGEN: Generating Nested XML With Object Types

This example uses object types to represent nested structures.

```
CREATE TABLE new_departments(department_id   NUMBER PRIMARY KEY,
                             department_name VARCHAR2(20));
CREATE TABLE new_employees(employee_id       NUMBER PRIMARY KEY,
                           last_name         VARCHAR2(20),
                           department_id     NUMBER REFERENCES new_departments);
CREATE TYPE emp_t AS OBJECT("@employee_id"   NUMBER,
                            last_name        VARCHAR2(20));
/
INSERT INTO new_departments VALUES(10, 'SALES');
INSERT INTO new_departments VALUES(20, 'ACCOUNTING');
INSERT INTO new_employees   VALUES(30, 'Scott', 10);
INSERT INTO new_employees   VALUES(31, 'Mary',  10);
INSERT INTO new_employees   VALUES(40, 'John',  20);
INSERT INTO new_employees   VALUES(41, 'Jerry', 20);
COMMIT;
CREATE TYPE emplist_t AS TABLE OF emp_t;
/
CREATE TYPE dept_t AS OBJECT("@department_id" NUMBER,
                             department_name  VARCHAR2(20),
                             emplist          emplist_t);
/
CREATE TABLE temp_clob_tab(result CLOB);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  DBMS_XMLGEN.setRowTag(qryCtx, NULL);
  qryCtx := DBMS_XMLGEN.newContext
    ('SELECT dept_t(department_id,
                    department_name,
                    CAST(MULTISET
                           (SELECT e.employee_id, e.last_name
                              FROM new_employees e
                              WHERE e.department_id = d.department_id)
                         AS emplist_t))
        AS deptxml
        FROM new_departments d');
  -- now get the result
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES (result);
  -- close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/
SELECT * FROM temp_clob_tab;
```

Here is the resulting XML:

```
RESULT
-----------------------------------------
```

```
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <DEPTXML department_id="10">
   <DEPARTMENT_NAME>SALES</DEPARTMENT_NAME>
   <EMPLIST>
    <EMP_T employee_id="30">
     <LAST_NAME>Scott</LAST_NAME>
    </EMP_T>
    <EMP_T employee_id="31">
     <LAST_NAME>Mary</LAST_NAME>
    </EMP_T>
   </EMPLIST>
  </DEPTXML>
 </ROW>
 <ROW>
  <DEPTXML department_id="20">
   <DEPARTMENT_NAME>ACCOUNTING</DEPARTMENT_NAME>
   <EMPLIST>
    <EMP_T employee_id="40">
     <LAST_NAME>John</LAST_NAME>
    </EMP_T>
    <EMP_T employee_id="41">
     <LAST_NAME>Jerry</LAST_NAME>
    </EMP_T>
   </EMPLIST>
  </DEPTXML>
 </ROW>
</ROWSET>

1 row selected.
```

With relational data, the result is an XML document without nested elements. To obtain nested XML structures, you can use object-relational data, where the mapping is as follows:

- *Object types* map as an XML element – see Chapter 6, "XML Schema Storage and Query: Basic".
- *Attributes of the type* map to sub-elements of the parent element

> **Note:** Complex structures can be obtained by using object types and creating object views or object tables. A canonical mapping is used to map object instances to XML.
>
> When used in column names or attribute names, the at-sign (`@`) is translated into an attribute of the enclosing XML element in the mapping.

Example 17–27 DBMS_XMLGEN: Generating Nested XML With User-Defined Data-Type Instances

When you provide a user-defined data-type instance to `DBMS_XMLGEN` functions, the user-defined data-type instance is mapped to an XML document using canonical mapping: the *attributes* of the user-defined data type are mapped to XML *elements*. Attributes with names starting with an at-sign character (`@`) are mapped to attributes of the preceding element.

User-defined data-type instances can be used for nesting in the resulting XML document. For example, consider tables, `emp` and `dept`:

```
CREATE TABLE dept(deptno NUMBER PRIMARY KEY, dname VARCHAR2(20));
CREATE TABLE emp(empno   NUMBER PRIMARY KEY, ename VARCHAR2(20),
                 deptno  NUMBER REFERENCES dept);
```

To generate a hierarchical view of the data, that is, departments with employees in them, you can define suitable object types to create the structure inside the database as follows:

```
-- empno is preceded by an at-sign (@) to indicate that it must
-- be mapped as an attribute of the enclosing Employee element.
CREATE TYPE emp_t AS OBJECT("@empno" NUMBER,  -- empno defined as attribute
                            ename   VARCHAR2(20));
/
INSERT INTO DEPT VALUES(10, 'Sports');
INSERT INTO DEPT VALUES(20, 'Accounting');
INSERT INTO EMP VALUES(200, 'John',  10);
INSERT INTO EMP VALUES(300, 'Jack',  10);
INSERT INTO EMP VALUES(400, 'Mary',  20);
INSERT INTO EMP VALUES(500, 'Jerry', 20);
COMMIT;
CREATE TYPE emplist_t AS TABLE OF emp_t;
/
CREATE TYPE dept_t AS OBJECT("@deptno" NUMBER,
                            dname     VARCHAR2(20),
                            emplist   emplist_t);
/
-- Department type dept_t contains a list of employees.
-- We can now query the employee and department tables and get
-- the result as an XML document, as follows:
CREATE TABLE temp_clob_tab(result CLOB);
DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  RESULT CLOB;
BEGIN
  -- get query context
  qryCtx := DBMS_XMLGEN.newContext(
    'SELECT dept_t(deptno,
                   dname,
                   CAST(MULTISET(SELECT empno, ename
                                 FROM emp e
                                 WHERE e.deptno = d.deptno)
                        AS emplist_t))
       AS deptxml
       FROM dept d');
  -- set maximum number of rows to 5
  DBMS_XMLGEN.setMaxRows(qryCtx, 5);
  -- set no row tag for this result, since there is a single ADT column
  DBMS_XMLGEN.setRowTag(qryCtx, NULL);
  LOOP
    -- get result
    result := DBMS_XMLGEN.getXML(qryCtx);
    -- if there were no rows processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;
    -- do something with the result
    INSERT INTO temp_clob_tab VALUES (result);
  END LOOP;
END;
/
```

Function MULTISET treats the employees working in the department as a list, and function CAST assigns this list to the appropriate collection type. A department instance is created, and DBMS_XMLGEN routines create the XML for the object instance.

```
SELECT * FROM temp_clob_tab;

RESULT
--------------------------------
<?xml version="1.0"?>
<ROWSET>
 <DEPTXML deptno="10">
  <DNAME>Sports</DNAME>
  <EMPLIST>
   <EMP_T empno="200">
    <ENAME>John</ENAME>
   </EMP_T>
   <EMP_T empno="300">
    <ENAME>Jack</ENAME>
   </EMP_T>
  </EMPLIST>
 </DEPTXML>
 <DEPTXML deptno="20">
  <DNAME>Accounting</DNAME>
  <EMPLIST>
   <EMP_T empno="400">
    <ENAME>Mary</ENAME>
   </EMP_T>
   <EMP_T empno="500">
    <ENAME>Jerry</ENAME>
   </EMP_T>
  </EMPLIST>
 </DEPTXML>
</ROWSET>

1 row selected.
```

The default name ROW is not present because we set that to NULL. The deptno and empno have become attributes of the enclosing element.

Example 17–28 DBMS_XMLGEN: Generating an XML Purchase Order

This example uses DBMS_XMLGEN.getXMLType() to generate a purchase order in XML format using object views.

```
-- Create relational schema and define object views
-- DBMS_XMLGEN maps user-defined data-type attribute names that start
--    with an at-sign (@) to XML attributes

-- Purchase Order Object View Model

-- PhoneList varray object type
CREATE TYPE phonelist_vartyp AS VARRAY(10) OF VARCHAR2(20)
/
-- Address object type
CREATE TYPE address_typ AS OBJECT(Street VARCHAR2(200),
                                  City   VARCHAR2(200),
                                  State  CHAR(2),
                                  Zip    VARCHAR2(20))
/
-- Customer object type
```

```
CREATE TYPE customer_typ AS OBJECT(CustNo    NUMBER,
                                   CustName  VARCHAR2(200),
                                   Address   address_typ,
                                   PhoneList phonelist_vartyp)
/
-- StockItem object type
CREATE TYPE stockitem_typ AS OBJECT("@StockNo" NUMBER,
                                    Price      NUMBER,
                                    TaxRate    NUMBER)
/
-- LineItems object type
CREATE TYPE lineitem_typ AS OBJECT("@LineItemNo" NUMBER,
                                   Item          stockitem_typ,
                                   Quantity      NUMBER,
                                   Discount      NUMBER)
/
-- LineItems ordered collection table
CREATE TYPE lineitems_ntabtyp AS TABLE OF lineitem_typ
/
-- Purchase Order object type
CREATE TYPE po_typ AUTHID CURRENT_USER
  AS OBJECT(PONO            NUMBER,
            Cust_ref        REF customer_typ,
            OrderDate       DATE,
            ShipDate        TIMESTAMP,
            LineItems_ntab  lineitems_ntabtyp,
            ShipToAddr      address_typ)
/
-- Create Purchase Order relational model tables
-- Customer table
CREATE TABLE customer_tab(CustNo     NUMBER NOT NULL,
                          CustName   VARCHAR2(200),
                          Street     VARCHAR2(200),
                          City       VARCHAR2(200),
                          State      CHAR(2),
                          Zip        VARCHAR2(20),
                          Phone1     VARCHAR2(20),
                          Phone2     VARCHAR2(20),
                          Phone3     VARCHAR2(20),
                          CONSTRAINT cust_pk PRIMARY KEY (CustNo));
-- Purchase Order table
CREATE TABLE po_tab (PONo       NUMBER,        /* purchase order number */
                     Custno     NUMBER     /*  foreign KEY referencing customer */
                                CONSTRAINT po_cust_fk REFERENCES customer_tab,
                     OrderDate  DATE,          /*  date of order */
                     ShipDate   TIMESTAMP,     /* date to be shipped */
                     ToStreet   VARCHAR2(200), /* shipto address */
                     ToCity     VARCHAR2(200),
                     ToState    CHAR(2),
                     ToZip      VARCHAR2(20),
                     CONSTRAINT po_pk PRIMARY KEY(PONo));
--Stock Table
CREATE TABLE stock_tab (StockNo NUMBER CONSTRAINT stock_uk UNIQUE,
                        Price   NUMBER,
                        TaxRate NUMBER);
--Line Items table
CREATE TABLE lineitems_tab(LineItemNo NUMBER,
                           PONo       NUMBER
                                      CONSTRAINT li_po_fk REFERENCES po_tab,
                           StockNo    NUMBER,
```

```
                          Quantity   NUMBER,
                          Discount   NUMBER,
                          CONSTRAINT li_pk PRIMARY KEY (PONo, LineItemNo));
-- Create Object views
-- Customer Object View
CREATE OR REPLACE VIEW customer OF customer_typ
  WITH OBJECT IDENTIFIER(CustNo)
  AS SELECT c.custno, c.custname,
            address_typ(c.street, c.city, c.state, c.zip),
            phonelist_vartyp(phone1, phone2, phone3)
       FROM customer_tab c;
--Purchase order view
CREATE OR REPLACE VIEW po OF po_typ
  WITH OBJECT IDENTIFIER (PONo)
  AS SELECT p.pono, make_ref(Customer, P.Custno), p.orderdate, p.shipdate,
            CAST(MULTISET(
                   SELECT lineitem_typ(l.lineitemno, stockitem_typ(l.stockno,
                                                                   s.price,
                                                                   s.taxrate),
                                       l.quantity, l.discount)
                     FROM lineitems_tab l, stock_tab s
                     WHERE l.pono = p.pono AND s.stockno=l.stockno)
                AS lineitems_ntabtyp),
            address_typ(p.tostreet,p.tocity, p.tostate, p.tozip)
       FROM po_tab p;
-- Create table with XMLType column to store purchase order in XML format
CREATE TABLE po_xml_tab(poid  NUMBER, podoc XMLType)
/
-- Populate data
-------------------
-- Establish Inventory
INSERT INTO stock_tab VALUES(1004, 6750.00, 2);
INSERT INTO stock_tab VALUES(1011, 4500.23, 2);
INSERT INTO stock_tab VALUES(1534, 2234.00, 2);
INSERT INTO stock_tab VALUES(1535, 3456.23, 2);
-- Register Customers
INSERT INTO customer_tab
  VALUES (1, 'Jean Nance', '2 Avocet Drive',
          'Redwood Shores', 'CA', '95054',
          '415-555-1212', NULL, NULL);
INSERT INTO customer_tab
  VALUES (2, 'John Nike', '323 College Drive',
          'Edison', 'NJ', '08820',
          '609-555-1212', '201-555-1212', NULL);
-- Place orders
INSERT INTO po_tab
  VALUES (1001, 1, '10-APR-1997', '10-MAY-1997',
          NULL, NULL, NULL, NULL);
INSERT INTO po_tab
  VALUES (2001, 2, '20-APR-1997', '20-MAY-1997',
          '55 Madison Ave', 'Madison', 'WI', '53715');
-- Detail line items
INSERT INTO lineitems_tab VALUES(01, 1001, 1534, 12,  0);
INSERT INTO lineitems_tab VALUES(02, 1001, 1535, 10, 10);
INSERT INTO lineitems_tab VALUES(01, 2001, 1004,  1,  0);
INSERT INTO lineitems_tab VALUES(02, 2001, 1011,  2,  1);

-- Use package DBMS_XMLGEN to generate purchase order in XML format
--   and store XMLType in table po_xml
DECLARE
```

```
  qryCtx DBMS_XMLGEN.ctxHandle;
  pxml XMLType;
  cxml CLOB;
BEGIN
  -- get query context;
  qryCtx := DBMS_XMLGEN.newContext('SELECT pono,deref(cust_ref) customer,
                                           p.orderdate,
                                           p.shipdate,
                                           lineitems_ntab lineitems,
                                           shiptoaddr
                                      FROM po p');
  -- set maximum number of rows to be 1,
  DBMS_XMLGEN.setMaxRows(qryCtx, 1);
  -- set ROWSET tag to NULL and ROW tag to PurchaseOrder
  DBMS_XMLGEN.setRowSetTag(qryCtx, NULL);
  DBMS_XMLGEN.setRowTag(qryCtx, 'PurchaseOrder');
  LOOP
    -- get purchase order in XML format
    pxml := DBMS_XMLGEN.getXMLType(qryCtx);
    -- if there were no rows processed, then quit
    EXIT WHEN DBMS_XMLGEN.getNumRowsProcessed(qryCtx) = 0;
    -- Store XMLType po in po_xml table (get the pono out)
    INSERT INTO po_xml_tab(poid, poDoc)
      VALUES(pxml.extract('//PONO/text()').getNumberVal(), pxml);
  END LOOP;
END;
/
```

This query then produces two XML purchase-order documents:

```
SELECT x.podoc.getCLOBVal() xpo FROM po_xml_tab x;

XPO
--------------------------------------------------
 <PurchaseOrder>
  <PONO>1001</PONO>
  <CUSTOMER>
   <CUSTNO>1</CUSTNO>
   <CUSTNAME>Jean Nance</CUSTNAME>
   <ADDRESS>
    <STREET>2 Avocet Drive</STREET>
    <CITY>Redwood Shores</CITY>
    <STATE>CA</STATE>
    <ZIP>95054</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>415-555-1212</VARCHAR2>
   </PHONELIST>
  </CUSTOMER>
  <ORDERDATE>10-APR-97</ORDERDATE>
  <SHIPDATE>10-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1534">
     <PRICE>2234</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>12</QUANTITY>
    <DISCOUNT>0</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
```

```
    <ITEM StockNo="1535">
     <PRICE>3456.23</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>10</QUANTITY>
    <DISCOUNT>10</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR/>
 </PurchaseOrder>

 <PurchaseOrder>
  <PONO>2001</PONO>
  <CUSTOMER>
   <CUSTNO>2</CUSTNO>
   <CUSTNAME>John Nike</CUSTNAME>
   <ADDRESS>
    <STREET>323 College Drive</STREET>
    <CITY>Edison</CITY>
    <STATE>NJ</STATE>
    <ZIP>08820</ZIP>
   </ADDRESS>
   <PHONELIST>
    <VARCHAR2>609-555-1212</VARCHAR2>
    <VARCHAR2>201-555-1212</VARCHAR2>
   </PHONELIST>
  </CUSTOMER>
  <ORDERDATE>20-APR-97</ORDERDATE>
  <SHIPDATE>20-MAY-97 12.00.00.000000 AM</SHIPDATE>
  <LINEITEMS>
   <LINEITEM_TYP LineItemNo="1">
    <ITEM StockNo="1004">
     <PRICE>6750</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>1</QUANTITY>
    <DISCOUNT>0</DISCOUNT>
   </LINEITEM_TYP>
   <LINEITEM_TYP LineItemNo="2">
    <ITEM StockNo="1011">
     <PRICE>4500.23</PRICE>
     <TAXRATE>2</TAXRATE>
    </ITEM>
    <QUANTITY>2</QUANTITY>
    <DISCOUNT>1</DISCOUNT>
   </LINEITEM_TYP>
  </LINEITEMS>
  <SHIPTOADDR>
   <STREET>55 Madison Ave</STREET>
   <CITY>Madison</CITY>
   <STATE>WI</STATE>
   <ZIP>53715</ZIP>
  </SHIPTOADDR>
 </PurchaseOrder>

2 rows selected.
```

Example 17–29 DBMS_XMLGEN: Generating a New Context Handle from a REF Cursor

This example shows how to open a cursor variable for a query and use that cursor variable to create a new context handle for DBMS_XMLGEN.

```
CREATE TABLE emp_tab(emp_id       NUMBER PRIMARY KEY,
                     name         VARCHAR2(20),
                     dept_id      NUMBER);
Table created.
INSERT INTO emp_tab VALUES(122, 'Scott',  301);
1 row created.
INSERT INTO emp_tab VALUES(123, 'Mary',   472);
1 row created.
INSERT INTO emp_tab VALUES(124, 'John',   93);
1 row created.
INSERT INTO emp_tab VALUES(125, 'Howard', 488);
1 row created.
INSERT INTO emp_tab VALUES(126, 'Sue',    16);
1 row created.
COMMIT;

DECLARE
  ctx     NUMBER;
  maxrow  NUMBER;
  xmldoc  CLOB;
  refcur  SYS_REFCURSOR;
BEGIN
  DBMS_LOB.createtemporary(xmldoc, TRUE);
  maxrow := 3;
  OPEN refcur FOR 'SELECT * FROM emp_tab WHERE ROWNUM <= :1' USING maxrow;
  ctx := DBMS_XMLGEN.newContext(refcur);
   -- xmldoc will have 3 rows
  DBMS_XMLGEN.getXML(ctx, xmldoc, DBMS_XMLGEN.NONE);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_LOB.freetemporary(xmldoc);
  CLOSE refcur;
  DBMS_XMLGEN.closeContext(ctx);
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMP_ID>122</EMP_ID>
  <NAME>Scott</NAME>
  <DEPT_ID>301</DEPT_ID>
 </ROW>
 <ROW>
  <EMP_ID>123</EMP_ID>
  <NAME>Mary</NAME>
  <DEPT_ID>472</DEPT_ID>
 </ROW>
 <ROW>
  <EMP_ID>124</EMP_ID>
  <NAME>John</NAME>
  <DEPT_ID>93</DEPT_ID>
 </ROW>
</ROWSET>

PL/SQL procedure successfully completed.
```

See Also: *Oracle Database PL/SQL Language Reference* for more information about cursor variables (`REF CURSOR`)

Example 17–30 DBMS_XMLGEN: Specifying NULL Handling

```
CREATE TABLE emp_tab(emp_id       NUMBER PRIMARY KEY,
                     name         VARCHAR2(20),
                     dept_id      NUMBER);
Table created.
INSERT INTO emp_tab VALUES(30, 'Scott', NULL);
1 row created.
INSERT INTO emp_tab VALUES(31, 'Mary', NULL);
1 row created.
INSERT INTO emp_tab VALUES(40, 'John', NULL);
1 row created.
COMMIT;
CREATE TABLE temp_clob_tab(result CLOB);
Table created.

DECLARE
  qryCtx DBMS_XMLGEN.ctxHandle;
  result CLOB;
BEGIN
  qryCtx := DBMS_XMLGEN.newContext('SELECT * FROM emp_tab where name = :NAME');
  -- Set the row header to be EMPLOYEE
  DBMS_XMLGEN.setRowTag(qryCtx, 'EMPLOYEE');
  -- Drop nulls
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'Scott');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.DROP_NULLS);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  -- Null attribute
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'Mary');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.NULL_ATTR);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  -- Empty tag
  DBMS_XMLGEN.setBindValue(qryCtx, 'NAME', 'John');
  DBMS_XMLGEN.setNullHandling(qryCtx, DBMS_XMLGEN.EMPTY_TAG);
  result := DBMS_XMLGEN.getXML(qryCtx);
  INSERT INTO temp_clob_tab VALUES(result);
  --Close context
  DBMS_XMLGEN.closeContext(qryCtx);
END;
/

PL/SQL procedure successfully completed.

SELECT * FROM temp_clob_tab;

RESULT
-----------------------------------------
<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
  <EMP_ID>30</EMP_ID>
  <NAME>Scott</NAME>
 </EMPLOYEE>
</ROWSET>
```

```
<?xml version="1.0"?>
<ROWSET xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance">
 <EMPLOYEE>
  <EMP_ID>31</EMP_ID>
  <NAME>Mary</NAME>
  <DEPT_ID xsi:nil = "true"/>
 </EMPLOYEE>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <EMPLOYEE>
  <EMP_ID>40</EMP_ID>
  <NAME>John</NAME>
  <DEPT_ID/>
 </EMPLOYEE>
</ROWSET>

3 rows selected.
```

Example 17–31 DBMS_XMLGEN: Generating Recursive XML with a Hierarchical Query

Function `DBMS_XMLGEN.newContextFromHierarchy` takes as argument a hierarchical query string, which is typically formulated with a `CONNECT BY` clause. It returns a context that can be used to generate a hierarchical XML document with recursive elements.

The hierarchical query returns two columns, the level number (a pseudocolumn generated by `CONNECT BY` query) and an `XMLType`. The level is used to determine the position of the `XMLType` value within the hierarchy of the result XML document.

Setting skip number of rows or maximum number of rows for a context created from `newContextFromHierarchy()` is an error.

For example, you can generate a manager employee hierarchy by using `DBMS_XMLGEN.newContextFormHierarchy()`.

```
CREATE TABLE sqlx_display(id NUMBER, xmldoc XMLType);
Table created.
DECLARE
  qryctx DBMS_XMLGEN.ctxhandle;
  result XMLType;
BEGIN
  qryctx :=
    DBMS_XMLGEN.newcontextFromHierarchy(
      'SELECT level,
              XMLElement("employees",
                         XMLElement("enumber", employee_id),
                         XMLElement("name", last_name),
                         XMLElement("Salary", salary),
                         XMLElement("Hiredate", hire_date))
         FROM hr.employees
         START WITH last_name=''De Haan'' CONNECT BY PRIOR employee_id=manager_id
         ORDER SIBLINGS BY hire_date');
  result := DBMS_XMLGEN.getxmltype(qryctx);
  DBMS_OUTPUT.put_line('<result num rows>');
  DBMS_OUTPUT.put_line(to_char(DBMS_XMLGEN.getNumRowsProcessed(qryctx)));
  DBMS_OUTPUT.put_line('</result num rows>');
  INSERT INTO sqlx_display VALUES (2, result);
  COMMIT;
  DBMS_XMLGEN.closecontext(qryctx);
```

```
END;
/
<result num rows>
6
</result num rows>
PL/SQL procedure successfully completed.

SELECT xmldoc FROM sqlx_display WHERE id = 2;

XMLDOC
--------------------------------------------------
<?xml version="1.0"?>
<employees>
  <enumber>102</enumber>
  <name>De Haan</name>
  <Salary>17000</Salary>
  <Hiredate>1993-01-13</Hiredate>
  <employees>
    <enumber>103</enumber>
    <name>Hunold</name>
    <Salary>9000</Salary>
    <Hiredate>1990-01-03</Hiredate>
    <employees>
      <enumber>104</enumber>
      <name>Ernst</name>
      <Salary>6000</Salary>
      <Hiredate>1991-05-21</Hiredate>
    </employees>
    <employees>
      <enumber>105</enumber>
      <name>Austin</name>
      <Salary>4800</Salary>
      <Hiredate>1997-06-25</Hiredate>
    </employees>
    <employees>
      <enumber>106</enumber>
      <name>Pataballa</name>
      <Salary>4800</Salary>
      <Hiredate>1998-02-05</Hiredate>
    </employees>
    <employees>
      <enumber>107</enumber>
      <name>Lorentz</name>
      <Salary>4200</Salary>
      <Hiredate>1999-02-07</Hiredate>
    </employees>
  </employees>
</employees>

1 row selected.
```

By default, the `ROWSET` tag is `NULL`: there is no default `ROWSET` tag used to enclose the XML result. However, you can explicitly set the `ROWSET` tag by using procedure `setRowSetTag()`, as follows:

```
CREATE TABLE gg(x XMLType);
Table created.
DECLARE
  qryctx DBMS_XMLGEN.ctxhandle;
  result CLOB;
```

```
BEGIN
  qryctx := DBMS_XMLGEN.newcontextFromHierarchy(
              'SELECT level,
                     XMLElement("NAME", last_name) AS myname FROM hr.employees
               CONNECT BY PRIOR employee_id=manager_id
               START WITH employee_id = 102');
  DBMS_XMLGEN.setRowSetTag(qryctx, 'mynum_hierarchy');
  result:=DBMS_XMLGEN.getxml(qryctx);
  DBMS_OUTPUT.put_line('<result num rows>');
  DBMS_OUTPUT.put_line(to_char(DBMS_XMLGEN.getNumRowsProcessed(qryctx)));
  DBMS_OUTPUT.put_line('</result num rows>');
  INSERT INTO gg VALUES(XMLType(result));
  COMMIT;
  DBMS_XMLGEN.closecontext(qryctx);
END;
/
<result num rows>
6
</result num rows>
PL/SQL procedure successfully completed.

SELECT * FROM gg;

X
------------------------------------------------------------
<?xml version="1.0"?>
<mynum_hierarchy>
  <NAME>De Haan
    <NAME>Hunold
      <NAME>Ernst</NAME>
      <NAME>Austin</NAME>
      <NAME>Pataballa</NAME>
      <NAME>Lorentz</NAME>
    </NAME>
  </NAME>
</mynum_hierarchy>

1 row selected.
```

Example 17–32 DBMS_XMLGEN: Binding Query Variables with Method setBindValue()

If the query string used to create a context contains host variables, you can use method `setBindValue()` to give the variables values before query execution.

```
-- Bind one variable
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext(
           'SELECT * FROM employees WHERE employee_id = :NO');
  DBMS_XMLGEN.setBindValue(ctx, 'NO', '145');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
```

```
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-96</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>

PL/SQL procedure successfully completed.

--Bind one variable twice with different values
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext('SELECT * FROM employees
                                   WHERE hire_date = :MDATE');
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '01-OCT-96');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '10-MAR-97');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-96</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>

<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>147</EMPLOYEE_ID>
  <FIRST_NAME>Alberto</FIRST_NAME>
  <LAST_NAME>Errazuriz</LAST_NAME>
```

```
  <EMAIL>AERRAZUR</EMAIL>
  <PHONE_NUMBER>011.44.1344.429278</PHONE_NUMBER>
  <HIRE_DATE>10-MAR-97</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>12000</SALARY>
  <COMMISSION_PCT>.3</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>159</EMPLOYEE_ID>
  <FIRST_NAME>Lindsey</FIRST_NAME>
  <LAST_NAME>Smith</LAST_NAME>
  <EMAIL>LSMITH</EMAIL>
  <PHONE_NUMBER>011.44.1345.729268</PHONE_NUMBER>
  <HIRE_DATE>10-MAR-97</HIRE_DATE>
  <JOB_ID>SA_REP</JOB_ID>
  <SALARY>8000</SALARY>
  <COMMISSION_PCT>.3</COMMISSION_PCT>
  <MANAGER_ID>146</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>
PL/SQL procedure successfully completed.
-- Bind two variables
DECLARE
  ctx NUMBER;
  xmldoc CLOB;
BEGIN
  ctx := DBMS_XMLGEN.newContext('SELECT * FROM employees
                                   WHERE employee_id = :NO
                                     AND hire_date = :MDATE');
  DBMS_XMLGEN.setBindValue(ctx, 'NO', '145');
  DBMS_XMLGEN.setBindValue(ctx, 'MDATE', '01-OCT-96');
  xmldoc := DBMS_XMLGEN.getXML(ctx);
  DBMS_OUTPUT.put_line(xmldoc);
  DBMS_XMLGEN.closeContext(ctx);
EXCEPTION
  WHEN OTHERS THEN DBMS_XMLGEN.closeContext(ctx);
  RAISE;
END;
/
<?xml version="1.0"?>
<ROWSET>
 <ROW>
  <EMPLOYEE_ID>145</EMPLOYEE_ID>
  <FIRST_NAME>John</FIRST_NAME>
  <LAST_NAME>Russell</LAST_NAME>
  <EMAIL>JRUSSEL</EMAIL>
  <PHONE_NUMBER>011.44.1344.429268</PHONE_NUMBER>
  <HIRE_DATE>01-OCT-96</HIRE_DATE>
  <JOB_ID>SA_MAN</JOB_ID>
  <SALARY>14000</SALARY>
  <COMMISSION_PCT>.4</COMMISSION_PCT>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>
</ROWSET>
PL/SQL procedure successfully completed.
```

Generating XML Using SQL Function SYS_XMLGEN

This Oracle Database-specific SQL function is similar to the SQL/XML standard function `XMLElement`, except that it takes a single argument and converts the result to an `XMLType` instance. Unlike the other XML generation functions, `sys_XMLGen` always returns a well-formed XML *document*. Unlike package `DBMS_XMLGEN`, which operates at a query level, `sys_XMLGen` operates at the row level, returning an XML *document for each row*.

Example 17–33 Using SYS_XMLGEN to Create XML

In this query, SQL function `sys_XMLGen` queries XML instances and returns an XML document for each row of relational data:

```
SELECT sys_XMLGen(employee_id) AS "result"
  FROM employees WHERE first_name LIKE 'John%';
```

The resulting XML documents are as follows:

```
result
---------------
<?xml version="1.0"?>
<EMPLOYEE_ID>110</EMPLOYEE_ID>

<?xml version="1.0"?>
<EMPLOYEE_ID>139</EMPLOYEE_ID>

<?xml version="1.0"?>
<EMPLOYEE_ID>145</EMPLOYEE_ID>

3 rows selected.
```

SYS_XMLGEN Syntax

SQL function `sys_XMLGen` takes as argument a scalar value, object type, or `XMLType` instance to be converted to an XML document. It also takes an optional `XMLFormat` object (previously called `XMLGenFormatType`), which you can use to specify formatting options for the resulting XML document. The syntax is shown in Figure 17–15.

Figure 17–15 SYS_XMLGEN Syntax

Expression *expr* evaluates to a particular row and column of the database. It can be a scalar value, a user-defined data-type instance, or an `XMLType` instance.

- If *expr* evaluates to a scalar value, then the function returns an XML element containing the scalar value.
- If *expr* evaluates to a user-defined data-type instance, then the function maps the user-defined data-type attributes to XML elements.
- If *expr* evaluates to an `XMLType` instance, then the function encloses the document in an XML element whose default tag name is `ROW`.

By default, the elements of the XML document match the *expr*. For example, if *expr* resolves to a column name, then the enclosing XML element will have the same name

as the column. If you want to format the XML document differently, then specify *fmt*, which is an instance of the XMLFormat object.

You can use a WHERE clause in a query to suppress <ROW/> tags with sys_XMLGen, if you do not want NULL values represented:

```
SELECT sys_XMLGen(x) FROM table_name WHERE x IS NOT NULL;
```

Example 17–34 SYS_XMLGEN: Generating an XML Element from a Database Column

The following example retrieves the employee first_name from sample-schema table hr.employees, where the employee_id value is 110, and generates an XMLType instance containing an XML document with an FIRST_NAME element.

```
SELECT sys_XMLGen(first_name).getStringVal()
  FROM employees
  WHERE employee_id = 110;

SYS_XMLGEN(FIRST_NAME).GETSTRINGVAL()
--------------------------------------
<?xml version="1.0"?>
<FIRST_NAME>John</FIRST_NAME>

1 row selected.
```

Advantages of Using SYS_XMLGEN

SQL function sys_XMLGen has the following advantages:

- You can create and query XML instances *within* SQL queries.
- Using the object-relational infrastructure, you can create complex and nested XML instances from simple relational tables. For example, when you use an XMLType view that uses sys_XMLGen on top of an object type, Oracle XML DB rewrites these queries when possible. See also Chapter 7, "XPath Rewrite".

sys_XMLGen creates an XML document from a user-defined data-type instance, a scalar value, or an XMLType instance. It returns an XMLType instance.

sys_XMLGen also accepts an optional XMLFormat object as argument, which you can use to customize the result. A NULL format object implies that the default mapping action is to be used.

Using XMLFormat Object Type

You can use the XMLFormat object to specify formatting arguments for SQL functions sys_XMLGen and sys_XMLAgg.

Function sys_XMLGen returns an XMLType instance containing an XML document. Oracle Database provides the XMLFormat object to format the output of sys_XMLGen.

Table 17–2 lists the attributes of object XMLFormat.

Table 17–2 Attributes of the XMLFormat Object

Attribute	Data Type	Purpose
enclTag	VARCHAR2(100)	The name of the enclosing tag for the result of the sys_XMLGen function. If the input to the function is a column name, then the column name is used as the default value. Otherwise, the default value is ROWSET. When schemaType is set to USE_GIVEN_SCHEMA, this attribute also provides the name of the XML schema element.
schemaType	VARCHAR2(100)	The type of schema generation for the output document. Valid values are 'NO_SCHEMA' and 'USE_GIVEN_SCHEMA'. The default value is 'NO_SCHEMA'.
schemaName	VARCHAR2(4000)	The name of the target schema used if schemaType is 'USE_GIVEN_SCHEMA'. If you specify schemaName, then the enclosing tag is used as the element name.
targetNameSpace	VARCHAR2(4000)	The target namespace if the schema is specified (that is, schemaType is GEN_SCHEMA_*, or USE_GIVEN_SCHEMA)
dburl	VARCHAR2(2000)	The URL to the database to be used if WITH_SCHEMA is specified. If this attribute is not specified, then a relative URL reference is used for the URL to the types.
processingIns	VARCHAR2(4000)	User-provided processing instructions. They are appended to the top of the function output, before the element.

You can use method createFormat() to implement the XMLFormat object. Method createFormat() of object XMLFormat accepts as arguments the enclosing element name, the XML-schema type, and the XML-schema name. Default values are provided for the other XMLFormat attributes.

See Also:

- Example 17–37 for an example of using createFormat() to name the root element that is output by sys_XMLGen
- *Oracle Database SQL Language Reference* for more information about sys_XMLGen and the XMLFormat object

Example 17–35 SYS_XMLGEN: Converting a Scalar Value to XML Element Contents

SQL function sys_XMLGen converts a scalar value to an element that contains the scalar value. For example, the following query returns an XML document that contains the employee_id value as an element containing that value:

```
SELECT sys_XMLGen(employee_id) FROM hr.employees WHERE ROWNUM < 2;

SYS_XMLGEN(EMPLOYEE_ID)
--------------------------
<?xml version="1.0"?>
<EMPLOYEE_ID>100</EMPLOYEE_ID>

1 row selected.
```

The enclosing element name, in this case EMPLOYEE_ID, is derived from the column name passed to sys_XMLGen. The query result is a single row containing an XMLType instance that corresponds to a complete XML document.

Example 17–36 SYS_XMLGEN: Default Element Name ROW

In Example 17–35, the column name EMPLOYEE_ID is used by default for the XML element name. If the column name cannot be derived directly, then the default name ROW is used instead:

```
SELECT sys_XMLGen(employee_id*2) FROM hr.employees WHERE ROWNUM < 2;

SYS_XMLGEN(EMPLOYEE_ID*2)
-------------------------
<?xml version="1.0"?>
<ROW>200</ROW>

1 row selected.
```

In this example, the argument to sys_XMLGen is not a simple column name, so the name of the output element tag cannot be a column name – the default element name, ROW, is used.

You can override the default ROW tag by supplying an XMLFormat object as the second sys_XMLGen argument – see Example 17–37 for an example.

Example 17–37 Overriding the Default Element Name: Using SYS_XMLGEN with XMLFormat

In this example, a formatting argument is supplied to sys_XMLGen, to name the element explicitly:

```
SELECT sys_XMLGen(employee_id*2,
                  XMLFormat.createformat('DOUBLE_ID')).getclobval()
 FROM hr.employees WHERE ROWNUM < 2;

SYS_XMLGEN(EMPLOYEE_ID*2,XMLFORMAT.CREATEFORMAT('EMPLOYEE_ID')).GETCLOBVAL()
--------------------------------------------------------------------------------
<?xml version="1.0"?>
<DOUBLE_ID>200</DOUBLE_ID>

1 row selected.
```

Example 17–38 SYS_XMLGEN: Converting a User-Defined Data-Type Instance to XML

When you provide a user-defined data-type instance as an argument to sys_XMLGen, the instance is canonically mapped to an XML document. In this mapping, the user-defined data-type attributes are mapped to XML elements.

Any data-type attributes with names that start with an at sign (@) are mapped to attributes of the preceding XML element. User-defined data-type instances can be used to obtain nesting in the resulting XML document.

You can generate hierarchical XML for the employee-and-department example (see "Generating XML Using DBMS_XMLGEN" on page 17-24) as follows:

```
CREATE OR REPLACE TYPE hr.emp_t AS OBJECT(empno    NUMBER(6),
                                          ename    VARCHAR2(25),
                                          job      VARCHAR2(10),
                                          mgr      NUMBER(6),
                                          hiredate DATE,
                                          sal      NUMBER(8,2),
                                          comm     NUMBER(2,2));
/
Type created.
CREATE OR REPLACE TYPE hr.emplist_t AS TABLE OF emp_t;
```

```
/
Type created.
CREATE OR REPLACE TYPE hr.dept_t AS OBJECT(deptno  NUMBER(4),
                                          dname   VARCHAR2(30),
                                          loc     VARCHAR2(4),
                                          emplist emplist_t);
/
Type created.

SELECT sys_XMLGen(
         dept_t(department_id,
                department_name,
                d.location_id,
                CAST(MULTISET(SELECT emp_t(e.employee_id, e.last_name, e.job_id,
                                          e.manager_id, e.hire_date, e.salary,
                                          e.commission_pct)
                              FROM hr.employees e
                              WHERE e.department_id = d.department_id)
                     AS emplist_t))).getCLOBVal()
  AS deptxml
  FROM hr.departments d WHERE department_id = 10 OR department_id = 20;
```

SQL function `MULTISET` treats the result of the subset of employees working in the department as a list, and the `CAST` then assigns this to the appropriate collection type. A department-type (`dept_t`) element is wrapped around this to create the XML data for the object instance.

The result is as follows. The default name `ROW` is present because the function cannot deduce the name of the input operand directly.

```
DEPTXML
-------------------------------------
<?xml version="1.0"?>
<ROW>
 <DEPTNO>10</DEPTNO>
 <DNAME>Administration</DNAME>
 <LOC>1700</LOC>
 <EMPLIST>
  <EMP_T>
   <EMPNO>200</EMPNO>
   <ENAME>Whalen</ENAME>
   <JOB>AD_ASST</JOB>
   <MGR>101</MGR>
   <HIREDATE>17-SEP-87</HIREDATE>
   <SAL>4400</SAL>
  </EMP_T>
 </EMPLIST>
</ROW>

<?xml version="1.0"?>
<ROW>
 <DEPTNO>20</DEPTNO>
 <DNAME>Marketing</DNAME>
 <LOC>1800</LOC>
 <EMPLIST>
  <EMP_T>
   <EMPNO>201</EMPNO>
   <ENAME>Hartstein</ENAME>
   <JOB>MK_MAN</JOB>
   <MGR>100</MGR>
   <HIREDATE>17-FEB-96</HIREDATE>
```

```
   <SAL>13000</SAL>
  </EMP_T>
  <EMP_T>
   <EMPNO>202</EMPNO>
   <ENAME>Fay</ENAME>
   <JOB>MK_REP</JOB>
   <MGR>201</MGR>
   <HIREDATE>17-AUG-97</HIREDATE>
   <SAL>6000</SAL>
  </EMP_T>
 </EMPLIST>
</ROW>

2 rows selected.
```

> **Note:** The difference between using SQL function `sys_XMLGen` and PL/SQL package `DBMS_XMLGEN` is apparent from the preceding example. Function `sys_XMLGen` works inside SQL queries, and operates on the expressions and columns within the rows; package `DBMS_XMLGEN` works on the entire result set.

Example 17–39 SYS_XMLGEN: Converting an XMLType Instance

If you pass an XML document to function `sys_XMLGen`, this function encloses the document (or fragment) with an element, whose tag name is the default `ROW`, or the name passed in through the `XMLFormat` formatting object. This functionality can be used to turn XML fragments into well-formed documents. Consider this XML data:

```
CREATE TABLE po_xml_tab(podoc XMLType);
Table created.
INSERT INTO po_xml_tab VALUES(XMLType('<DOCUMENT>
                                         <EMPLOYEE>
                                           <ENAME>John</ENAME>
                                           <EMPNO>200</EMPNO>
                                         </EMPLOYEE>
                                         <EMPLOYEE>
                                           <ENAME>Jack</ENAME>
                                           <EMPNO>400</EMPNO>
                                         </EMPLOYEE>
                                         <EMPLOYEE>
                                           <ENAME>Joseph</ENAME>
                                           <EMPNO>300</EMPNO>
                                         </EMPLOYEE>
                                       </DOCUMENT>'));
1 row created.
COMMIT;
```

This query extracts `ENAME` elements:

```
SELECT e.podoc.extract('/DOCUMENT/EMPLOYEE/ENAME') FROM po_xml_tab e;
```

The query result is an XML document fragment:

```
<ENAME>John</ENAME>
<ENAME>Jack</ENAME>
<ENAME>Joseph</ENAME>
```

You can make such a fragment into a valid XML document by calling `sys_XMLGen` to wrap a root element around the fragment, as follows:

```
SELECT sys_XMLGen(e.podoc.extract('/DOCUMENT/EMPLOYEE/ENAME')).getCLOBVal()
  FROM po_xml_tab e;
```

This places a ROW element around the fragment, as follows:

```
<?xml version="1.0"?>
<ROW>
  <ENAME>John</ENAME>
  <ENAME>Jack</ENAME>
  <ENAME>Joseph</ENAME>
</ROW>
```

> **Note:** If the input to sys_XMLGen is a column, then the column name is used as the default element name. You can override the element name using the XMLFormat formatting object as a second argument to sys_XMLGen. See "Using XMLFormat Object Type" on page 17-50.

Example 17–40 Using SYS_XMLGEN with Object Views

For any undefined entities here, refer to the code in Example 17–28 on page 17-37.

```
-- Create purchase order object type
CREATE OR REPLACE TYPE po_typ AUTHID CURRENT_USER
  AS OBJECT(pono            NUMBER,
            customer        customer_typ,
            orderdate       DATE,
            shipdate        TIMESTAMP,
            lineitems_ntab  lineitems_ntabtyp,
            shiptoaddr      address_typ)
/
--Purchase order view
CREATE OR REPLACE VIEW po OF po_typ
  WITH OBJECT IDENTIFIER (PONO)
  AS SELECT p.pono, customer_typ(p.custno, c.custname, c.address, c.phonelist),
            p.orderdate, p.shipdate,
            CAST(MULTISET(
                   SELECT
                     lineitem_typ(l.lineitemno,
                                  stockitem_typ(l.stockno, s.price, s.taxrate),
                                                l.quantity, l.discount)
                     FROM lineitems_tab l, stock_tab s
                     WHERE l.pono = p.pono AND s.stockno=l.stockno)
                 AS lineitems_ntabtyp),
            address_typ(p.tostreet, p.tocity, p.tostate, p.tozip)
       FROM po_tab p, customer c
       WHERE p.custno=c.custno;

-- Use sys_XMLGen to generate PO in XML format
SELECT  sys_XMLGen(OBJECT_VALUE,
                   XMLFormat.createFormat('PurchaseOrder')).getCLOBVal() PO
  FROM po p
  WHERE p.pono=1001;
```

The query returns the purchase order in XML format:

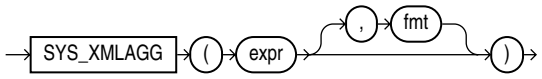
```
PO
--------------------------------------------
<?xml version="1.0"?>
```

```
<PurchaseOrder>
 <PONO>1001</PONO>
 <CUSTOMER>
  <CUSTNO>1</CUSTNO>
  <CUSTNAME>Jean Nance</CUSTNAME>
  <ADDRESS>
   <STREET>2 Avocet Drive</STREET>
   <CITY>Redwood Shores</CITY>
   <STATE>CA</STATE>
   <ZIP>95054</ZIP>
  </ADDRESS>
  <PHONELIST>
   <VARCHAR2>415-555-1212</VARCHAR2>
  </PHONELIST>
 </CUSTOMER>
 <ORDERDATE>10-APR-97</ORDERDATE>
 <SHIPDATE>10-MAY-97 12.00.00.000000 AM</SHIPDATE>
 <LINEITEMS_NTAB>
  <LINEITEM_TYP LineItemNo="1">
   <ITEM StockNo="1534">
    <PRICE>2234</PRICE>
    <TAXRATE>2</TAXRATE>
   </ITEM>
   <QUANTITY>12</QUANTITY>
   <DISCOUNT>0</DISCOUNT>
  </LINEITEM_TYP>
  <LINEITEM_TYP LineItemNo="2">
   <ITEM StockNo="1535">
    <PRICE>3456.23</PRICE>
    <TAXRATE>2</TAXRATE>
   </ITEM>
   <QUANTITY>10</QUANTITY>
   <DISCOUNT>10</DISCOUNT>
  </LINEITEM_TYP>
 </LINEITEMS_NTAB>
 <SHIPTOADDR/>
</PurchaseOrder>

1 row selected.
```

Generating XML Using SQL Function SYS_XMLAGG

SQL function `sys_XMLAgg` aggregates all XML documents or fragments represented by an expression and produces a single XML document. It adds a new enclosing element with a default name, `ROWSET`. To format the XML document differently, use the `fmt` parameter.

Figure 17–16 SYS_XMLAGG Syntax



See Also: *Oracle Database SQL Language Reference*

Generating XML Using XSQL Pages Publishing Framework

Oracle9*i* introduced `XMLType` for use with storing and querying XML-based database content. You can use these database XML features to produce XML for inclusion in your XSQL pages by using the `<xsql:include-xml>` action element.

The `SELECT` statement that appears inside a `<xsql:include-xml>` element should return a *single row* containing a *single column*. The column can be either a `CLOB` instance or a `VARCHAR2` value. It must contain a well-formed XML document. The XML document is parsed and included in your XSQL page.

> **See Also:** *Oracle XML Developer's Kit Programmer's Guide* for information about element `<xsql:include-xml>` and XSQL pages

Example 17–41 Using XSQL Servlet <xsql:include-xml> with Nested XMLAgg Functions

This example uses nested calls to function `XMLAgg` to aggregate the results of a dynamically-constructed XML document containing departments and their employees into a single XML result document, which is wrapped in a `DepartmentList` element. The call to method `getCLOBVal()` provides XSQL Servlet with a `CLOB` value instead of an `XMLType` instance. To display the results, XSQL Servlet needs a special environment, such as the XSQL Command-Line Utility, XSQL Servlet installed in a Web server, Java Server Pages (JSP), or a Java `XSQLRequest` object.

```
<xsql:include-xml connection="orcl92" xmlns:xsql="urn:oracle-xsql">
  SELECT
    XMLElement("DepartmentList",
               XMLAgg(XMLElement(
                        "Department",
                        XMLAttributes(department_id as "Id"),
                        XMLForest(department_name as "Name"),
                        (SELECT XMLElement("Employees",
                                           XMLAgg(XMLElement(
                                                    "Employee",
                                                    XMLAttributes(
                                                      employee_id as "Id"),
                                                    XMLForest(
                                                      last_name as "Name",
                                                      salary as "Salary",
                                                      job_id as "Job"))))
                           FROM employees e
                           WHERE e.department_id=d.department_id)))).getCLOBVal()
    FROM departments d
    ORDER BY department_name
</xsql:include-xml>
```

The query itself produces the following result:

```
XMLELEMENT("DEPARTMENTLIST",XMLAGG(XMLELEMENT("DEPARTMENT",XMLATTRIBUTES(DEPARTM
--------------------------------------------------------------------------------
<DepartmentList><Department Id="10"><Name>Administration</Name><Employees><Emplo
yee Id="200"><Name>Whalen</Name><Salary>4400</Salary><Job>AD_ASST</Job></Employe
e></Employees></Department><Department Id="20"><Name>Marketing</Name><Employees>
<Employee Id="201"><Name>Hartstein</Name><Salary>13000</Salary><Job>MK_MAN</Job>
</Employee><Employee Id="202"><Name>Fay</Name><Salary>6000</Salary><Job>MK_REP</
Job></Employee></Employees></Department>
...
</DepartmentList>

1 row selected.
```

Example 17–42 Using XSQL Servlet <xsql:include-xml> with XMLElement and XMLAgg

It is more efficient for the database to aggregate XML fragments into a single result document. Element `<xsql:include-xml>` encourages this approach by retrieving only the first row from the query you provide.

You can use the built-in Oracle Database XPath query features to extract an aggregate list of all purchase orders of the film *Grand Illusion*. This example uses the `purchaseorder` table in sample schema `OE`.

```
CONNECT oe/oe;
Connected.

SELECT
  XMLElement(
    "GrandIllusionOrders",
    XMLAgg(extract(OBJECT_VALUE,
                   '/PurchaseOrder/LineItems/*[Part[@Id="37429121924"]]')))
  FROM purchaseorder;
```

This produces the following result.

```
XMLELEMENT("GRANDILLUSIONORDERS",XMLAGG(EXTRACT(OBJECT_VALUE,'/PURCHASEORDER/LIN
--------------------------------------------------------------------------------
<GrandIllusionOrders>
  <LineItem ItemNumber="14">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="14">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="6">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="19">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
  <LineItem ItemNumber="21">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="3"/>
  </LineItem>
  <LineItem ItemNumber="15">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="3"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="8">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="1"/>
  </LineItem>
  <LineItem ItemNumber="17">
    <Description>Grand Illusion</Description>
    <Part Id="37429121924" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
</GrandIllusionOrders>
```

```
1 row selected.
```

To include this XMLType query result in your XSQL page, paste the query inside an <xsql:include-xml> element, and call method getCLOBVal(), so that the result is returned to the client as a CLOB value instead of as an XMLType instance:

```
<xsql:include-xml connection="orcl92" xmlns:xsql="urn:oracle-xsql">
  SELECT
    XMLElement(
      "GrandIllusionOrders",
      XMLAgg(
        extract(
          OBJECT_VALUE,
          '/PurchaseOrder/LineItems/*[Part[@Id="37429121924"]]'))).getCLOBval()
    FROM purchaseorder;
</xsql:include-xml>
```

SQL functions XMLElement and XMLAgg are used together here to aggregate all of the XML fragments identified by the query into a single, well-formed XML document. Failing to do this results in an attempt by the XSQL page processor to parse a CLOB value that looks like this:

```
<LineItem>...</LineItem>
<LineItem>...</LineItem>
...
```

This is not well-formed XML because it does not have a single root element as required by the XML 1.0 recommendation. Functions XMLElement and XMLAgg work together to produce a well-formed result with single root element GrandIllusionOrders. This well-formed XML is then parsed and included in your XSQL page.

> **See Also:** *Oracle XML Developer's Kit Programmer's Guide*, the chapter, 'XSQL Page Publishing Framework'

Using XSLT and XSQL

With XSQL Pages, you have control over where XSLT is executed: in the database, the middle-tier, or the client. For database execution, use SQL function XMLtransform (or the equivalent) in your query. For middle-tier execution, add <?xml-stylesheet?> at the top of your template page. For client execution, add attribute client="yes" to PI <?xml-stylesheet?>.

With XSQL Pages, you can build pages that conditionally off-load style-sheet processing to the client, depending, for example, on what browser is used.

To improve performance and throughput, XSQL caches and pools XSLT style sheets (as well as database connections) in the middle tier. Depending on the application, you can further improve performance by avoiding transformation using Web Cache or other techniques as well as a further performance optimization to avoid transforming the same (or static) data repeatedly.

XSQL Pages can include a mix of static XML and dynamically produced XML. You can take advantage of this by using the database to create only the dynamic part of the page.

Generating XML Using XML SQL Utility (XSU)

Oracle XML SQL Utility (XSU) can be used with Oracle Database to generate XML. You can use XSU l to generate XML on either the middle tier or the client. XSU also supports generating XML on tables with `XMLType` columns.

> **See Also:** *Oracle XML Developer's Kit Programmer's Guide* for information about XSU

Guidelines for Generating XML With Oracle XML DB

This section describes additional guidelines for generating XML using Oracle XML DB.

Using XMLAGG ORDER BY Clause to Order Query Results Before Aggregation

To use the `XMLAgg ORDER BY` clause before aggregation, specify the `ORDER BY` clause following the first `XMLAGG` argument.

Example 17–43 Using XMLAGG ORDER BY Clause

Consider this table:

```
CREATE TABLE dev_tab (dev         NUMBER,
                      dev_total   NUMBER,
                      devname     VARCHAR2(20));
Table created.
INSERT INTO dev_tab VALUES (16, 5,  'Alexis');
1 row created.
INSERT INTO dev_tab VALUES (2,  14, 'Han');
1 row created.
INSERT INTO dev_tab VALUES (1,  2,  'Jess');
1 row created.
INSERT INTO dev_tab VALUES (9,  88, 'Kurt');
1 row created.
COMMIT;
```

In this example, the result is aggregated according to the order of the `dev` column. (The result is shown here pretty-printed, for clarity.)

```
SELECT XMLAgg(XMLElement("Dev",
                         XMLAttributes(dev AS "id", dev_total AS "total"),
                         devname)
              ORDER BY dev)
  FROM tab1 dev_total;

XMLAGG(XMLELEMENT("DEV",XMLATTRIBUTES(DEVAS"ID",DEV_TOTALAS"TOTAL"),DEVNAME)ORDE
--------------------------------------------------------------------------------
<Dev id="1" total="2">Jess</Dev>
<Dev id="2" total="14">Han</Dev>
<Dev id="9" total="88">Kurt</Dev>
<Dev id="16" total="5">Alexis</Dev>

1 row selected.
```

Using XMLTABLE to Return a Rowset

You can use standard SQL/XML function `XMLTable` to return a rowset with relevant portions of a document extracted as multiple rows, as shown in Example 17–44.

Example 17–44 Returning a Rowset using XMLTABLE

This example uses the `purchaseorder` table in sample schema `OE`.

```
CONNECT oe/oe;
Connected.

SELECT item.descr, item.partid
  FROM purchaseorder,
       XMLTable('/PurchaseOrder/LineItems/LineItem' PASSING OBJECT_VALUE
                COLUMNS descr  VARCHAR2(256) PATH 'Description',
                        partid VARCHAR2(14)  PATH 'Part/@Id') item
  WHERE item.partid = '715515012027'
     OR item.partid = '715515011921'
  ORDER BY partid;
```

This returns a rowset with just the descriptions and part IDs, ordered by part ID.

```
DESCR
--------------
PARTID
--------------
My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

My Man Godfrey
715515011921

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

Mona Lisa
```

```
715515012027

Mona Lisa
715515012027

Mona Lisa
715515012027

16 rows selected.
```

18

Using XQuery with Oracle XML DB

This chapter describes how to use the XQuery language with Oracle XML DB. It covers Oracle XML DB support for the language, including SQL functions `XMLQuery` and `XMLTable` and the SQL*Plus `XQUERY` command.

This chapter contains these topics:

Overview of XQuery in Oracle XML DB

Oracle XML DB support for the XQuery language is provided through a native implementation of SQL/XML functions `XMLQuery` and `XMLTable`. As a convenience, SQL*Plus command `XQUERY` is also provided, which lets you enter XQuery expressions directly—in effect, this command turns SQL*Plus into an XQuery command-line interpreter.

Oracle XML DB compiles XQuery expressions that are passed as arguments to SQL functions `XMLQuery`, `XMLTable`, `XMLExists`, and `XMLCast`. This compilation produces SQL query blocks and operator trees that use SQL/XML functions and XPath functions. A SQL statement that includes `XMLQuery`, `XMLTable`, `XMLExists`, or `XMLCast` is compiled and optimized as a whole, leveraging both relational database and XQuery-specific optimization technologies. Depending on the XML storage and indexing methods used, XPath functions can be further optimized. The resulting optimized operator tree is executed in a streaming fashion.

See Also:

- SQL Functions XMLQUERY and XMLTABLE and SQL*Plus XQUERY Command
- Oracle XQuery Extension Functions for Oracle-specific XQuery functions that extend the language
- Oracle XML DB Support for XQuery for details on Oracle XML DB support for XQuery

Overview of the XQuery Language

Oracle XML DB supports the latest version of the XQuery language specification, W3C XQuery 1.0 Recommendation. This section presents a brief overview of the language. For more information, consult a recent book on the language or refer to the standards documents that define it, which are available at `http://www.w3c.org`.

Functional Language Based on Sequences

XQuery 1.0 is the W3C language designed for querying XML data. It is similar to SQL in many ways, but just as SQL is designed for querying structured, relational data, XQuery is designed especially for querying semi-structured, XML data from a variety of data sources. You can use XQuery to query XML data wherever it is found, whether it is stored in database tables, available through Web Services, or otherwise created on the fly. In addition to querying XML data, XQuery can be used to *construct* XML data. In this regard, XQuery can serve as an alternative or a complement to both XSLT and the other SQL/XML publishing functions, such as `XMLElement`.

XQuery builds on the Post-Schema-Validation Infoset (PSVI) data model, which unites the XML Information Set (Infoset) data model and the XML Schema type system. XQuery defines a new data model based on *sequences*: the result of *each* XQuery expression is a sequence. XQuery is all about manipulating sequences. This makes XQuery similar to a set-manipulation language, except that sequences are ordered and can contain duplicate items. XQuery sequences differ from the sequences in some other languages in that nested XQuery sequences are always *flattened* in their effect.

In many cases, sequences can be treated as unordered, to maximize optimization – where this is available, it is under your control. This **unordered mode** can be applied to join order in the treatment of nested iterations (`for`), and it can be applied to the treatment of XPath expressions (for example, in `/a/b`, the matching `b` elements can be processed without regard to document order).

An XQuery **sequence** consists of zero or more **items**, which can be either *atomic* (scalar) values or XML *nodes*. Items are typed using a rich type system that is based upon the types of XML Schema. This type system is a major change from that of XPath 1.0, which is limited to simple scalar types such as Boolean, number, and string.

XQuery is a *functional* language. As such, it consists of a set of possible *expressions* that are *evaluated* and return *values* (which, for XQuery, are sequences). As a functional language, XQuery is also **referentially transparent**, generally: the *same expression* evaluated in the *same context* returns the *same value*.

Exceptions to this desirable mathematical property include the following:

- XQuery expressions that derive their value from interaction with the external environment. For example, an expression such as `fn:current-time(...)` or `fn:doc(...)` does not necessarily always return the same value, since it depends

on external conditions that can change (the time changes; the content of the target document might change).

In some cases, like that of `fn:doc`, XQuery is defined to be referentially transparent within the execution of a single query: within a query, each invocation of `fn:doc` with the same argument results in the same document.

- XQuery expressions that are defined to be dependent on the particular XQuery language implementation. The result of evaluating such expressions might vary between implementations. Function `fn:doc` is an example of a function that is essentially implementation-defined.

Referential transparency applies also to XQuery *variables*: the same variable in the same context has the same value. Functional languages are like mathematics formalisms in this respect and unlike procedural, or imperative, programming languages. A variable in a procedural language is really a name for a memory location; it has a *current* value, or state, as represented by its content at any time. A variable in a declarative language such as XQuery is really a name for a *static* value.

XQuery Expressions

XQuery expressions are case-sensitive. The expressions include the following:

- **primary expression –** literal, variable, or function application. A variable name starts with a dollar-sign (`$`) – for example, `$foo`. Literals include numerals, strings, and character or entity references.
- **XPath expression –** Any XPath expression. The developing XPath 2.0 standard will be a subset of XQuery. XPath 1.0 is currently a subset, although XQuery uses a richer type system.
- **FLWOR expression –** The most important XQuery expression, composed of the following, in order, from which FLWOR takes its name: `for`, `let`, `where`, `order by`, `return`.
- **XQuery sequence** – The comma (`,`) constructor creates sequences. Sequence-manipulating functions such as `union` and `intersect` are also available. All XQuery sequences are effectively **flat**: a nested sequence is treated as its flattened equivalent. Thus, for instance, `(1, 2, (3, 4, (5), 6), 7)` is treated as `(1, 2, 3, 4, 5, 6, 7)`. A singleton sequence, such as `(42)`, acts the same in most XQuery contexts as does its single item, `42`. Remember that the result of any XQuery expression is a sequence.
- **Direct (literal) constructions** – XML element and attribute syntax automatically constructs elements and attributes: what you see is what you get. For example, the XQuery expression `<a>33</a>` constructs the XML element `<a>33</a>`.
- **Computed (dynamic) constructions –** You can construct XML data at runtime using computed values. For example, the following XQuery expression constructs this XML data: `<foo toto="5"><bar>tata titi</bar> why? </foo>`.

  ```
  <foo>{attribute toto {2+3}, element bar {"tata", "titi"}, text {" why? "}</foo>
  ```

  In this example, element `foo` is a direct construction; the other constructions are computed. In practice, the arguments to computed constructors are not literals (such as `toto` and `"tata"`), but expressions to be evaluated (such as `2+3`). Both the name and the value arguments of an element or attribute constructor can be computed. Braces (`{,}`) are used to mark off an XQuery expression to be evaluated.

- **Conditional expression –** As usual, but remember that each part of the expression is itself an arbitrary expression. For instance, in this conditional expression, each of these subexpressions can be any XQuery expression: `something`, `somethingElse`, `expression1`, and `expression2`.

  ```
  if (something < somethingElse) then expression1 else expression2
  ```

- **Arithmetic, relational expression –** As usual, but remember that each relational expression returns a (Boolean[1]) value. Examples:

  ```
  2 + 3
  42 < $a + 5
  (1, 4) = (1, 2)
  5 > 3 eq true()
  ```

- **Quantifier expression –** Universal (`every`) and existential (`some`) quantifier functions provide shortcuts to using a FLWOR expression in some cases. Examples:

  ```
  every $foo in doc("bar.xml")//Whatever satisfies $foo/@bar > 42
  some $toto in (42, 5), $titi in (123, 29, 5) satisfies $toto = $titi
  ```

- **Regular expression –** XQuery regular expressions are based on XML Schema 1.0 and Perl. (See Support for XQuery Functions and Operators on page 18-38.)

- **Type expression –** An XQuery expression that represents an XQuery type. Examples: `item()`, `node()`, `attribute()`, `element()`, `document-node()`, `namespace()`, `text()`, `xs:integer`, `xs:string`.[2]

  Type expressions can have **occurrence indicators**: **`?`** (optional: zero or one), **`*`** (zero or more), **`+`** (one or more). Examples: `document-node(element())*`, `item()+`, `attribute()?`.

  XQuery also provides operators for working with types. These include `cast as`, `castable as`, `treat as`, `instance of`, `typeswitch`, and `validate`. For example, `"42" cast as xs:integer` is an expression whose value is the integer 2. (It is not, strictly speaking, a type expression, because its value does not represent a type.)

FLWOR Expressions

As for XQuery in general, there is a lot to learn about FLWOR expressions. This section provides only a brief overview.

FLWOR is the most general expression syntax in XQuery. FLWOR (pronounced "flower") stands for `for`, `let`, `where`, `order by`, and `return`. A FLWOR expression has at least one `for` or `let` clause and a `return` clause; single `where` and `order by` clauses are optional.

- **`for`** – Bind one or more variables each to any number of values, in turn. That is, for each variable, iterate, binding the variable to a different value for each iteration.

  At each iteration, the variables are bound in the order they appear, so that the value of a variable `$earlier` that is listed before a variable `$later` in the `for`

[1] The value returned is a sequence, as always. However, in XQuery, a sequence of one item is equivalent to that item itself. In this case, the single item is a Boolean value.

[2] Namespace prefix `xs` is predefined for the XML Schema namespace, `http://www.w3.org/2001/XMLSchema`.

list, can be used in the binding of variable `$later`. For example, during its second iteration, this expression binds `$i` to `4` and `$j` to `6` (2+4):

```
for $i in (3, 4), $j in ($i, 2+$i)
```

- **`let`** – Bind one or more variables.

  Just as with `for`, a variable can be bound by `let` to a value computed using another variable that is listed previously in the binding list of the `let` (or an enclosing `for` or `let`). For example, this expression binds `$j` to `5` (3+2):

  ```
  let $i := 3, $j := $i + 2
  ```

- **`where`** – Filter the `for` and `let` variable bindings according to some condition. This is similar to a SQL `WHERE` clause.
- **`order by`** – Sort the result of `where` filtering.
- **`return`** – Construct a result from the ordered, filtered values. This is the result of the FLWOR expression as a whole. It is a flattened sequence.

Expressions `for` and `let` function similarly to a SQL `FROM` clause; `where` acts like a SQL `WHERE` clause; `order by` is similar to `ORDER BY` in SQL; and `return` is like `SELECT` in SQL. In other words, except for the two keywords whose names are the same in both languages (`where`, `order by`), FLWOR clause order is more or less opposite to the SQL clause order, but the meanings of the corresponding clauses are quite similar.

Note that using a FLWOR expression (with `order by`) is the *only* way to construct a sequence in any order other than document order.

SQL Functions XMLQUERY and XMLTABLE

SQL functions `XMLQuery` and `XMLTable` are defined by the SQL/XML standard as a general interface between the SQL and XQuery languages. As is the case for the other SQL/XML functions, `XMLQuery` and `XMLTable` let you take advantage of the power and flexibility of both SQL and XML. Using these functions, you can construct XML data using relational data, query relational data as if it were XML, and construct relational data from XML data.

Both `XMLQuery` and `XMLTable` evaluate an XQuery expression. In the XQuery language, an expression always returns a sequence of items. Function `XMLQuery` aggregates the items in this sequence to return a single XML document or fragment. Function `XMLTable` returns a SQL table whose rows each contain one item from the XQuery sequence.

The SQL/XML standard is ISO/IEC 9075–14:2006(E), Information technology – Database languages – SQL – Part 14: XML-Related Specifications (SQL/XML). As part of the SQL standard, it is aligned with SQL:2003. It is being developed under the auspices of these two standards bodies:

- ISO/IEC JTC1/SC32 ("International Organization for Standardization and International Electrotechnical Committee Joint Technical Committee 1, Information technology, Subcommittee 32, Data Management and Interchange").
- INCITS Technical Committee H2 ("INCITS" stands for "International Committee for Information Technology Standards"). INCITS is an Accredited Standards Development Organization operating under the policies and procedures of ANSI, the American National Standards Institute. Committee H2 is the committee responsible for SQL and SQL/MM.

This SQL/XML standardization process is ongoing. Please refer to `http://www.sqlx.org` for the latest information about `XMLQuery` and `XMLTable`.

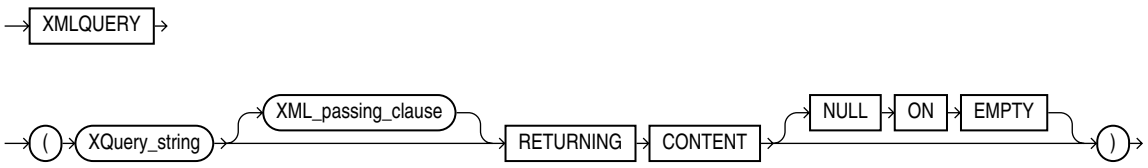
See Also:

- `http://www.sqlx.org` for information about SQL functions `XMLQuery` and `XMLTable`
- `http://www.w3.org` for information about the XQuery language
- "Generating XML Using SQL Functions" on page 17-2 for information about using other SQL/XML functions with Oracle XML DB

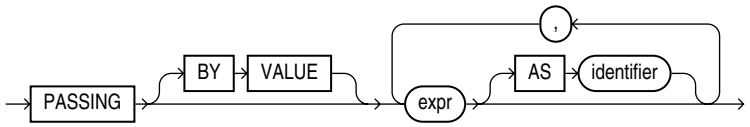
XMLQUERY SQL Function in Oracle XML DB

You use SQL function `XMLQuery` to construct or query XML data. This function takes as arguments an *XQuery expression*, as a string literal, and an optional XQuery *context item*, as a SQL expression. The context item establishes the XPath context in which the XQuery expression is evaluated. Additionally, `XMLQuery` accepts as arguments any number of SQL expressions whose values are bound to XQuery variables during the XQuery expression evaluation. The function returns the result of evaluating the XQuery expression, as an `XMLType` instance.

Figure 18–1 XMLQUERY Syntax



XML_passing_clause ::=



- *`XQuery_string`* is a complete XQuery expression, possibly including a prolog, as a literal string.
- The *`XML_passing_clause`* is the keyword `PASSING` followed by one or more SQL expressions (*`expr`*) that each return an `XMLType` instance or an instance of a SQL scalar data type (that is, not an object or collection data type). Each expression (*`expr`*) can be a table or view column value, a PL/SQL variable, or a bind variables with proper casting. All but possibly one of the expressions must each be followed by the keyword `AS` and an XQuery *`identifier`*. The result of evaluating each *`expr`* is bound to the corresponding *`identifier`* for the evaluation of *`XQuery_string`*. If there is an *`expr`* that is not followed by an `AS` clause, then the result of evaluating that *`expr`* is used as the *context* item for evaluating *`XQuery_string`*. Oracle XML DB supports only passing `BY VALUE`, not passing `BY REFERENCE`, so the clause `BY VALUE` is implicit and can be omitted.
- `RETURNING CONTENT` indicates that the value returned by an application of `XMLQuery` is an instance of parameterized XML type `XML(CONTENT)`, not

parameterized type `XML(SEQUENCE)`. It is a document fragment that conforms to the *extended* Infoset data model. As such, it is a single document node with any number of children. The children can each be of any XML node type; in particular, they can be text nodes.

Oracle XML DB supports only the `RETURNING CONTENT` clause of SQL/XML function `XMLQuery`; it does *not* support the `RETURNING SEQUENCE` clause.

You can pass an `XMLType` column, table, or view as the context-item argument to function `XMLQuery`—see, for example, Example 18–8. To query a relational table or view as if it were XML, without having to first create a SQL/XML view on top of it, use XQuery function `ora:view` within an XQuery expression—see, for example, Example 18–6.

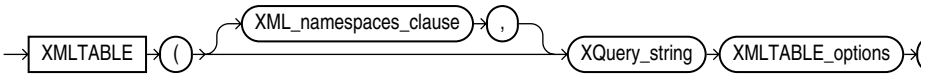
See Also:

- `http://www.sqlx.org` for information about the definition of SQL function `XMLQuery`
- *Oracle Database SQL Language Reference* for reference information about SQL function `XMLQuery` in Oracle Database
- "ora:view XQuery Function" on page 18-12

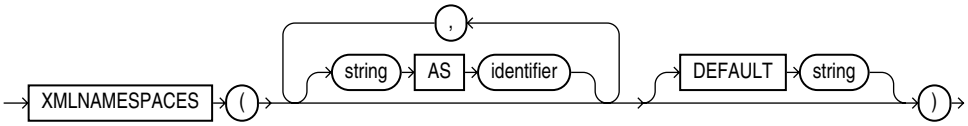
XMLTABLE SQL Function in Oracle XML DB

You use SQL function `XMLTable` to decompose the result of an XQuery-expression evaluation into the relational rows and columns of a new, virtual table. You can then insert the virtual table into a pre-existing database table, or you can query it using SQL—in a join expression, for example (see Example 18–9). You use `XMLTable` in a SQL `FROM` clause.

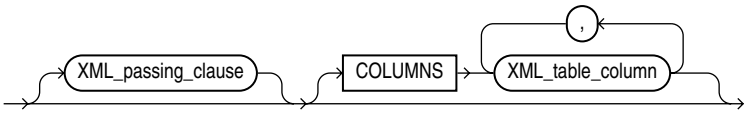
Figure 18–2 XMLTABLE Syntax



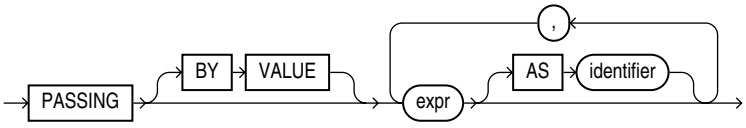
XML_namespaces_clause ::=



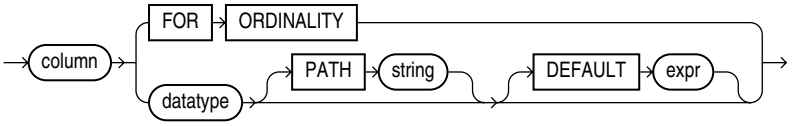
XMLTABLE_options ::=



XML_passing_clause ::=



XML_table_column ::=



- *XQuery_string* is a complete XQuery expression, possibly including a prolog, as a literal string. The value of the expression serves as input to the XMLTable function; it is this XQuery result that is decomposed and stored as relational data.
- The optional XMLNAMESPACES clause contains XML namespace declarations that are referenced by *XQuery_string* and by the XPath expression in the PATH clause of *XML_table_column*.
- The *XML_passing_clause* is the keyword PASSING followed by one or more SQL expressions (*expr*) that each return an XMLType instance or an instance of a SQL scalar data type (that is, not an object or collection data type). Each expression (*expr*) can be a table or view column value, a PL/SQL variable, or a bind variables with proper casting. All but possibly one of the expressions must each be followed by the keyword AS and an XQuery *identifier*. The result of evaluating each *expr* is bound to the corresponding *identifier* for the evaluation of *XQuery_string*. If there is an *expr* that is not followed by an AS clause, then the result of evaluating that *expr* is used as the *context* item for evaluating *XQuery_string*. Oracle XML DB supports only passing BY VALUE, not passing BY REFERENCE, so the clause BY VALUE is implicit and can be omitted.
- The optional COLUMNS clause defines the columns of the virtual table to be created by XMLTable.
  - If you omit the COLUMNS clause, then XMLTable returns a row with a single XMLType pseudo-column, named COLUMN_VALUE.
  - FOR ORDINALITY specifies that *column* is to be a column of generated row numbers (SQL data type NUMBER). There must be at most one FOR ORDINALITY clause.
  - You must specify the *datatype* of each resulting *column* except the FOR ORDINALITY column. However, see next bullet.
  - When XMLTable is used with XML schema-based storage of XMLType, *datatype* is optional. If not present, the data type will be inferred from the XML schema. If Oracle XML DB is unable to determine the proper type for a node, a default type of VARCHAR2(4000) is used.

    This is an *Oracle extension*; in the SQL/XML standard, *datatype* is always required.

    Note: The inferred data type might change as the result of upgrading Oracle XML DB or applying a patch. In particular, a new release or patch set might be able to determine the datatype when the previous release was unable to do so (and so defaulted to VARCHAR2(4000)). To protect against such an eventuality, specify an explicit data type with *datatype*.

  - The optional PATH clause specifies that the portion of the XQuery result that is addressed by XQuery expression *string* is to be used as the *column* content.

You can use multiple PATH clauses to split the XQuery result into different virtual-table columns.

If you omit PATH, then the XQuery expression *column* is assumed. For example, these two expressions are equivalent:

```
XMLTable(... COLUMNS foo)
XMLTable(... COLUMNS foo PATH 'FOO')
```

- The optional DEFAULT clause specifies the value to use when the PATH expression results in an empty sequence (or NULL). Its *expr* is an XQuery expression that is evaluated to produce the default value.

See Also:

- http://www.sqlx.org for information about the definition of SQL function XMLTable
- *Oracle Database SQL Language Reference* for reference information about SQL function XMLTable in Oracle Database

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Note: Prior to Oracle Database 10g Release 2, XMLSequence was used with SQL function table to do some of what can now be done better with standard function XMLTable. See Chapter 3, "Using Oracle XML DB" for examples.

When To Use XQuery

You can use XQuery to do many of the same things that you might do using the SQL/XML generation functions or XSLT; there is a great deal of overlap. The decision to use one or the other tool to accomplish a given task can be based on many considerations, most of which are not specific to Oracle Database. Please consult external documentation on this general question.

One general rule of thumb is that XQuery is often used when the focus is the world of XML data, while the SQL/XML generation functions (XMLElement, XMLAgg, and so on) are often used when the focus is the world of relational data.

Other things being equal, if a query constructs an XML document from fragments extracted from existing XML documents, then it is likely that an XQuery FLOWR expression will be simpler (simplifying code maintenance) than extracting scalar values from relational data and constructing appropriate XML data using SQL/XML generation functions. If, instead, a query constructs an XML document from existing relational data, the SQL/XML generation functions can often be more suitable.

With respect to Oracle XML DB, you can expect the same general level of performance using the SQL/XML generation functions as with XMLQuery and XMLTable—all are subject to rewrite optimizations.

Predefined Namespaces and Prefixes

The following namespaces and prefixes are predefined for use with XQuery in Oracle XML DB:

Table 18–1 Predefined Namespaces and Prefixes

Prefix	Namespace	Description
ora	http://xmlns.oracle.com/xdb	Oracle XML DB namespace
local	http://www.w3.org/2003/11/xpath-local-functions	XPath local function declaration namespace
fn	http://www.w3.org/2003/11/xpath-functions	XPath function namespace
xml	http://www.w3.org/XML/1998/namespace	XML namespace
xs	http://www.w3.org/2001/XMLSchema	XML Schema namespace
xsi	http://www.w3.org/2001/XMLSchema-instance	XML Schema instance namespace

You can use these prefixes in XQuery expressions without first declaring them in the XQuery-expression prolog. You can redefine any of them *except* `xml` in the prolog. All of these prefixes except `ora` are predefined in the XQuery standard.

Oracle XQuery Extension Functions

Oracle XML DB adds some XQuery functions to those provided in the W3C standard. These additional functions are in the Oracle XML DB namespace, `http://xmlns.oracle.com/xdb`, which uses the predefined prefix **`ora`**. This section describes these Oracle extension functions.

ora:contains XQuery Function

Syntax

```
ora:contains (input_text, text_query [, policy_name] [, policy_owner])
```

XPath function `ora:contains` can be used in an XPath expression inside an XQuery expression or in a call to SQL function `existsNode`, `extract`, or `extractValue`. It is used to restrict a structural search with a full-text predicate. Function `ora:contains` returns a positive integer when the *`input_text`* matches *`text_query`* (the higher the number, the more relevant the match), and zero otherwise. When used in an XQuery expression, the XQuery return type is `xs:integer()`; when used in an XPath expression outside of an XQuery expression, the XPath return type is `number`.

Argument *`input_text`* must evaluate to a single text node or an attribute. The syntax and semantics of *`text_query`* in `ora:contains` are the same as *`text_query`* in `contains`, with a few restrictions.

See Also: "ora:contains XPath Function" on page 11-18

ora:matches XQuery Function

Syntax

```
ora:matches (target_string, match_pattern [, match_parameter])
```

XQuery function `ora:matches` lets you use a regular expression to match text in a string. It returns `true()` if its *`target_string`* argument matches its regular-expression *`match_pattern`* argument and `false()` otherwise. If *`target_`*

string is the empty sequence, `false()` is returned. Optional argument *match_parameter* is a code that qualifies matching: case-sensitivity and so on.

The behavior of XQuery function `ora:matches` is the same as that of SQL condition `REGEXP_LIKE`, but the types of its arguments are XQuery types instead of SQL data types. The argument types are as follows:

- *target_string* – `xs:string?`[3]
- *match_pattern* – `xs:string`
- *match_parameter* – `xs:string`

> **See Also:** *Oracle Database SQL Language Reference* for information about SQL condition `REGEXP_LIKE`

ora:replace XQuery Function

Syntax

```
ora:replace (target_string, match_pattern, replace_string [, match_parameter])
```

XQuery function `ora:replace` lets you use a regular expression to replace matching text in a string. *Each* occurrence in *target_string* that matches regular-expression *match_pattern* is replaced by *replace_string*. It returns the new string that results from the replacement. If *target_string* is the empty sequence, then the empty string (`""`) is returned. Optional argument *match_parameter* is a code that qualifies matching: case-sensitivity and so on.

The behavior of XQuery function `ora:matches` is the same as that of SQL function `regexp_replace`, but the types of its arguments are XQuery types instead of SQL data types. The argument types are as follows:

- *target_string* – `xs:string?`[4]
- *match_pattern* – `xs:string`
- *replace_string* – `xs:string`
- *match_parameter* – `xs:string`

In addition, `ora:replace` requires argument *replace_string* (it is optional in `regexp_replace`) and it does not use arguments for position and number of occurrences – search starts with the first character and all occurrences are replaced.

> **See Also:** *Oracle Database SQL Language Reference* for information about SQL function `regexp_replace`

ora:sqrt XQuery Function

Syntax

```
ora:sqrt (number)
```

[3] The question mark (`?`) here is a zero-or-one occurrence indicator that indicates that the argument can be the empty sequence. See "XQuery Expressions" on page 18-3.

[4] The question mark (`?`) here is a zero-or-one occurrence indicator that indicates that the argument can be the empty sequence. See "XQuery Expressions" on page 18-3.

XQuery function `ora:sqrt` returns the square root of its numerical argument, which can be of XQuery type `xs:decimal`, `xs:float`, or `xs:double`. The returned value is of the same XQuery type as the argument.

ora:view XQuery Function

Syntax

```
ora:view ([db-schema STRING,] db-table STRING)
RETURNS document-node(element())*[5]
```

XQuery function `ora:view` lets you query existing database tables or views inside an XQuery expression, as if they were XML documents. In effect, `ora:view` creates XML views over the relational data, on the fly. You can thus use `ora:view` to avoid explicitly creating XML views on top of relational data.

The input parameters are as follows:

- *db-schema* – An optional string literal that names a database schema.
- *db-table* – A string literal naming a database table or view. If *db-schema* is present, then *db-table* is in database schema *db-schema*.

Function `ora:view` returns an unordered sequence of `document` nodes, one for each row of *db-table*. The SQL/XML standard is used to map each input row to the output XML document: relational column names become XML element names. Unless *db-table* is of type `XMLType`, the column elements derived from a given table row are wrapped together in a `ROW` element. In that case, the return type is, more precisely, `document-node(element(ROW))*`.

XMLQUERY and XMLTABLE Examples

XQuery is a very general and expressive language, and SQL functions `XMLQuery`, `XMLTable`, and `XMLExists` combine that power of expression and computation with the similar strengths of SQL. This section illustrates some of what you can do with these two SQL/XML functions. See "XMLEXISTS SQL Function" on page 4-4 for information about `XMLExists`.

You will typically use XQuery with Oracle XML DB in the following ways. The examples here are organized to reflect these different uses.

- Query XML data in Oracle XML DB Repository.

  See "Using XQuery to Query XML Data in Oracle XML DB Repository".

- Query a relational table or view as if it were XML data. To do this, you use Oracle XQuery function `ora:view` to create an XML view over the relational data, on the fly.

  See "Using ora:view to Query Relational Data in XQuery Expressions".

- Query `XMLType` relational data, possibly decomposing the resulting XML into relational data using function `XMLTable`.

  See "Using XQuery with XMLType Data".

[5] The asterisk (`*`) here is a zero-or-more occurrence indicator that indicates that the argument can be a possibly empty sequence of document nodes of type element. See "XQuery Expressions" on page 18-3.

Example 18–1 Creating Resources for Examples

This example creates repository resources that are used in some of the other examples.

```
DECLARE
  res BOOLEAN;
  empsxmlstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <emps>
       <emp empno="1" deptno="10" ename="John" salary="21000"/>
       <emp empno="2" deptno="10" ename="Jack" salary="310000"/>
       <emp empno="3" deptno="20" ename="Jill" salary="100001"/>
     </emps>';
  empsxmlnsstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <emps xmlns="http://emp.com">
       <emp empno="1" deptno="10" ename="John" salary="21000"/>
       <emp empno="2" deptno="10" ename="Jack" salary="310000"/>
       <emp empno="3" deptno="20" ename="Jill" salary="100001"/>
     </emps>';
  deptsxmlstring VARCHAR2(300):=
    '<?xml version="1.0"?>
     <depts>
       <dept deptno="10" dname="Administration"/>
       <dept deptno="20" dname="Marketing"/>
       <dept deptno="30" dname="Purchasing"/>
     </depts>';
BEGIN
  res := DBMS_XDB.createResource('/public/emps.xml',   empsxmlstring);
  res := DBMS_XDB.createResource('/public/empsns.xml', empsxmlnsstring);
  res := DBMS_XDB.createResource('/public/depts.xml',  deptsxmlstring);
END;
/
```

XQuery Is About Sequences

It is important to keep in mind that XQuery is a general *sequence*-manipulation language. Its expressions and their results are not necessarily XML data. An XQuery sequence can contain items of any XQuery type, which includes numbers, strings, Boolean values, dates, as well as various types of XML node (`document-node()`, `element()`, `attribute()`, `text()`, `namespace()`, and so on). Example 18–2 provides a sampling.

Example 18–2 XMLQuery Applied to a Sequence of Items of Different Types

This example applies SQL function `XMLQuery` to an XQuery sequence that contains items of several different kinds:

- an integer literal: `1`
- a arithmetic expression: `2 + 3`
- a string literal: `"a"`
- a sequence of integers: `100 to 102`
- a constructed XML element node: `<A>33</A>`

This example also shows construction of a sequence using the comma operator (**`,`**) and parentheses (**`(,)`**) for grouping.

```
SELECT XMLQuery('(1, 2 + 3, "a", 100 to 102, <A>33</A>)'
                RETURNING CONTENT) AS output
```

```
  FROM DUAL;

OUTPUT
-------------------------
1 5 a 100 101 102<A>33</A>

1 row selected.
```

The sequence expression `100 to 102` evaluates to the sequence `(100, 101, 102)`, so the argument to `XMLQuery` is a sequence that contains a nested sequence. The sequence argument is automatically flattened, as is always the case for XQuery sequences. The argument is, in effect, `(1, 5, "a", 100, 101, 102, <A>33</A>)`.

Using XQuery to Query XML Data in Oracle XML DB Repository

This section presents examples of using XQuery with XML data in Oracle XML DB Repository. In Oracle XML DB, functions `fn:doc` and `fn:collection` return file and folder resources in the repository, respectively. Each example in this section uses XQuery function `fn:doc` to obtain a repository file that contains XML data, and then binds XQuery variables to parts of that data using `for` and `let` FLWOR-expression clauses.

> **See Also:** XQuery Functions fn:doc, fn:collection, and fn:doc-available

Example 18–3 FLOWR Expression Using For, Let, Order By, Where, and Return

This example queries two XML-document resources in Oracle XML DB Repository: `/public/emps.xml` and `/public/depts.xml`. It illustrates the use of *each* of the possible FLWOR-expression clauses, as well as the use of `fn:doc`.

```
SELECT XMLQuery('for $e in doc("/public/emps.xml")/emps/emp
                 let $d :=
                   doc("/public/depts.xml")//dept[@deptno = $e/@deptno]/@dname
                 where $e/@salary > 100000
                 order by $e/@empno
                 return <emp ename="{$e/@ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL;

XMLQUERY('FOR$EINDOC("/PUBLIC/EMPS.XML")/EMPS/EMPLET$D:=DOC("/PUBLIC/DEPTS.XML")
--------------------------------------------------------------------------------
<emp ename="Jack" dept="Administration"></emp><emp ename="Jill" dept="Marketing"
></emp>

1 row selected.
```

In Example 18–3, the various FLWOR clauses perform these operations:

- **`for`** iterates over the `emp` elements in `/public/emps.xml`, binding variable `$e` to the value of each such element, in turn. That is, it iterates over a general list of employees, binding `$e` to each employee.
- **`let`** binds variable `$d` to a *sequence* consisting of all of the values of `dname` attributes of those `dept` elements in `/public/emps.xml` whose `deptno` attributes have the same value as the `deptno` attribute of element `$e` (this is a join operation). That is, it binds `$d` to the names of all of the departments that have the same department number as the department of employee `$e`. (It so happens that

the dname value is unique for each deptno value in depts.xml.) Note that, unlike for, let never iterates over values; $d is bound only once in this example.

- Together, for and let produce a stream of tuples ($e, $d), where $e represents an employee and $d represents the names of all of the departments to which that employee belongs—in this case, the unique name of the employee's unique department.
- **where** filters this tuple stream, keeping only tuples with employees whose salary is greater than 100,000.
- **order by** sorts the filtered tuple stream by employee number, empno (in ascending order, by default).
- **return** constructs emp elements, one for each tuple. Attributes ename and dept of these elements are constructed using attribute ename from the input and $d, respectively. Note that the element and attribute names emp and ename in the output have no necessary connection with the same names in the input document emps.xml.

Example 18–4 also uses each of the FLWOR-expression clauses. In addition, it demonstrates the use of other XQuery functions, besides fn:doc.

Example 18–4 FLOWR Expression Using Built-In Functions

This example shows the use of XQuery functions doc, count, avg, and integer, which are in the namespace for built-in XQuery functions, http://www.w3.org/2003/11/xpath-functions. This namespace is bound to the prefix fn.

```
SELECT XMLQuery('for $d in fn:doc("/public/depts.xml")/depts/dept/@deptno
                 let $e := fn:doc("/public/emps.xml")/emps/emp[@deptno = $d]
                 where fn:count($e) > 1
                 order by fn:avg($e/@salary) descending
                 return
                   <big-dept>{$d,
                              <headcount>{fn:count($e)}</headcount>,
                              <avgsal>{xs:integer(fn:avg($e/@salary))}</avgsal>}
                   </big-dept>'
                RETURNING CONTENT) FROM DUAL;

XMLQUERY('FOR$DINFN:DOC("/PUBLIC/DEPTS.XML")/DEPTS/DEPT/@DEPTNOLET$E:=FN:DOC("/P
--------------------------------------------------------------------------------
<big-dept deptno="10"><headcount>2</headcount><avgsal>165500</avgsal></big-dept>

1 row selected.
```

In Example 18–4, the various FLWOR clauses perform these operations:

- **for** iterates over deptno attributes in input document /public/depts.xml, binding variable $d to the value of each such attribute, in turn.
- **let** binds variable $e to a sequence consisting of all of the emp elements in input document /public/emps.xml whose deptno attributes have value $d (this is a join operation).
- Together, for and let produce a stream of tuples ($d, $e), where $d represents a department number and $e represents the set of employees in that department.
- **where** filters this tuple stream, keeping only tuples with more than one employee.

- **`order by`** sorts the filtered tuple stream by average salary in descending order. The average is computed by applying XQuery function `avg` (in namespace `fn`) to the values of attribute `salary`, which is attached to the `emp` elements of `$e`.
- **`return`** constructs `big-dept` elements, one for each tuple produced by `order by`. The `text()` node of `big-dept` contains the department number, bound to `$d`. A `headcount` child element contains the number of employees, bound to `$e`, as determined by XQuery function `count`. An `avgsal` child element contains the computed average salary.

Using ora:view to Query Relational Data in XQuery Expressions

This section presents examples of using Oracle XQuery function `ora:view` to query relational data as if it were XML data, from within an XQuery expression.

See Also: "ora:view XQuery Function" on page 18-12

Example 18–5 Using ora:view to Query Relational Tables as XML Views

This example uses Oracle XQuery function `ora:view` in a FLWOR expression to query two relational tables, `regions` and `countries` joining. Both tables belong to sample database schema `hr`. The example also passes scalar SQL value `Asia` to XQuery variable `$regionname`. Any SQL expression can be evaluated to produce a value passed to XQuery using `PASSING`. In this case, the value comes from a SQL*Plus variable, `REGION`. You must cast the value to the scalar SQL data type expected, in this case, `VARCHAR2(40)`.

```
DEFINE REGION = 'Asia'
SELECT XMLQuery('for $i in ora:view("REGIONS"), $j in ora:view("COUNTRIES")
                   where $i/ROW/REGION_ID = $j/ROW/REGION_ID
                     and $i/ROW/REGION_NAME = $regionname
                   return $j'
                PASSING CAST('&REGION' AS VARCHAR2(40)) AS "regionname"
                RETURNING CONTENT) AS asian_countries
  FROM DUAL;
```

This produces the following result. (The result is shown here pretty-printed, for clarity.)

```
ASIAN_COUNTRIES
----------------------------------------
<ROW>
  <COUNTRY_ID>AU</COUNTRY_ID>
  <COUNTRY_NAME>Australia</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>CN</COUNTRY_ID>
  <COUNTRY_NAME>China</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>HK</COUNTRY_ID>
  <COUNTRY_NAME>HongKong</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>IN</COUNTRY_ID>
  <COUNTRY_NAME>India</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
```

```
</ROW>
<ROW>
  <COUNTRY_ID>JP</COUNTRY_ID>
  <COUNTRY_NAME>Japan</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>
<ROW>
  <COUNTRY_ID>SG</COUNTRY_ID>
  <COUNTRY_NAME>Singapore</COUNTRY_NAME>
  <REGION_ID>3</REGION_ID>
</ROW>

1 row selected.
```

In Example 18–5, the various FLWOR clauses perform these operations:

- **for** iterates over sequences of XML elements returned by calls to `ora:view`. In the first call, each element corresponds to a row of relational table `regions` and is bound to variable `$i`. Similarly, in the second call to `ora:view`, `$j` is bound to successive rows of table `countries`. Since `regions` and `countries` are not `XMLType` tables, the top-level element corresponding to a row in each table is `ROW` (a wrapper element). Iteration over the row elements is unordered.
- **where** filters the rows from both tables, keeping only those pairs of rows whose `region_id` is the same for each table (it performs a join on `region_id`) and whose `region_name` is `Asia`.
- **return** returns the filtered rows from the `countries` table as an XML document containing XML fragments with `ROW` as their top-level element.

Example 18–6 uses `ora:view` within nested FLWOR expressions.

Example 18–6 Using ora:view in a Nested FLWOR Query

This query is an example of using nested FLWOR expressions. It accesses relational table `warehouses`, which is in sample database schema `oe`, and relational table `locations`, which is in sample database schema `hr`. To run this example as user `oe`, you must first connect as user `hr` and grant permission to user `oe` to perform `SELECT` operations on table `locations`. The two-argument form of `ora:view` is used here, to specify the database schema (first argument) in addition to the table (second argument).

```
CONNECT hr/hr
GRANT SELECT ON LOCATIONS TO OE
/
CONNECT oe/oe

SELECT XMLQuery(
         'for $i in ora:view("OE", "WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                 <Location>
                   {for $j in ora:view("HR", "LOCATIONS")/ROW
                    where $j/LOCATION_ID eq $i/LOCATION_ID
                    return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                 </Location>
                 </Warehouse>'
        RETURNING CONTENT) FROM DUAL;
```

This produces the following result. (The result is shown here pretty-printed, for clarity.)

```
XMLQUERY('FOR$IINORA:VIEW("OE","WAREHOUSES")/ROWRETURN<WAREHOUSEID="{$I/WAREHOUS
--------------------------------------------------------------------------------
<Warehouse id="1">
  <Location>
    <STREET_ADDRESS>2014 Jabberwocky Rd</STREET_ADDRESS>
    <CITY>Southlake</CITY>
    <STATE_PROVINCE>Texas</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="2">
  <Location>
    <STREET_ADDRESS>2011 Interiors Blvd</STREET_ADDRESS>
    <CITY>South San Francisco</CITY>
    <STATE_PROVINCE>California</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="3">
  <Location>
    <STREET_ADDRESS>2007 Zagora St</STREET_ADDRESS>
    <CITY>South Brunswick</CITY>
    <STATE_PROVINCE>New Jersey</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="4">
  <Location>
    <STREET_ADDRESS>2004 Charade Rd</STREET_ADDRESS>
    <CITY>Seattle</CITY>
    <STATE_PROVINCE>Washington</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="5">
  <Location>
    <STREET_ADDRESS>147 Spadina Ave</STREET_ADDRESS>
    <CITY>Toronto</CITY>
    <STATE_PROVINCE>Ontario</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="6">
  <Location>
    <STREET_ADDRESS>12-98 Victoria Street</STREET_ADDRESS>
    <CITY>Sydney</CITY>
    <STATE_PROVINCE>New South Wales</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="7">
  <Location>
    <STREET_ADDRESS>Mariano Escobedo 9991</STREET_ADDRESS>
    <CITY>Mexico City</CITY>
    <STATE_PROVINCE>Distrito Federal,</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="8">
  <Location>
    <STREET_ADDRESS>40-5-12 Laogianggen</STREET_ADDRESS>
    <CITY>Beijing</CITY>
  </Location>
</Warehouse>
<Warehouse id="9">
  <Location>
    <STREET_ADDRESS>1298 Vileparle (E)</STREET_ADDRESS>
```

```
    <CITY>Bombay</CITY>
    <STATE_PROVINCE>Maharashtra</STATE_PROVINCE>
  </Location>
</Warehouse>

1 row selected.
```

In Example 18–6, the various FLWOR clauses perform these operations:

- The outer **for** iterates over the sequence of XML elements returned by `ora:view`: each element corresponds to a row of relational table `warehouses` and is bound to variable `$i`. Since `warehouses` is not an `XMLType` table, the top-level element corresponding to a row is `ROW`. The iteration over the row elements is unordered.
- The inner **for** iterates, similarly, over a sequence of XML elements returned by `ora:view`: each element corresponds to a row of relational table `locations` and is bound to variable `$j`.
- **where** filters the tuples (`$i`, `$j`), keeping only those whose `location_id` child is the same for `$i` and `$j` (it performs a join on `location_id`).
- The inner **return** constructs an XQuery sequence of elements `STREET_ADDRESS`, `CITY`, and `STATE_PROVINCE`, all of which are children of locations-table `ROW` element `$j`; that is, they are the values of the locations-table columns of the same name.
- The outer **return** wraps the result of the inner `return` in a `Location` element, and wraps that in a `Warehouse` element. It provides the `Warehouse` element with an `id` attribute whose value comes from the `warehouse_id` column of table `warehouses`.

See Also: Example 18–15 for the `EXPLAIN PLAN` of Example 18–6

Example 18–7 Using ora:view with XMLTable to Query a Relational Table as XML

In this example, SQL function `XMLTable` is used to decompose the result of an XQuery query to virtual relational data. The XQuery expression used in this example is identical to the one used in Example 18–6; the result of evaluating the XQuery expression is a sequence of `Warehouse` elements. Function `XMLTable` produces a virtual relational table whose rows are those `Warehouse` elements. More precisely, the value of pseudocolumn `COLUMN_VALUE` for each virtual-table row is an XML fragment (of type `XMLType`) with a single `Warehouse` element.

```
SELECT *
  FROM XMLTable(
         'for $i in ora:view("OE", "WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in ora:view("HR", "LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>');
```

This produces the same result as Example 18–6, except that each `Warehouse` element is output as a separate row, instead of all `Warehouse` elements being output together in a single row.

```
COLUMN_VALUE
------------------------------------------------------------
<Warehouse id="1">
```

```
  <Location>
    <STREET_ADDRESS>2014 Jabberwocky Rd</STREET_ADDRESS>
    <CITY>Southlake</CITY>
    <STATE_PROVINCE>Texas</STATE_PROVINCE>
  </Location>
</Warehouse>
<Warehouse id="2">
  <Location>
    <STREET_ADDRESS>2011 Interiors Blvd</STREET_ADDRESS>
    <CITY>South San Francisco</CITY>
    <STATE_PROVINCE>California</STATE_PROVINCE>
  </Location>
</Warehouse>
. . .

9 rows selected.
```

See Also: Example 18–16 for the `EXPLAIN PLAN` of Example 18–7

Using XQuery with XMLType Data

This section presents examples of using XQuery with `XMLType` relational data.

Example 18–8 Using XMLQuery with PASSING Clause, to Query an XMLType Column

This example passes an `XMLType` column, `oe.warehouse_spec`, as *context* item to XQuery, using function `XMLQuery` with the `PASSING` clause. It constructs a `Details` element for each of the warehouses whose area is greater than 80,000: `/Warehouse/Area > 80000`.

```
SELECT warehouse_name,
       XMLQuery(
         'for $i in /Warehouse
          where  $i/Area > 80000
          return <Details>
                   <Docks num="{$i/Docks}"/>
                   <Rail>{if ($i/RailAccess = "Y") then "true" else "false"}
                   </Rail>
                 </Details>'
         PASSING warehouse_spec RETURNING CONTENT) big_warehouses
  FROM warehouses;
```

This produces the following output:

```
WAREHOUSE_NAME
--------------
BIG_WAREHOUSES
--------------
Southlake, Texas


San Francisco


New Jersey
<Details><Docks num=""></Docks><Rail>false</Rail></Details>

Seattle, Washington
<Details><Docks num="3"></Docks><Rail>true</Rail></Details>

Toronto
```

```
Sydney


Mexico City


Beijing


Bombay


9 rows selected.
```

In Example 18–8, function `XMLQuery` is applied to the `warehouse_spec` column in each row of table `warehouses`. The various FLWOR clauses perform these operations:

- **`for`** iterates over the `Warehouse` elements in each row of column `warehouse_spec` (the passed context item): each such element is bound to variable `$i`, in turn. The iteration is unordered.
- **`where`** filters the `Warehouse` elements, keeping only those whose `Area` child has a value greater than 80,000.
- **`return`** constructs an XQuery sequence of `Details` elements, each of which contains a `Docks` and a `Rail` child elements. The `num` attribute of the constructed `Docks` element is set to the `text()` value of the `Docks` child of `Warehouse`. The `text()` content of `Rail` is set to `true` or `false`, depending on the value of the `RailAccess` attribute of element `Warehouse`.

The `SELECT` statement applies to each row in table `warehouses`. The `XMLQuery` expression returns the *empty sequence* for those rows that do not match the XQuery expression. Only the warehouses in New Jersey and Seattle satisfy the XQuery query, so they are the only warehouses for which `<Details>...</Details>` is returned.

Example 18–9 Using XMLTable with XML Schema-Based Data

This example uses SQL function `XMLTable` to query an `XMLType` table, `hr.purchaseorder`, which contains XML Schema-based data. It uses the `PASSING` clause to provide the `purchaseorder` table as the context item for the XQuery-expression argument to `XMLTable`. Pseudocolumn `COLUMN_VALUE` of the resulting virtual table holds a constructed element, `A10po`, which contains the `Reference` information for those purchase orders whose `CostCenter` element has value `A10` and whose `User` element has value `SMCCAIN`. The query performs a join between the virtual table and database table `purchaseorder`.

```
SELECT xtab.COLUMN_VALUE
  FROM purchaseorder, XMLTable('for $i in /PurchaseOrder
                                where $i/CostCenter eq "A10"
                                  and $i/User eq "SMCCAIN"
                                return <A10po pono="{$i/Reference}"/>'
                               PASSING OBJECT_VALUE) xtab;

COLUMN_VALUE
--------------------------------------------------
<A10po pono="SMCCAIN-20021009123336151PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336341PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337173PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335681PDT"></A10po>
```

```
<A10po pono="SMCCAIN-20021009123335470PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336972PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336842PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336512PDT"></A10po>
<A10po pono="SMCCAIN-20021009123333894PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337403PDT"></A10po>

10 rows selected.
```

The `PASSING` clause of function `XMLTable` passes the `OBJECT_VALUE` of `XMLType` table `purchaseorder`, to serve as the XPath context. This means that the `XMLTable` expression *depends* on the `purchaseorder` table. Because of this, table `purchaseorder` must appear *before* the `XMLTable` expression in the `FROM` list. This is a general requirement in any situation involving data dependence.

Note: Whenever a `PASSING` clause refers to a column of an `XMLType` table in a query, that table ***must appear before*** the `XMLTable` expression in the query `FROM` list. This is because the `XMLTable` expression *depends* on the `XMLType` table—a *left lateral* (correlated) join is needed, to ensure a one-to-many (1:N) relationship between the `XMLType` table row accessed and the rows generated from it by `XMLTable`.

Example 18–10 Using XMLQuery with Schema-Based Data

This example is similar to Example 18–9 in its effect. It uses `XMLQuery`, instead of `XMLTable`, to query `hr.purchaseorder`. These two examples differ in their treatment of the empty sequences returned by the XQuery expression. In Example 18–9, these empty sequences are not joined with the `purchaseorder` table, so the overall SQL-query result set has only ten rows. In Example 18–10, these empty sequences are part of the overall result set of the SQL query, which contains 132 rows, one for each of the rows in table `purchaseorder`. All but ten of those rows are empty, and show up in the output as empty lines. To save space here, those empty lines have been removed.

```
SELECT XMLQuery('for $i in /PurchaseOrder
                 where $i/CostCenter eq "A10"
                   and $i/User eq "SMCCAIN"
                 return <A10po pono="{$i/Reference}"/>'
                PASSING OBJECT_VALUE
                RETURNING CONTENT)
  FROM purchaseorder;

XMLQUERY('FOR$IIN/PURCHASEORDERWHERE$I/COSTCENTEREQ"A10"AND$I/USEREQ"SMCCAIN"RET
--------------------------------------------------------------------------------
<A10po pono="SMCCAIN-20021009123336151PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336341PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337173PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335681PDT"></A10po>
<A10po pono="SMCCAIN-20021009123335470PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336972PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336842PDT"></A10po>
<A10po pono="SMCCAIN-20021009123336512PDT"></A10po>
<A10po pono="SMCCAIN-20021009123333894PDT"></A10po>
<A10po pono="SMCCAIN-20021009123337403PDT"></A10po>

132 rows selected.
```

See Also: Example 18–17 for the EXPLAIN PLAN of Example 18–10

Example 18–11 Using XMLTable with PASSING and COLUMNS Clauses

This example uses XMLTable clauses PASSING and COLUMNS. The XQuery expression iterates over top-level PurchaseOrder elements, constructing a PO element for each purchase order with cost center A10. The resulting PO elements are then passed to XMLTable for processing.

Data from the children of PurchaseOrder is used to construct the children of PO, which are Ref, Type, and Name. The content of Type is taken from the content of /PurchaseOrder/SpecialInstructions, but the classes of SpecialInstructions are divided up differently for Type.

Function XMLTable breaks up the result of XQuery evaluation, returning it as three VARCHAR2 columns of a virtual table: poref, priority, and contact. The DEFAULT clause is used to supply a default priority of Regular.

```
SELECT xtab.poref, xtab.priority, xtab.contact
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder
                 let $spl := $i/SpecialInstructions
                 where $i/CostCenter eq "A10"
                 return <PO>
                          <Ref>{$i/Reference}</Ref>
                          {if ($spl eq "Next Day Air" or $spl eq "Expedite") then
                             <Type>Fastest</Type>
                           else if ($spl eq "Air Mail") then
                             <Type>Fast</Type>
                           else ()}
                          <Name>{$i/Requestor}</Name>
                        </PO>'
                PASSING OBJECT_VALUE
                COLUMNS poref    VARCHAR2(20) PATH 'Ref',
                        priority VARCHAR2(8)  PATH 'Type' DEFAULT 'Regular',
                        contact  VARCHAR2(20) PATH 'Name') xtab;

POREF                PRIORITY CONTACT
-------------------- -------- --------------------
SKING-20021009123336 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
SMCCAIN-200210091233 Fastest  Samuel B. McCain
JCHEN-20021009123337 Fastest  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123338 Regular  John Z. Chen
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123335 Regular  Steven X. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123336 Regular  Steven A. King
SMCCAIN-200210091233 Fast     Samuel B. McCain
SKING-20021009123336 Fastest  Steven A. King
SKING-20021009123336 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123335 Regular  John Z. Chen
SKING-20021009123336 Regular  Steven A. King
JCHEN-20021009123336 Regular  John Z. Chen
SKING-20021009123336 Regular  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
SKING-20021009123337 Regular  Steven A. King
```

```
SKING-20021009123338 Fastest  Steven A. King
SMCCAIN-200210091233 Regular  Samuel B. McCain
JCHEN-20021009123337 Regular  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
JCHEN-20021009123337 Regular  John Z. Chen
SKING-20021009123337 Regular  Steven A. King
SKING-20021009123337 Regular  Steven A. King
SMCCAIN-200210091233 Fast     Samuel B. McCain

32 rows selected.
```

Example 18–12 Using XMLTable to Decompose XML Collection Elements into Relational Data

In this example, SQL function `XMLTable` is used to break up the XML data in an `XMLType` collection element, `LineItem`, into separate columns of a virtual table.

```
SELECT lines.lineitem, lines.description, lines.partid,
       lines.unitprice, lines.quantity
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder/LineItems/LineItem
                 where $i/@ItemNumber >= 8
                  and $i/Part/@UnitPrice > 50
                  and $i/Part/@Quantity > 2
                 return $i'
                PASSING OBJECT_VALUE
                COLUMNS lineitem    NUMBER       PATH '@ItemNumber',
                        description VARCHAR2(30) PATH 'Description',
                        partid      NUMBER       PATH 'Part/@Id',
                        unitprice   NUMBER       PATH 'Part/@UnitPrice',
                        quantity    NUMBER       PATH 'Part/@Quantity') lines;

LINEITEM DESCRIPTION                         PARTID UNITPRICE QUANTITY
-------- ------------------------------ ------------- --------- --------
      11 Orphic Trilogy                  37429148327        80        3
      22 Dreyer Box Set                  37429158425        80        4
      11 Dreyer Box Set                  37429158425        80        3
      16 Dreyer Box Set                  37429158425        80        3
       8 Dreyer Box Set                  37429158425        80        3
      12 Brazil                          37429138526        60        3
      18 Eisenstein: The Sound Years     37429149126        80        4
      24 Dreyer Box Set                  37429158425        80        3
      14 Dreyer Box Set                  37429158425        80        4
      10 Brazil                          37429138526        60        3
      17 Eisenstein: The Sound Years     37429149126        80        3
      16 Orphic Trilogy                  37429148327        80        4
      13 Orphic Trilogy                  37429148327        80        4
      10 Brazil                          37429138526        60        4
      12 Eisenstein: The Sound Years     37429149126        80        3
      12 Dreyer Box Set                  37429158425        80        4
      13 Dreyer Box Set                  37429158425        80        4

17 rows selected.
```

See Also:

- Example 18–18 for the `EXPLAIN PLAN` of Example 18–12
- "Breaking Up Multiple Levels of XML Data" on page 3-50, for an example of applying `XMLTable` to multiple document levels

Using Namespaces with XQuery

You can use the XQuery `declare namespace` declaration in the prolog of an XQuery expression to define a namespace prefix. You can use `declare` **`default`** `namespace` to establish the namespace as the default namespace for the expression.

Be aware of the following pitfall, if you use SQL*Plus: If the semicolon (`;`) at the end of a namespace declaration terminates a line, SQL*Plus will interpret it as a SQL terminator. To avoid this, you can do one of the following:

- Place the text that follows the semicolon on the same line.
- Place a comment, such as **`(: :)`**, after the semicolon, on the same line.
- Turn off the recognition of the SQL terminator with SQL*Plus command `SET SQLTERMINATOR`.

Example 18–13 Using XMLQuery with a Namespace Declaration

```
SELECT XMLQuery('declare namespace e = "http://emp.com";
ERROR:
ORA-01756: quoted string not properly terminated

                for $i in doc("/public/empsns.xml")/e:emps/e:emp
SP2-0734: unknown command beginning "for $i in ..." - rest of line ignored.
...

-- This works - do not end the line with ";".
SELECT XMLQuery('declare namespace e = "http://emp.com"; for
                    $i in doc("/public/empsns.xml")/e:emps/e:emp
                let $d :=
                  doc("/public/depts.xml")//dept[deptno=$i/@e:deptno]/@dname
                where $i/@e:salary > 100000
                order by $i/@e:empno
                return <emp ename="{$i/@e:ename}" dept="{$d}"/>'
               RETURNING CONTENT) FROM DUAL;

XMLQUERY('DECLARENAMESPACEE="HTTP://EMP.COM";FOR$IINDOC("/PUBLIC/EMPSNS.XML")/E:
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>

-- This works too - add a comment after the ";".
SELECT XMLQuery('declare namespace e = "http://emp.com";  (: :)
                for $i in doc("/public/empsns.xml")/e:emps/e:emp
                let $d :=
doc("/public/depts.xml")//dept[deptno=$i/@e:deptno]/@dname
                where $i/@e:salary > 100000
                order by $i/@e:empno
                return <emp ename="{$i/@e:ename}" dept="{$d}"/>'
               RETURNING CONTENT) FROM DUAL;

XMLQUERY('DECLARENAMESPACEE="HTTP://EMP.COM";(::)FOR$IINDOC("/PUBLIC/EMPSNS.XML"
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>
```

```
1 row selected.

-- This works too - tell SQL*Plus to ignore the ";".
SET SQLTERMINATOR OFF

SELECT XMLQuery('declare namespace e = "http://emp.com";
                 for $i in doc("/public/empsns.xml")/e:emps/e:emp
                 let $d :=
                   doc("/public/depts.xml")//dept[deptno=$i/@e:deptno]/@dname
                 where $i/@e:salary > 100000
                 order by $i/@e:empno
                 return <emp ename="{$i/@e:ename}" dept="{$d}"/>'
                RETURNING CONTENT) FROM DUAL
/

XMLQUERY('DECLARENAMESPACEE="HTTP://EMP.COM";FOR$IINDOC("/PUBLIC/EMPSNS.XML")/E:
--------------------------------------------------------------------------------
<emp ename="Jack" dept=""></emp><emp ename="Jill" dept=""></emp>
```

An XQuery namespace declaration has no effect outside of its XQuery expression. To declare a namespace prefix for use in an `XMLTable` expression outside of the XQuery expression, use the `XMLNAMESPACES` clause. This clause also covers the XQuery expression argument to `XMLTable`, eliminating the need for a separate declaration in the XQuery prolog.

In Example 18–14, `XMLNAMESPACES` is used to define the prefix `e` for the namespace `http://emp.com`. This namespace is used in the `COLUMNS` clause as well as the XQuery expression of the `XMLTable` expression.

Example 18–14 Using XMLTable with the XMLNAMESPACES Clause

```
SELECT * FROM XMLTable(XMLNAMESPACES('http://emp.com' AS "e"),
                       'for $i in doc("/public/empsns.xml")
                        return $i/e:emps/e:emp'
                       COLUMNS name VARCHAR2(6) PATH '@ename',
                               id   NUMBER      PATH '@empno');
```

This produces the following result:

```
NAME           ID
------ ----------
John            1
Jack            2
Jill            3

3 rows selected.
```

It is the presence of qualified names `e:ename` and `e:empno` in the `COLUMNS` clause that necessitates using the `XMLNAMESPACES` clause. Otherwise, a prolog namespace declaration (`declare namespace e = "http://emp.com"`) would suffice for the XQuery expression itself.

Because the same namespace is used throughout the `XMLTable` expression, a default namespace could be used: `XMLNAMESPACES (DEFAULT 'http://emp.com')`. The qualified name `$i/e:emps/e:emp` could then be written without an explicit prefix: `$i/emps/emp`.

Performance Tuning for XQuery

As mentioned, Oracle XML DB generally evaluates XQuery expressions by executing equivalent relational expressions. This optimization uses the same mechanism as XPath rewrite, and it provides the same benefits. Just as query tuning can improve SQL performance, so it can improve XQuery performance. You tune XQuery performance by choosing appropriate XML storage models and indexes.

As with database queries generally, you determine whether tuning is required by examining the `EXPLAIN PLAN` for a query. If the plan is not optimal, then consult the following documentation for specific tuning information:

- For structured storage: "Understanding and Optimizing XPath Rewrite" on page 3-59 and Chapter 7, "XPath Rewrite"
- For unstructured storage and binary XML storage: Chapter 5, "Indexing XMLType Data"

In addition, be aware that the following XQuery expressions can be expensive to process, so they might add performance overhead when processing large volumes of data:

- Reverse axes, that is, axes `ancestor`, `ancestor-or-self`, `parent`, `preceding`, and `preceding-sibling`
- XQuery function `fn:position` and positional predicates, such as [1]

> **See Also:** "Oracle XML DB Support for XQuery" on page 18-36

This section presents the `EXPLAIN PLAN`s for some of the examples shown earlier in this chapter, to indicate how they are executed. The examples are organized into the following groups according to the target of the XQuery expression:

- a SQL/XML view created on the fly using `ora:view`
- an XML schema-based `XMLType` table stored object-relationally

To further improve the performance of XQuery expressions when querying `XMLType` data in unstructured storage or binary XML storage, you can use `XMLIndex`.

> **See Also:**
>
> - "Understanding and Optimizing XPath Rewrite" on page 3-59
> - "Diagnosing XPath Rewrite" on page 7-13
> - Chapter 5, "Indexing XMLType Data" for information about using `XMLIndex`

XQuery Optimization over a SQL/XML View Created by ora:view

Example 18–15 shows the optimization of `XMLQuery` over a SQL/XML view created by `ora:view`. Example 18–16 shows the optimization of `XMLTable` in the same context.

Example 18–15 Optimization of XMLQuery with ora:view

Here, again, is Example 18–6:

```
SELECT XMLQuery(
         'for $i in ora:view("OE", "WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
```

```
                        <Location>
                          {for $j in ora:view("HR", "LOCATIONS")/ROW
                           where $j/LOCATION_ID eq $i/LOCATION_ID
                           return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                        </Location>
                        </Warehouse>'
                RETURNING CONTENT) FROM DUAL;
```

The EXPLAIN PLAN for this example shows that the query has been optimized:

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 2976528487

-------------------------------------------------------------------------------------------
| Id  | Operation                     | Name       | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |            |     1 |       |     2   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE               |            |     1 |    41 |            |          |
|   2 |   NESTED LOOPS                |            |     1 |    41 |     3   (0)| 00:00:01 |
|   3 |    TABLE ACCESS BY INDEX ROWID| LOCATIONS  |     1 |    41 |     1   (0)| 00:00:01 |
|*  4 |     INDEX UNIQUE SCAN         | LOC_ID_PK  |     1 |       |     0   (0)| 00:00:01 |
|   5 |    FAST DUAL                  |            |     1 |       |     2   (0)| 00:00:01 |
|   6 |     SORT AGGREGATE            |            |     1 |   185 |            |          |
|   7 |      NESTED LOOPS             |            |     9 |  1665 |     4   (0)| 00:00:01 |
|   8 |       FAST DUAL               |            |     1 |       |     2   (0)| 00:00:01 |
|   9 |       TABLE ACCESS FULL       | WAREHOUSES |     9 |  1665 |     2   (0)| 00:00:01 |
|  10 |        FAST DUAL              |            |     1 |       |     2   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

 4 - access("LOCATION_ID"=:B1)

22 rows selected.
```

Example 18–16 Optimization of XMLTable with ora:view

Here, again, is Example 18–7:

```
SELECT *
  FROM XMLTable(
         'for $i in ora:view("OE", "WAREHOUSES")/ROW
          return <Warehouse id="{$i/WAREHOUSE_ID}">
                   <Location>
                     {for $j in ora:view("HR", "LOCATIONS")/ROW
                      where $j/LOCATION_ID eq $i/LOCATION_ID
                      return ($j/STREET_ADDRESS, $j/CITY, $j/STATE_PROVINCE)}
                   </Location>
                 </Warehouse>');
```

The EXPLAIN PLAN for this example shows that the query has been optimized:

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 2573750906

-------------------------------------------------------------------------------------------
| Id  | Operation                     | Name       | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |            |     9 |  1665 |     4   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE               |            |     1 |    41 |            |          |
|   2 |   NESTED LOOPS                |            |     1 |    41 |     3   (0)| 00:00:01 |
|   3 |    TABLE ACCESS BY INDEX ROWID| LOCATIONS  |     1 |    41 |     1   (0)| 00:00:01 |
```

```
|*  4 |     INDEX UNIQUE SCAN         | LOC_ID_PK  |     1 |       |     0   (0)| 00:00:01 |
|   5 |    FAST DUAL                  |            |     1 |       |     2   (0)| 00:00:01 |
|   6 |     NESTED LOOPS              |            |     9 |  1665 |     4   (0)| 00:00:01 |
|   7 |      FAST DUAL                |            |     1 |       |     2   (0)| 00:00:01 |
|   8 |      TABLE ACCESS FULL        | WAREHOUSES |     9 |  1665 |     2   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   4 - access("LOCATION_ID"=:B1)

20 rows selected.
```

XQuery Optimization over XML Schema-Based XMLType Data

Example 18–17 shows the optimization of `XMLQuery` over an XML schema-based `XMLType` table. Example 18–18 shows the optimization of `XMLTable` in the same context.

Example 18–17 Optimization of XMLQuery with Schema-Based XMLType Data

Here, again, is Example 18–10:

```
SELECT XMLQuery('for $i in /PurchaseOrder
                 where $i/CostCenter eq "A10"
                   and $i/User eq "SMCCAIN"
                 return <A10po pono="{$i/Reference}"/>'
                PASSING OBJECT_VALUE
                RETURNING CONTENT)
  FROM purchaseorder;
```

The `EXPLAIN PLAN` for this example shows that the query has been optimized.

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 3611789148

-------------------------------------------------------------------------------------------
| Id  | Operation           | Name          | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT    |               |     1 |   530 |     5   (0)| 00:00:01 |
|   1 |  SORT AGGREGATE     |               |     1 |       |            |          |
|*  2 |   FILTER            |               |       |       |            |          |
|   3 |    FAST DUAL        |               |     1 |       |     2   (0)| 00:00:01 |
|*  4 |    TABLE ACCESS FULL| PURCHASEORDER |     1 |   530 |     5   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(:B1='SMCCAIN' AND :B2='A10')
   4 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
               xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
               http://xmlns.oracle.com/xdb/acl.xsd DAV:http://xmlns.oracle.com/xdb/dav.xsd">
               <read-properties/><read-contents/></privilege>'))=1)

22 rows selected.
```

Example 18–18 Optimization of XMLTable with Schema-Based XMLType Data

Here, again, is Example 18–12:

```
SELECT lines.lineitem, lines.description, lines.partid,
       lines.unitprice, lines.quantity
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder/LineItems/LineItem
                 where $i/@ItemNumber >= 8
                  and $i/Part/@UnitPrice > 50
                  and $i/Part/@Quantity > 2
                 return $i'
                PASSING OBJECT_VALUE
                COLUMNS lineitem    NUMBER       PATH '@ItemNumber',
                        description VARCHAR2(30) PATH 'Description',
                        partid      NUMBER       PATH 'Part/@Id',
                        unitprice   NUMBER       PATH 'Part/@UnitPrice',
                        quantity    NUMBER       PATH 'Part/@Quantity') lines;
```

The `EXPLAIN PLAN` for this example shows that the query has been optimized. The XQuery result is never materialized. Instead, the underlying storage columns for the XML collection element `LineItem` are used to generate the overall result set.

```
PLAN_TABLE_OUTPUT
-------------------------------------------------------------------------------------------
Plan hash value: 3113556559

-------------------------------------------------------------------------------------------
| Id  | Operation          | Name              | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT   |                   |     4 |   376 |     6   (0)| 00:00:01 |
|   1 |  NESTED LOOPS      |                   |     4 |   376 |     6   (0)| 00:00:01 |
|*  2 |   TABLE ACCESS FULL| PURCHASEORDER     |     1 |    37 |     5   (0)| 00:00:01 |
|*  3 |   INDEX RANGE SCAN | SYS_IOT_TOP_48748 |     3 |   171 |     1   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - filter(SYS_CHECKACL("ACLOID","OWNERID",xmltype('<privilege
               xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
               http://xmlns.oracle.com/xdb/acl.xsd DAV:http://xmlns.oracle.com/xdb/dav.xsd"><re
               ad-properties/><read-contents/></privilege>'))=1)
   3 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")
       filter("SYS_NC00013$">50 AND "SYS_NC00012$">2 AND "ITEMNUMBER">=8)

22 rows selected.
```

In this example, table `hr.purchaseorder` is traversed completely; the `XMLTable` expression is evaluated for each purchase-order document. It is more efficient, however, to have the `XMLTable` expression, not the `purchaseorder` table, drive the SQL-query execution. That is, although the XQuery expression has been rewritten to relational expressions, you can improve this optimization by creating an *index* on the underlying relational data—you can optimize this query in the same way that you would optimize a purely SQL query.

That is always the case with XQuery in Oracle XML DB: the optimization techniques you use are the same that you use in SQL.

The `UnitPrice` attribute of collection element `LineItem` is an appropriate index target. The governing XML schema specifies that an ordered collection table (OCT) is used to store the `LineItem` elements.

However, the name of this OCT was generated by Oracle XML DB when the XML purchase-order documents were decomposed as XML schema-based data. Instead of using table `purchaseorder` from sample database-schema `hr`, for illustration we will manually create a new `purchaseorder` table (in a different database schema) with the same properties and same data, but having OCTs with user-friendly names. Refer to Example 3–11 on page 3-27 for how to do this.

Assuming that a `purchaseorder` table has been created as in Example 3–11, the following statement creates the appropriate index:

```
CREATE INDEX unitprice_index ON lineitem_table("PART"."UNITPRICE");
```

With this index defined, Example 18–12 results in the following `EXPLAIN PLAN`, which shows that the `XMLTable` expression has driven the overall evaluation.

```
PLAN_TABLE_OUTPUT
------------------------------------------------------------------------------------------
Plan hash value: 1578014525

-------------------------------------------------------------------------------------------
| Id  | Operation          | Name              | Rows  | Bytes | Cost (%CPU)| Time     |
-------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT   |                   |     3 |   624 |     8   (0)| 00:00:01 |
|   1 |  NESTED LOOPS      |                   |     3 |   624 |     8   (0)| 00:00:01 |
|*  2 |   INDEX UNIQUE SCAN| SYS_IOT_TOP_49323 |     3 |   564 |     5   (0)| 00:00:01 |
|*  3 |    INDEX RANGE SCAN| UNITPRICE_INDEX   |    20 |       |     2   (0)| 00:00:01 |
|*  4 |   INDEX UNIQUE SCAN| SYS_C004411       |     1 |       |     0   (0)| 00:00:01 |
-------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("SYS_NC00013$">50)
       filter("ITEMNUMBER">=8 AND "SYS_NC00012$">2)
   3 - access("SYS_NC00013$">50)
   4 - access("NESTED_TABLE_ID"="PURCHASEORDER"."SYS_NC0003400035$")

Note
-----
   - dynamic sampling used for this statement

23 rows selected.
```

XQuery Static Type-Checking in Oracle XML DB

Oracle XML DB type-checks *all* XQuery expressions. Doing this at runtime can be costly, however. As an optimization technique, whenever there is sufficient static type information available for a given query at compile time, Oracle XML DB performs *static* (compile time) type-checking of that query. Whenever sufficient static type information is not available for a given query at compile time, Oracle XML DB uses dynamic (runtime) type checking for that query.

Static type-checking can save execution time by raising errors at compile time. Static type-checking errors include both data-type errors and the use of XPath expressions that are invalid with respect to an XML schema.

Typical ways of providing sufficient static type information at query compile time include the following:

- Using XQuery with `ora:view` to query an XML view over relational data.
- Using XQuery to query an `XMLType` table, column, or view whose XML Schema information is available at query compile time.

This section presents examples that demonstrate the utility of static type-checking and the use of these two means of communicating type information.

Example 18–19 Static Type-Checking of XQuery Expressions: ora:view

The XML view produced on the fly by Oracle XQuery function `ora:view` has `ROW` as its top-level element, but this example incorrectly lacks that `ROW` wrapper element. This omission raises a compile-time error. Forgetting that `ora:view` wraps relational data in this way is an easy mistake to make, and one that could be difficult to diagnose without static type-checking. Example 18–5 shows the correct code.

```
-- This produces a static-type-check error, because "ROW" is missing.
SELECT XMLQuery('for $i in ora:view("REGIONS"), $j in ora:view("COUNTRIES")
                 where $i/REGION_ID = $j/REGION_ID and $i/REGION_NAME = "Asia"
                 return $j'
                RETURNING CONTENT) AS asian_countries
  FROM DUAL;
SELECT XMLQuery('for $i in ora:view("REGIONS"), $j in ora:view("COUNTRIES")
*
ERROR at line 1:
ORA-19276: XPST0005 - XPath step specifies an invalid element/attribute name:
(REGION_ID)
```

Example 18–20 Static Type-Checking of XQuery Expressions: Schema-Based XML

In this example, XQuery static type-checking finds a mismatch between an XPath expression and its target XML schema-based data. Element `CostCenter` is misspelled here as `costcenter` (XQuery and XPath are case-sensitive). Example 18–11 shows the correct code.

```
-- This results in a static-type-check error: CostCenter is not the right case.
SELECT xtab.poref, xtab.usr, xtab.requestor
  FROM purchaseorder,
       XMLTable('for $i in /PurchaseOrder where $i/costcenter eq "A10" return $i'
                PASSING OBJECT_VALUE
                COLUMNS poref     VARCHAR2(20) PATH 'Reference',
                        usr       VARCHAR2(20) PATH 'User' DEFAULT 'Unknown',
                        requestor VARCHAR2(20) PATH 'Requestor') xtab;
  FROM purchaseorder,
       *
ERROR at line 2:
ORA-19276: XPST0005 - XPath step specifies an invalid element/attribute name:
(costcenter)
```

SQL*Plus XQUERY Command

Example 18–21 shows how you can enter an XQuery expression directly at the SQL*Plus command line, by preceding the expression with the SQL*Plus command **`XQUERY`** and following it with a slash (`/`) on a line by itself. Oracle Database treats XQuery expressions submitted with this command the same way it treats XQuery expressions in SQL functions `XMLQuery` and `XMLTable`. Execution is identical, with the same optimizations.

Example 18–21 Using the SQL*Plus XQUERY Command

```
SQL> XQUERY for $i in ora:view("departments")
  2  where $i/ROW/DEPARTMENT_ID < 50
  3  return $i
  4  /
```

```
Result Sequence
--------------------------------------------------------------------------------
<ROW><DEPARTMENT_ID>10</DEPARTMENT_ID><DEPARTMENT_NAME>Administration</DEPARTMEN
T_NAME><MANAGER_ID>200</MANAGER_ID><LOCATION_ID>1700</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>20</DEPARTMENT_ID><DEPARTMENT_NAME>Marketing</DEPARTMENT_NAM
E><MANAGER_ID>201</MANAGER_ID><LOCATION_ID>1800</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>30</DEPARTMENT_ID><DEPARTMENT_NAME>Purchasing</DEPARTMENT_NA
ME><MANAGER_ID>114</MANAGER_ID><LOCATION_ID>1700</LOCATION_ID></ROW>

<ROW><DEPARTMENT_ID>40</DEPARTMENT_ID><DEPARTMENT_NAME>Human Resources</DEPARTME
NT_NAME><MANAGER_ID>203</MANAGER_ID><LOCATION_ID>2400</LOCATION_ID></ROW>
```

There are also a few SQL*Plus `SET` commands that you can use for settings that are specific to XQuery. Use `SHOW XQUERY` to see the current settings.

- **`SET XQUERY BASEURI`** – Set the base URI for `XQUERY`. URIs in XQuery expressions are relative to this URI.
- **`SET XQUERY CONTEXT`** – Specify a context item for subsequent `XQUERY` evaluations.

See Also: *SQL*Plus User's Guide and Reference*

Using XQuery with PL/SQL, JDBC, and ODP.NET

Previous sections in this chapter have shown how to invoke XQuery from SQL. This section provides examples of using XQuery with the Oracle APIs for PL/SQL, JDBC, and Oracle Data Provider for .NET (ODP.NET).

Example 18–22 Using XQuery with PL/SQL

This example shows how to use XQuery with PL/SQL, in particular, how to bind *dynamic variables* to an XQuery expression using the `XMLQuery PASSING` clause. The bind variables `:1` and `:2` are bound to the PL/SQL bind arguments `nbitems` and `partid`, respectively. These are then passed to XQuery as XQuery variables `itemno` and `id`, respectively.

```
DECLARE
  sql_stmt VARCHAR2(2000); -- Dynamic SQL statement to execute
  nbitems  NUMBER := 3; -- Number of items
  partid   VARCHAR2(20):= '715515009058'; -- Part ID
  result   XMLType;
  doc      DBMS_XMLDOM.DOMDocument;
  ndoc     DBMS_XMLDOM.DOMNode;
  buf      VARCHAR2(20000);
BEGIN
  sql_stmt :=
    'SELECT XMLQuery(
               ''for $i in ora:view("PURCHASEORDER") ' ||
                'where count($i/PurchaseOrder/LineItems/LineItem) = $itemno ' ||
                  'and $i/PurchaseOrder/LineItems/LineItem/Part/@Id = $id ' ||
                'return $i/PurchaseOrder/LineItems'' ' ||
               'PASSING :1 AS "itemno", :2 AS "id" ' ||
               'RETURNING CONTENT) FROM DUAL';

  EXECUTE IMMEDIATE sql_stmt INTO result USING nbitems, partid;
  doc  := DBMS_XMLDOM.newDOMDocument(result);
  ndoc := DBMS_XMLDOM.makeNode(doc);
```

```
  DBMS_XMLDOM.writeToBuffer(ndoc, buf);
  DBMS_OUTPUT.put_line(buf);
END;
/
```

This produces the following output:

```
<LineItems>
  <LineItem ItemNumber="1">
    <Description>Samurai 2: Duel at Ichijoji Temple</Description>
    <Part Id="37429125526" UnitPrice="29.95" Quantity="3"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>The Red Shoes</Description>
    <Part Id="37429128220" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>A Night to Remember</Description>
    <Part Id="715515009058" UnitPrice="39.95" Quantity="1"/>
  </LineItem>
</LineItems>
<LineItems>
  <LineItem ItemNumber="1">
    <Description>A Night to Remember</Description>
    <Part Id="715515009058" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>The Unbearable Lightness Of Being</Description>
    <Part Id="37429140222" UnitPrice="29.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>Sisters</Description>
    <Part Id="715515011020" UnitPrice="29.95" Quantity="4"/>
  </LineItem>
</LineItems>

PL/SQL procedure successfully completed.
```

Example 18–23 Using XQuery with JDBC

This example shows how to use XQuery with JDBC, binding variables by position with the `PASSING` clause of SQL function `XMLTable`.

```
import java.sql.*;
import oracle.sql.*;
import oracle.jdbc.*;
import oracle.xdb.XMLType;
import java.util.*;

public class QueryBindByPos
{
  public static void main(String[] args) throws Exception, SQLException
  {
    System.out.println("*** JDBC Access of XQuery using Bind Variables ***");
    DriverManager.registerDriver(new oracle.jdbc.driver.OracleDriver());
    OracleConnection conn
      = (OracleConnection)
        DriverManager.getConnection("jdbc:oracle:oci8:@localhost:1521:ora11gR1", "oe", "oe");
    String xqString
      = "SELECT COLUMN_VALUE" +
          "FROM XMLTable('for $i in ora:view(\"PURCHASEORDER\") " +
```

```
                        "where $i/PurchaseOrder/Reference= $ref " +
                        "return $i/PurchaseOrder/LineItems' " +
                       "PASSING ? AS \"ref\")";
    OraclePreparedStatement stmt = (OraclePreparedStatement)conn.prepareStatement(xqString);
    String refString = "EABEL-20021009123336251PDT"; // Set the filter value
    stmt.setString(1, refString); // Bind the string
    ResultSet rs = stmt.executeQuery();
    while (rs.next())
    {
       XMLType desc = (XMLType) rs.getObject(1);
       System.out.println("LineItem Description: " + desc.getStringVal());
    }
    rs.close();
    stmt.close();
  }
}
```

This produces the following output:

```
*** JDBC Access of Database XQuery with Bind Variables ***
LineItem Description: Samurai 2: Duel at Ichijoji Temple
LineItem Description: The Red Shoes
LineItem Description: A Night to Remember
```

Example 18–24 Using XQuery with ODP.NET and C#

This example shows how to use XQuery with ODP.NET and the C# language. The C# input parameters `:nbitems` and `:partid` are passed to XQuery as XQuery variables `itemno` and `id`, respectively.

```
using System;
using System.Data;
using System.Text;
using System.IO;
using System.Xml;
using Oracle.DataAccess.Client;
using Oracle.DataAccess.Types;

namespace XQuery
{
  /// <summary>
  /// Demonstrates how to bind variables for XQuery calls
  /// </summary>
  class XQuery
  {
    /// <summary>
    /// The main entry point for the application.
    /// </summary>
    static void Main(string[] args)
    {
      int rows = 0;
      StreamReader sr = null;

      // Create the connection.
      string constr = "User Id=oe;Password=oe;Data Source=ora11gr1";
      OracleConnection con = new OracleConnection(constr);
      con.Open();

      // Create the command.
      OracleCommand cmd = new OracleCommand("", con);

      // Set the XML command type to query.
      cmd.CommandType   = CommandType.Text;

      // Create the SQL query with the XQuery expression.
```

```
      StringBuilder blr = new StringBuilder();
      blr.Append("SELECT column_value FROM XMLTable");
      blr.Append("(\'for $i in ora:view(\"PURCHASEORDER\") ");
      blr.Append("   where count($i/PurchaseOrder/LineItems/LineItem) = $itemno ");
      blr.Append("      and $i/PurchaseOrder/LineItems/LineItem/Part/@Id = $id ");
      blr.Append("   return $i/PurchaseOrder/LineItems\' ");
      blr.Append("  PASSING :nbitems AS \"itemno\", :partid AS \"id\")");

      cmd.CommandText = blr.ToString();
      cmd.Parameters.Add(":nbitems", OracleDbType.Int16, 3, ParameterDirection.Input);
      cmd.Parameters.Add(":partid", OracleDbType.Varchar2, "715515009058", ParameterDirection.Input);

      // Get the XML document as an XmlReader.
      OracleDataReader dr = cmd.ExecuteReader();
      dr.Read();

      // Get the XMLType column as an OracleXmlType
      OracleXmlType xml = dr.GetOracleXmlType(0);

      // Print the XML data in the OracleXmlType object
      Console.WriteLine(xml.Value);
      xml.Dispose();

      // Clean up.
      cmd.Dispose();
      con.Close();
      con.Dispose();
    }
  }
}
```

This produces the following output:

```
<LineItems>
  <LineItem ItemNumber="1">
    <Description>Samurai 2: Duel at Ichijoji Temple</Description>
    <Part Id="37429125526" UnitPrice="29.95" Quantity="3"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>The Red Shoes</Description>
    <Part Id="37429128220" UnitPrice="39.95" Quantity="4"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>A Night to Remember</Description>
    <Part Id="715515009058" UnitPrice="39.95" Quantity="1"/>
  </LineItem>
</LineItems>
```

See Also:

- Chapter 12, "PL/SQL APIs for XMLType"
- Chapter 14, "Java DOM API for XMLType"
- Chapter 16, "Using Oracle Data Provider for .NET with Oracle XML DB"

Oracle XML DB Support for XQuery

This section describes Oracle XML DB for the XQuery language.

Support for XQuery and SQL

Support for the XQuery language in Oracle XML DB is designed to provide the best fit between the worlds of relational storage and querying XML data. That is, Oracle

XML DB is a general XQuery implementation, but it is in addition specifically designed to make relational and XQuery queries work well together.

The specific properties of the Oracle XML DB XQuery implementation are described in this section. The XQuery standard explicitly calls out certain aspects of the language processing as implementation-defined or implementation-dependent. There are also some features that are specified by the XQuery standard but are not supported by Oracle XML DB.

Implementation Choices Specified in the XQuery Standard

The XQuery specification specifies that each of the following aspects of language processing is to be defined by the implementation.

- *Implicit time zone support* – In Oracle XML DB, the implicit time zone is always assumed to be `Z`, and instances of `xs:date`, `xs:time`, and `xs:datetime` that are missing time zones are automatically converted to UTC.

XQuery Features Not Supported by Oracle XML DB

The following features specified by the XQuery standard are not supported by Oracle XML DB:

- *Copy-namespace mode* – Oracle XML DB supports only `preserve` and `inherit` for a `copy-namespaces` declaration. This means that when an existing element node is copied by an element constructor or document constructor, all in-scope namespaces of the original element are retained in the copy, and, otherwise, the copied node inherits all in-scope namespaces of the constructed node. An error is raised if you specify `no-preserve` or `no-inherit`.
- *Version encoding* – Oracle XML DB does not support an optional encoding declaration in a version declaration. That is, you cannot include `(encoding` *`an-encoding`*`)` in a declaration `xquery version` *`a-version`*`;`. This means that you cannot specify an encoding used in the query. An error is raised if you include an encoding declaration.
- *xml:id* – Oracle XML DB does not support use of `xml:id`. If you use `xml:id`, then an error is raised.
- XQuery prolog default-collation declaration.
- XQuery prolog boundary-space declaration.
- XQuery data type `xs:duration`. Use either `xs:yearMonthDuration` or `xs:DayTimeDuration` instead.

XQuery Optional Features

The following optional features specified by the XQuery standard are not supported by Oracle XML DB:

- Schema Validation Feature
- Module Feature

In addition to these defined optional features, the W3C specification lets an implementation provide implementation-defined pragmas and extensions. These include the following:

- Pragmas
- Must-understand extensions

The Oracle implementation does not require any such pragmas or extensions.

Support for XQuery Functions and Operators

Oracle XML DB supports all of the XQuery functions and operators included in the latest *XQuery 1.0 and XPath 2.0 Functions and Operators* specification, with the following exceptions. There is *no* support for the following:

- The XQuery regular-expression functions: `fn:matches`, `fn:replace`, and `fn:tokenizer`. Use Oracle XQuery functions `ora:matches` and `ora:replace` instead of `fn:matches` and `fn:replace`.
- Functions `fn:id` and `fn:idref`.
- Function `fn:collection` without arguments.
- Optional collation parameters for XQuery functions.

XQuery Functions fn:doc, fn:collection, and fn:doc-available

Oracle XML DB supports the XQuery functions `fn:doc`, `fn:collection`, and `fn:doc-available` for all *resources* in Oracle XML DB Repository.

Function `doc` returns the repository *file* resource that is targeted by its URI argument; it must be a file of well-formed XML data. Function `collection` is similar, but works on repository *folder* resources (each file in the folder must contain well-formed XML data). Each of these functions returns an empty sequence if the targeted resource is not found – it does *not* raise an error. Function `fn:doc-available` tests whether its resource argument exists; it returns `true` if so, `false` if not.

> **See Also:** `http://www.w3.org` for the definitions of XQuery functions and operators

19

XMLType Views

This chapter describes how to create and use XMLType views.

This chapter contains these topics:

What Are XMLType Views?

XMLType views wrap existing relational and object-relational data in XML formats. The major advantages of using XMLType views are:

- You can exploit Oracle XML DB XML features that use XML schema functionality without having to migrate your base legacy data.
- With XMLType views, you can experiment with various other forms of storage, besides the object-relational, CLOB, and binary XML storage available for XMLType tables.

XMLType views are similar to object views. Each row of an XMLType view corresponds to an XMLType instance. The object identifier for uniquely identifying each row in the view can be created using a function such as extract with getNumberVal() applied to the XMLType result. It is recommended that you use SQL function extract rather than XMLType method extract() in the OBJECT IDENTIFIER clause.

Throughout this chapter XML schema refers to the W3C XML Schema 1.0 recommendation, http://www.w3.org/XML/Schema.

There are two types of XMLType views:

- **Non-schema-based XMLType views.** These views do not confirm to a particular XML schema.

- **XML schema-based XMLType views.** As with `XMLType` tables, `XMLType` views that conform to a particular XML schema are called XML schema-based `XMLType` views. These provide stronger typing than non-schema-based `XMLType` views.

XPath rewrite of queries over `XMLType` views is enabled for both XML schema-based and non-schema-based `XMLType` views. XPath rewrite is described in "XPath Rewrite on XMLType Views" on page 19-19.

To create an XML schema-based `XMLType` view, first register your XML schema. If the view is an object view, that is, if it is constructed using an object type, then the XML schema should have annotations that represent the bidirectional mapping from XML to SQL object types. `XMLType` views conforming to this registered XML schema can then be created by providing an underlying query that constructs instances of the appropriate SQL object type.

See Also:

- "Relational Access to XML Content Stored in Oracle XML DB Using Views" on page 3-49
- Chapter 6, "XML Schema Storage and Query: Basic"

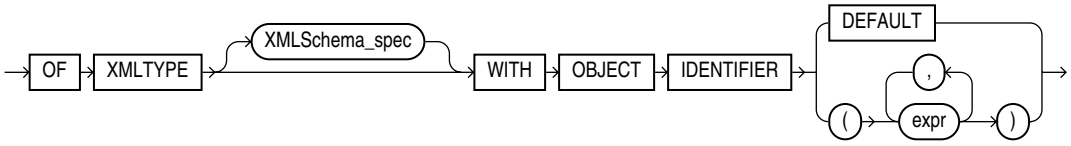
`XMLType` views can be constructed in the following ways:

- Based on SQL/XML generation functions, such as `XMLElement`, `XMLForest`, `XMLConcat`, `XMLAgg` and Oracle Database extension function `XMLColAttVal`. SQL/XML generation functions can be used to construct both non-schema-based `XMLType` views and XML schema-based `XMLType` views. This enables construction of `XMLType` view from the underlying relational tables directly without physically migrating those relational legacy data into XML. However, to construct XML schema-based `XMLType` view, the XML schema must be registered and the XML value generated by SQL/XML functions must be constrained to the XML schema.
- Based on object types, object views and SQL function `sys_XMLGen`. Non-schema-based `XMLType` views can be constructed using object types, object views, and function `sys_XMLGen` and XML schema-based `XMLType` view can be constructed using object types and object views. This enables the construction of the `XMLType` view from underlying relational or object relational tables directly without physically migrating the relational or object relational legacy data into XML. Creating non-schema-based `XMLType` view requires the use of `sys_XMLGen` over existing object types or object views. Creating XML-schema-based `XMLType` view requires to annotate the XML schema with a mapping to existing object types or to generate the XML schema from the existing object types.
- XML schema-based `XMLType` views can also be constructed directly from an `XMLType` table.

Creating XMLType Views: Syntax

Figure 19–1 shows the `CREATE VIEW` clause for creating `XMLType` views. See *Oracle Database SQL Language Reference* for details on the `CREATE VIEW` syntax.

Figure 19–1 Creating XMLType Views Clause: Syntax



Creating Non-Schema-Based XMLType Views

Non-schema-based `XMLType` views are `XMLType` views whose resultant XML value is not constrained to be a particular element in a registered XML schema. There are two main ways to create non-schema-based `XMLType` views:

- Using SQL/XML generation functions, such as `XMLElement`, `XMLForest`, `XMLConcat`, `XMLAgg`, and `XMLColAttVal`. Here you create the `XMLType` view using simple SQL/XML generation functions, without creating object types. Creating `XMLType` views using SQL/XML functions is simple as you do not have to create object types or object views.

  See Also: Chapter 17, "Generating XML Data from the Database", for details on SQL/XML generation functions

- Using object types and object views with SQL function `sys_XMLGen`. Here you create the `XMLType` view using object types with `sys_XMLGen`. This way of creating `XMLType` views is convenient when you already have an object-relational schema, such as object types, views, and tables, and want to map it directly to XML without the overhead of creating XML schema.

  See Also: "Using Object Types and Views to Create XML Schema-Based XMLType Views" on page 19-11

Using SQL/XML Generation Functions to Create Non-Schema-Based XMLType Views

Example 19–1 illustrates how to create an `XMLType` view using the SQL/XML function `XMLELement()`.

Example 19–1 Creating an XMLType View Using XMLELEMENT

The following statement creates an `XMLType` view using SQL function `XMLElement`:

```
CREATE OR REPLACE VIEW emp_view OF XMLType WITH OBJECT ID
  (extract(OBJECT_VALUE, '/Emp/@empno').getnumberval())
  AS SELECT XMLElement("Emp",
                       XMLAttributes(employee_id),
                       XMLForest(e.first_name ||' '|| e.last_name AS "name",
                                 e.hire_date AS "hiredate"))
       AS "result"
       FROM employees e
       WHERE salary > 15000;

SELECT * FROM emp_view;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<Emp EMPLOYEE_ID="100"><name>Steven King</name><hiredate>1987-06-17</hiredate></Emp>
<Emp EMPLOYEE_ID="101"><name>Neena Kochhar</name><hiredate>1989-09-21</hiredate></Emp>
<Emp EMPLOYEE_ID="102"><name>Lex De Haan</name><hiredate>1993-01-13</hiredate></Emp>
```

The empno attribute in the document will be used as the unique identifier for each row. As the result of XPath rewrite, the XPath expression /Emp/@empno can refer directly to the empno column.

Existing data in relational tables or views can be exposed as XML using this mechanism. If a view is generated using a SQL/XML generation function, then queries that access the view with XPath expressions can often be optimized (rewritten). The optimized queries can then directly access the underlying relational columns. See "XPath Rewrite on XMLType Views" on page 19-19 for details.

You can perform DML operations on these XMLType views, but, in general, you must write instead-of triggers to handle the DML operation.

Using Object Types with SYS_XMLGEN to Create Non-Schema-Based XMLType Views

You can also create XMLType views using SQL function sys_XMLGen with object types. Function sys_XMLGen inputs object type and generates an XMLType. Here is an equivalent query that produces the same query results using sys_XMLGen:

Example 19–2 Creating an XMLType View Using Object Types and SYS_XMLGEN

```
CREATE TYPE emp_t AS OBJECT ("@empno"  NUMBER(6),
                             fname     VARCHAR2(20),
                             lname     VARCHAR2(25),
                             hiredate  DATE);
/
CREATE OR REPLACE VIEW employee_view OF XMLType
  WITH OBJECT ID (extract(OBJECT_VALUE, '/Emp/@empno').getnumberval()) AS
  SELECT sys_XMLGen(emp_t(e.employee_id, e.first_name, e.last_name, e.hire_date),
                    XMLFormat('EMP'))
       FROM employees e
       WHERE salary > 15000;

SELECT * FROM employee_view;

SYS_NC_ROWINFO$
------------------------------------------------------------
<?xml version="1.0"?
<EMP empno="100">
  <FNAME>Steven</FNAME>
  <LNAME>King</LNAME>
  <HIREDATE>17-JUN-87</HIREDATE>
</EMP>

<?xml version="1.0"?>
<EMP empno="101">
  <FNAME>Neena</FNAME>
  <LNAME>Kochhar</LNAME>
  <HIREDATE>21-SEP-89</HIREDATE>
</EMP>

<?xml version="1.0"?>
<EMP empno="102">
  <FNAME>Lex</FNAME>
  <LNAME>De Haan</LNAME>
  <HIREDATE>13-JAN-93</HIREDATE>
</EMP>
```

Existing data in relational or object-relational tables or views can be exposed as XML using this mechanism. In addition, queries using SQL functions extract,

extractValue, and existsNode that involve simple XPath traversal over views generated by function sys_XMLGen, are candidates for XPath rewrite. XPath rewrite facilitates direct access to underlying object attributes or relational columns.

Creating XML Schema-Based XMLType Views

XML schema-based XMLType views are XMLType views whose resultant XML value is constrained to be a particular element in a registered XML schema. There are two main ways to create XML schema-based XMLType views:

- Using SQL/XML generation functions, such as XMLElement, XMLForest, XMLConcat, XMLAgg and XMLColAttVal: Here you create the XMLType view using simple XML generation functions, without needing to create any object types. This mechanism is simple as you do not have to create any object types or object views.

  See Also: "Using SQL/XML Generation Functions to Create XML Schema-Based XMLType Views" on page 19-5

- Using object types and or object views. Here you create the XMLType view either using object types or from object views. This mechanism for creating XMLType views is convenient when you already have an object-relational schema and want to map it directly to XML.

  See Also: "Using Object Types and Views to Create XML Schema-Based XMLType Views" on page 19-11

Using SQL/XML Generation Functions to Create XML Schema-Based XMLType Views

You can use SQL/XML generation functions to create XML schema-based XMLType views in a similar way as for the non-schema-based case described in section "Creating Non-Schema-Based XMLType Views". To create XML schema-based XMLType views perform these steps:

1. Create and register the XML schema document that contains the necessary XML structures. Note that since the XMLType view is constructed using SQL/XML generation functions, you do not need to annotate the XML schema to present the bidirectional mapping from XML to SQL object types.
2. Create an XMLType view conforming to the XML schema by using SQL/XML functions.

These two steps are illustrated in Example 19–3 and Example 19–4, respectively.

Example 19–3 Registering XML Schema emp_simple.xsd

Assume that you have an XML schema emp_simple.xsd that contains XML structures defining an employee. This example shows how to register the XML schema and identify it using a URL.

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/emp_simple.xsd',
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             targetNamespace="http://www.oracle.com/emp_simple.xsd" version="1.0"
             xmlns:xdb="http://xmlns.oracle.com/xdb"
             elementFormDefault="qualified">
       <element name = "Employee">
         <complexType>
           <sequence>
```

```
              <element name = "EmployeeId" type = "positiveInteger"/>
              <element name = "Name" type = "string"/>
              <element name = "Job" type = "string"/>
              <element name = "Manager" type = "positiveInteger"/>
              <element name = "HireDate" type = "date"/>
              <element name = "Salary" type = "positiveInteger"/>
              <element name = "Commission" type = "positiveInteger"/>
              <element name = "Dept">
                <complexType>
                  <sequence>
                    <element name = "DeptNo" type = "positiveInteger" />
                    <element name = "DeptName" type = "string"/>
                    <element name = "Location" type = "positiveInteger"/>
                  </sequence>
                </complexType>
              </element>
            </sequence>
          </complexType>
        </element>
      </schema>',
    TRUE,
    TRUE,
    FALSE);
END;
```

This registers the XML schema with the target location:

```
http://www.oracle.com/emp_simple.xsd
```

You can create an XML schema-based `XMLType` view using SQL/XML functions. The resulting XML data must conform to the XML schema specified for the view.

When using SQL/XML functions to generate XML schema-based content, you must specify the appropriate namespace information for all the elements and also indicate the location of the schema using the `xsi:schemaLocation` attribute. These can be specified using the `XMLAttributes` clause.

Example 19–4 Creating an XMLType View Using SQL/XML Functions

```
CREATE OR REPLACE VIEW emp_simple_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_simple.xsd" ELEMENT "Employee"
   WITH OBJECT ID (extract(OBJECT_VALUE,
                           '/Employee/EmployeeId/text()').getnumberval()) AS
   SELECT
     XMLElement("Employee",
                XMLAttributes(
                  'http://www.oracle.com/emp_simple.xsd' AS "xmlns",
                  'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                  'http://www.oracle.com/emp_simple.xsd
                   http://www.oracle.com/emp_simple.xsd'
                  AS "xsi:schemaLocation"),
                XMLForest(e.employee_id     AS "EmployeeId",
                          e.last_name       AS "Name",
                          e.job_id          AS "Job",
                          e.manager_id      AS "Manager",
                          e.hire_date       AS "HireDate",
                          e.salary          AS "Salary",
                          e.commission_pct  AS "Commission",
                          XMLForest(
                            d.department_id     AS "DeptNo",
                            d.department_name  AS "DeptName",
```

```
                          d.location_id      AS "Location") AS "Dept"))
     FROM employees e, departments d
     WHERE e.department_id = d.department_id;
```

In Example 19–4, `XMLElement` creates the `Employee` XML element and the inner `XMLForest` function call creates the children of the `Employee` element. The `XMLAttributes` clause inside `XMLElement` constructs the required XML `namespace` and schema `location` attributes, so that the XML data that is generated conforms to the XML schema of the view. The innermost `XMLForest` function call creates the `department` XML element that is nested inside the `Employee` element.

The XML generation functions generate a non-schema-based XML instance, by default. However, when the schema location is specified, using attribute `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation`, Oracle XML DB generates XML schema-based XML. For `XMLType` views, as long as the names of the elements and attributes match those in the XML schema, the XML is converted implicitly into a valid XML schema-based document. Any errors in the generated XML data are caught when further operations, such as validate or extract operations, are performed on the XML instance.

Example 19–5 Querying an XMLType View

This example queries the `XMLType` view, returning an XML result from the `employees` and `departments` tables. The result of the query is shown here pretty-printed, for clarity.

```
SELECT OBJECT_VALUE AS RESULT FROM emp_simple_xml WHERE ROWNUM < 2;

RESULT
--------------------------------------------------------------------
<Employee xmlns="http://www.oracle.com/emp_simple.xsd"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="http://www.oracle.com/emp_simple.xsd
                              http://www.oracle.com/emp_simple.xsd">
  <EmployeeId>200</EmployeeId>
  <Name>Whalen</Name>
  <Job>AD_ASST</Job>
  <Manager>101</Manager>
  <HireDate>1987-09-17</HireDate>
  <Salary>4400</Salary>
  <Dept>
    <DeptNo>10</Deptno>
    <DeptName>Administration</DeptName>
    <Location>1700</Location>
  </Dept>
</Employee>
```

Using Namespaces With SQL/XML Functions

If you have complex XML schemas involving namespaces, you must use the partially escaped mapping provided in the SQL/XML functions and create elements with appropriate namespaces and prefixes.

Example 19–6 Using Namespace Prefixes in XMLType Views

```
SELECT  XMLElement("ipo:Employee",
          XMLAttributes('http://www.oracle.com/emp_simple.xsd' AS "xmlns:ipo",
                        'http://www.oracle.com/emp_simple.xsd
                         http://www.oracle.com/emp_simple.xsd' AS "xmlns:xsi"),
```

```
            XMLForest(e.employee_id AS "ipo:EmployeeId",
                      e.last_name   AS "ipo:Name",
                      e.job_id      AS "ipo:Job",
                      e.manager_id  AS "ipo:Manager",
                      TO_CHAR(e.hire_date,'YYYY-MM-DD') AS "ipo:HireDate",
                      e.salary  AS "ipo:Salary",
                      e.commission_pct AS "ipo:Commission",
                  XMLForest(d.department_id   AS "ipo:DeptNo",
                            d.department_name AS "ipo:DeptName", d.location_id
       AS "ipo:Location") AS "ipo:Dept"))
       FROM employees e, departments d
       WHERE e.department_id = d.department_id
             AND d.department_id = 20;
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('emp-noname.xsd', 4);
END;
```

This SQL query creates the XML instances with the correct namespace, prefixes, and target schema location, and can be used as the query in the `emp_simple_xml` view definition. The instance created by this query looks like the following:

```
result
----------
<ipo:Employee
xmlns:ipo="http://www.oracle.com/emp_simple.xsd"
 xmlns:xsi="http://www.oracle.com/emp_simple.xsd
 http://www.oracle.com/emp_simple.xsd">
<ipo:EmployeeId>201</ipo:EmployeeId><ipo:Name>Hartstein</ipo:Name>
<ipo:Job>MK_MAN</ipo:Job><ipo:Manager>100</ipo:Manager>
<ipo:HireDate>1996-02-17</ipo:HireDate><ipo:Salary>13000</ipo:Salary>
<ipo:Dept><ipo:DeptNo>20</ipo:DeptNo><ipo:DeptName>Marketing</ipo:DeptName>
<ipo:Location>1800</ipo:Location></ipo:Dept></ipo:Employee>
<ipo:Employee xmlns:ipo="http://www.oracle.com/emp_simple.xsd"
 xmlns:xsi="http://www.oracle.com/emp_simple.xsd
 http://www.oracle.com/emp_simple.xsd"><ipo:EmployeeId>202</ipo:EmployeeId>
<ipo:Name>Fay</ipo:Name><ipo:Job>MK_REP</ipo:Job><ipo:Manager>201</ipo:Manager>
<ipo:HireDate>1997-08-17</ipo:HireDate><ipo:Salary>6000</ipo:Salary>
<ipo:Dept><ipo:DeptNo>20</ipo:Dept
No><ipo:DeptName>Marketing</ipo:DeptName><ipo:Location>1800</ipo:Location>
</ipo:Dept>
</ipo:Employee>
```

If the XML schema had no target namespace, then you could use the `xsi:noNamespaceSchemaLocation` attribute to denote that. For example, consider the following XML schema that is registered at location: "`emp-noname.xsd`":

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'emp-noname.xsd',
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"
             xmlns:xdb="http://xmlns.oracle.com/xdb">
       <element name = "Employee">
         <complexType>
           <sequence>
             <element name = "EmployeeId" type = "positiveInteger"/>
             <element name = "Name" type = "string"/>
             <element name = "Job" type = "string"/>
             <element name = "Manager" type = "positiveInteger"/>
             <element name = "HireDate" type = "date"/>
             <element name = "Salary" type = "positiveInteger"/>
```

```
            <element name = "Commission" type = "positiveInteger"/>
            <element name = "Dept">
              <complexType>
                <sequence>
                  <element name = "DeptNo" type = "positiveInteger" />
                  <element name = "DeptName" type = "string"/>
                  <element name = "Location" type = "positiveInteger"/>
                </sequence>
              </complexType>
            </element>
          </sequence>
        </complexType>
      </element>
    </schema>',
    TRUE,
    TRUE,
    FALSE);
END;
```

The following statement creates a view that conforms to this XML schema:

```
CREATE OR REPLACE VIEW emp_xml OF XMLType
     XMLSCHEMA "emp-noname.xsd" ELEMENT "Employee"
     WITH OBJECT ID (extract(OBJECT_VALUE,
                             '/Employee/EmployeeId/text()').getnumberval()) AS
     SELECT XMLElement(
       "Employee",
       XMLAttributes('http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                     'emp-noname.xsd' AS "xsi:noNamespaceSchemaLocation"),
       XMLForest(e.employee_id    AS "EmployeeId",
                 e.last_name      AS "Name",
                 e.job_id         AS "Job",
                 e.manager_id     AS "Manager",
                 e.hire_date      AS "HireDate",
                 e.salary         AS "Salary",
                 e.commission_pct AS "Commission",
                 XMLForest(d.department_id     AS "DeptNo",
                           d.department_name  AS "DeptName",
                           d.location_id      AS "Location") AS "Dept"))
       FROM employees e, departments d
       WHERE e.department_id = d.department_id;
```

The `XMLAttributes` clause creates an XML element that contains the `noNamespace` schema location attribute.

Example 19–7 Using SQL/XML Generation Functions in Schema-Based XMLType Views

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept.xsd', 4);
END;
/
BEGIN
DBMS_XMLSCHEMA.registerSchema(
  'http://www.oracle.com/dept.xsd',
  '<schema xmlns="http://www.w3.org/2001/XMLSchema"
           targetNamespace="http://www.oracle.com/dept.xsd" version="1.0"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           elementFormDefault="qualified">
     <element name = "Department">
       <complexType>
```

```
          <sequence>
            <element name = "DeptNo" type = "positiveInteger"/>
            <element name = "DeptName" type = "string"/>
            <element name = "Location" type = "positiveInteger"/>
            <element name = "Employee" maxOccurs = "unbounded">
              <complexType>
                <sequence>
                  <element name = "EmployeeId" type = "positiveInteger"/>
                  <element name = "Name" type = "string"/>
                  <element name = "Job" type = "string"/>
                  <element name = "Manager" type = "positiveInteger"/>
                  <element name = "HireDate" type = "date"/>
                  <element name = "Salary" type = "positiveInteger"/>
                  <element name = "Commission" type = "positiveInteger"/>
                </sequence>
              </complexType>
            </element>
          </sequence>
        </complexType>
      </element>
    </schema>',
  TRUE,
  FALSE,
  FALSE);
END;
/
CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/dept.xsd" ELEMENT "Department"
  WITH OBJECT ID (extract(OBJECT_VALUE, '/Department/DeptNo').getNumberVal()) AS
         SELECT  XMLElement(
           "Department",
           XMLAttributes(
             'http://www.oracle.com/emp.xsd' AS "xmlns" ,
             'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
             'http://www.oracle.com/dept.xsd
              http://www.oracle.com/dept.xsd' AS "xsi:schemaLocation"),
           XMLForest(d.department_id "DeptNo",
                     d.department_name "DeptName",
                     d.location_id "Location"),
           (SELECT Xmlagg(XMLElement("Employee",
                                XMLForest(e.employee_id  "EmployeeId",
                                     e.last_name "Name",
                                     e.job_id "Job",
                                     e.manager_id "Manager",
              to_char(e.hire_date,'YYYY-MM-DD') "Hiredate",
                                     e.salary "Salary",
                                     e.commission_pct "Commission")))
                 FROM employees e
                 WHERE e.department_id = d.department_id))
     FROM departments d;
```

This SQL query creates the XML instances with the correct namespace, prefixes, and target schema location, and can be used as the query in the `emp_simple_xml` view definition. The instance created by this query looks like the following:

```
SELECT OBJECT_VALUE AS result FROM dept_xml WHERE ROWNUM < 2;

RESULT
--------------------------------------------------------------------
<Department
```

```
    xmlns="http://www.oracle.com/emp.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.oracle.com/dept.xsd
                        http://www.oracle.com/dept.xsd">
  <DeptNo>10</DeptNo>
  <DeptName>Administration</DeptName>
  <Location>1700</Location>
  <Employee>
    <EmployeeId>200</EmployeeId>
    <Name>Whalen</Name>
    <Job>AD_ASST</Job>
    <Manager>101</Manager>
    <Hiredate>1987-09-17</Hiredate>
    <Salary>4400</Salary>
  </Employee>
</Department>
```

Using Object Types and Views to Create XML Schema-Based XMLType Views

To wrap relational or object-relational data with strongly-typed XML using the object view approach, perform the following steps:

1. Create object types.
2. Create (or generate) and then register an XML schema document that contains the XML structures, along with its mapping to the SQL object types and attributes. The XML schema can be generated from the existing object types and must be annotated to contain the bidirectional mapping from XML to the object types.

   You can fill in the optional Oracle XML DB attributes *before* registering the XML schema. In this case, Oracle validates the extra information to ensure that the specified values for the Oracle XML DB attributes are compatible with the rest of the XML schema declarations. This form of XML schema registration typically happens when wrapping existing data using `XMLType` views.

   > **See:** Chapter 6, "XML Schema Storage and Query: Basic" for more details on this process

   You can use PL/SQL functions `DBMS_XMLSchema.generateSchema` and `DBMS_XMLSchema.generateSchemas` to generate the default XML mapping for specified object types. The generated XML schema document has the `SQLType`, `SQLSchema`, and so on, attributes filled in. When these XML schema documents are then registered, the following validation forms can occur:

   - *SQLType for attributes or elements based on simpleType.* This is compatible with the corresponding `XMLType`. For example, an XML string data type can only be mapped to `VARCHAR2` or a Large Object (LOB) data type.
   - *SQLType specified for elements based on complexType.* This is either a LOB or an object type whose structure is compatible with the declaration of the `complexType`, that is, the object type has the right number of attributes with the right data types.
3. Create the `XMLType` view and specify the XML schema URL and the root element name. The underlying view query first constructs the object instances and then converts them to XML. This step can also be done in two parts:
   a. Create an object view.
   b. Create an `XMLType` view over the object view.

For examples, see the following sections, which are based on the employee and department relational tables and XML views of this data:

- "Creating Schema-Based XMLType Views Over Object Views"
- "Wrapping Relational Department Data with Nested Employee Data as XML"

Creating Schema-Based XMLType Views Over Object Views

For the first example view, to wrap the relational employee data with nested department information as XML, follow Step 1 through Step 4b.

Step 1. Create Object Types Example 19–8 creates the object types for the views.

Example 19–8 Creating Object Types for Schema-Based XMLType Views

```
CREATE TYPE dept_t AS OBJECT
      (deptno        NUMBER(4),
       dname         VARCHAR2(30),
       loc           NUMBER(4));
/

CREATE TYPE emp_t AS OBJECT
      (empno         NUMBER(6),
       ename         VARCHAR2(25),
       job           VARCHAR2(10),
       mgr           NUMBER(6),
       hiredate      DATE,
       sal           NUMBER(8,2),
       comm          NUMBER(2,2),
       dept          dept_t );
/
```

Step 2. Create or Generate XML Schema emp.xsd You can create an XML schema manually or use package `DBMS_XMLSCHEMA` to generate it automatically from the existing object types, as shown in Example 19–9.

Example 19–9 Generating an XML Schema with DBMS_XMLSCHEMA.GENERATESCHEMA

```
SELECT DBMS_XMLSCHEMA.generateSchema('HR','EMP_T') AS result FROM DUAL;
```

This generates the XML schema for the `employee` type. You can supply various arguments to this function to add namespaces, and so on. You can also edit the XML schema to change the various default mappings that were generated. Function `DBMS_XMLSCHEMA.generateSchemas` generates a list of XML schemas, one for each SQL database schema referenced by the object type and its attributes, embedded at any level.

Step 3. Register XML Schema, emp_complex.xsd XML schema, `emp_complex.xsd` also specifies how the XML elements and attributes are mapped to their corresponding attributes in the object types. Example 19–10 shows how to register XML schema `emp_complex.xsd`. See the `xdb:SQLType` annotation in Example 19–10.

Example 19–10 Registering XML Schema emp_complex.xsd

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/emp_complex.xsd', 4);
END;
```

```
/

COMMIT;

BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'http://www.oracle.com/emp_complex.xsd',
    '<?xml version="1.0"?>
    <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xmlns:xdb="http://xmlns.oracle.com/xdb"
                xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                    http://xmlns.oracle.com/xdb/XDBSchema.xsd">
      <xsd:element name="Employee" type="EMP_TType" xdb:SQLType="EMP_T"
                   xdb:SQLSchema="HR"/>
      <xsd:complexType name="EMP_TType" xdb:SQLType="EMP_T" xdb:SQLSchema="HR"
                       xdb:maintainDOM="false">
        <xsd:sequence>
          <xsd:element name="EMPNO" type="xsd:double" xdb:SQLName="EMPNO"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="ENAME" xdb:SQLName="ENAME" xdb:SQLType="VARCHAR2">
            <xsd:simpleType>
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="25"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
          <xsd:element name="JOB" xdb:SQLName="JOB" xdb:SQLType="VARCHAR2">
            <xsd:simpleType>
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="10"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
          <xsd:element name="MGR" type="xsd:double" xdb:SQLName="MGR"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="HIREDATE" type="xsd:date" xdb:SQLName="HIREDATE"
                       xdb:SQLType="DATE"/>
          <xsd:element name="SAL" type="xsd:double" xdb:SQLName="SAL"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="COMM" type="xsd:double" xdb:SQLName="COMM"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="DEPT" type="DEPT_TType" xdb:SQLName="DEPT"
                       xdb:SQLSchema="HR" xdb:SQLType="DEPT_T"/>
        </xsd:sequence>
      </xsd:complexType>
      <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T" xdb:SQLSchema="HR"
                       xdb:maintainDOM="false">
        <xsd:sequence>
          <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
            <xsd:simpleType>
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="30"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
         <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
                       xdb:SQLType="NUMBER"/>
```

```
        </xsd:sequence>
      </xsd:complexType>
    </xsd:schema>',
   TRUE,
   FALSE,
   FALSE);
END;
/
```

The preceding statement registers the XML schema with the target location:

```
"http://www.oracle.com/emp_complex.xsd"
```

Step 4a. Using the One-Step Process With the one-step process, you must create an `XMLType` view on the relational tables as shown in Example 19–11.

Example 19–11 Creating an XMLType View

```
CREATE OR REPLACE VIEW emp_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_complex.xsd"
  ELEMENT "Employee"
    WITH OBJECT ID (extractValue(OBJECT_VALUE, '/Employee/EMPNO')) AS
  SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id, e.hire_date,
               e.salary, e.commission_pct,
               dept_t(d.department_id, d.department_name, d.location_id))
    FROM employees e, departments d
    WHERE e.department_id = d.department_id;
```

This example uses SQL function `extractValue` in the `OBJECT ID` clause because `extractValue` can automatically calculate the appropriate SQL data-type mapping— in this case a SQL `NUMBER`—using the XML schema information. It is recommended that you use SQL function `extractValue` rather than `XMLType` method `extractValue()`.

Step 4b. Using the Two-Step Process by First Creating an Object View In the two-step process, you first create an object view, then create an `XMLType` view on the object view, as shown in Example 19–12.

Example 19–12 Creating an Object View and an XMLType View on the Object View

```
CREATE OR REPLACE VIEW emp_v OF emp_t WITH OBJECT ID (empno) AS
  SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id, e.hire_date,
               e.salary, e.commission_pct,
               dept_t(d.department_id, d.department_name, d.location_id))
    FROM employees e, departments d
    WHERE e.department_id = d.department_id;

CREATE OR REPLACE VIEW emp_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_complex.xsd" ELEMENT "Employee"
  WITH OBJECT ID DEFAULT
  AS SELECT VALUE(p) FROM emp_v p;
```

Wrapping Relational Department Data with Nested Employee Data as XML

For the second example view, to wrap the relational department data with nested employee information as XML, follow Step 1 through Step 3b.

Step 1. Create Object Types The first step is to create the object types needed, as shown in Example 19–13.

Example 19–13 Creating Object Types

```
CREATE TYPE emp_t AS OBJECT (empno         NUMBER(6),
                             ename         VARCHAR2(25),
                             job           VARCHAR2(10),
                             mgr           NUMBER(6),
                             hiredate      DATE,
                             sal           NUMBER(8,2),
                             comm          NUMBER(2,2));
/
CREATE OR REPLACE TYPE emplist_t AS TABLE OF emp_t;
/
CREATE TYPE dept_t AS OBJECT (deptno        NUMBER(4),
                              dname         VARCHAR2(30),
                              loc           NUMBER(4),
                              emps          emplist_t);
/
```

Step 2. Register XML Schema, dept_complex.xsd You can either use a pre-existing XML schema or generate an XML schema from the object type with function `DBMS_XMLSCHEMA.generateSchema` or `DBMS_XMLSCHEMA.generateSchemas`. Example 19–14 shows how to register the XML schema `dept_complex.xsd`.

Example 19–14 Registering XML Schema dept_complex.xsd

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept_complex.xsd', 4);
END;
/
BEGIN
 DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/dept_complex.xsd',
   '<?xml version="1.0"?>
   <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xmlns:xdb="http://xmlns.oracle.com/xdb"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                   http://xmlns.oracle.com/xdb/XDBSchema.xsd">
     <xsd:element name="Department" type="DEPT_TType" xdb:SQLType="DEPT_T"
                  xdb:SQLSchema="HR"/>
     <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T" xdb:SQLSchema="HR"
                      xdb:maintainDOM="false">
       <xsd:sequence>
         <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                      xdb:SQLType="NUMBER"/>
         <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
           <xsd:simpleType>
             <xsd:restriction base="xsd:string">
               <xsd:maxLength value="30"/>
             </xsd:restriction>
           </xsd:simpleType>
         </xsd:element>
         <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
                      xdb:SQLType="NUMBER"/>
         <xsd:element name="EMPS" type="EMP_TType" maxOccurs="unbounded"
                      minOccurs="0" xdb:SQLName="EMPS"
                      xdb:SQLCollType="EMPLIST_T" xdb:SQLType="EMP_T"
                      xdb:SQLSchema="HR" xdb:SQLCollSchema="HR"/>
       </xsd:sequence>
     </xsd:complexType>
     <xsd:complexType name="EMP_TType" xdb:SQLType="EMP_T" xdb:SQLSchema="HR"
```

```
                    xdb:maintainDOM="false">
        <xsd:sequence>
          <xsd:element name="EMPNO" type="xsd:double" xdb:SQLName="EMPNO"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="ENAME" xdb:SQLName="ENAME" xdb:SQLType="VARCHAR2">
            <xsd:simpleType>
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="25"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
          <xsd:element name="JOB" xdb:SQLName="JOB" xdb:SQLType="VARCHAR2">
            <xsd:simpleType>
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="10"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
          <xsd:element name="MGR" type="xsd:double" xdb:SQLName="MGR"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="HIREDATE" type="xsd:date" xdb:SQLName="HIREDATE"
                       xdb:SQLType="DATE"/>
          <xsd:element name="SAL" type="xsd:double" xdb:SQLName="SAL"
                       xdb:SQLType="NUMBER"/>
          <xsd:element name="COMM" type="xsd:double" xdb:SQLName="COMM"
                       xdb:SQLType="NUMBER"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:schema>',
  TRUE,
  FALSE,
  FALSE);
END;
/
```

Step 3a. Create XMLType Views on Relational Tables The next step is to create the `dept_xml` `XMLType` view from the department object type, as shown in Example 19–15.

Example 19–15 Creating XMLType Views on Relational Tables

```
CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSChema "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
  WITH OBJECT ID (extractValue(OBJECT_VALUE, '/Department/DEPTNO')) AS
  SELECT dept_t(d.department_id, d.department_name, d.location_id,
                CAST(MULTISET(SELECT emp_t(e.employee_id, e.last_name, e.job_id,
                                           e.manager_id, e.hire_date,
                                           e.salary, e.commission_pct)
                              FROM employees e
                              WHERE e.department_id = d.department_id)
                       AS emplist_t))
    FROM departments d;
```

Step 3b. Create XMLType Views Using SQL/XML Functions You can also create the `dept_xml` `XMLType` view from the relational tables without using the object type definitions, that is, using SQL/XML generation functions. Example 19–16 demonstrates this.

Example 19–16 Creating XMLType Views Using SQL/XML Functions

```
CREATE OR REPLACE VIEW dept_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
```

```
WITH OBJECT ID (extract(OBJECT_VALUE, '/Department/DEPTNO').getNumberVal()) AS
SELECT
  XMLElement(
    "Department",
    XMLAttributes('http://www.oracle.com/dept_complex.xsd' AS "xmlns",
                  'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                  'http://www.oracle.com/dept_complex.xsd
                   http://www.oracle.com/dept_complex.xsd'
                    AS "xsi:schemaLocation"),
    XMLForest(d.department_id "DeptNo", d.department_name "DeptName",
              d.location_id "Location"),
    (SELECT XMLAgg(XMLElement("Employee",
                              XMLForest(e.employee_id "EmployeeId",
                                        e.last_name "Name",
                                        e.job_id "Job",
                                        e.manager_id "Manager",
                                        e.hire_date "Hiredate",
                                        e.salary "Salary",
                                        e.commission_pct "Commission")))
                     FROM employees e WHERE e.department_id = d.department_id))
  FROM departments d;
```

Note: The XML schema and element information must be specified at the view level because the `SELECT` list could arbitrarily construct XML of a different XML schema from the underlying table.

Creating XMLType Views From XMLType Tables

An `XMLType` view can be created on an `XMLType` table, for example, to transform the XML or to restrict the rows returned by using some predicates.

Example 19–17 Creating an XMLType View by Restricting Rows From an XMLType Table

This is an example of creating an `XMLType` view by restricting the rows returned from an underlying `XMLType` table. This example uses the `dept_complex.xsd` XML schema, described in section "Wrapping Relational Department Data with Nested Employee Data as XML", to create the underlying table.

```
CREATE TABLE dept_xml_tab OF XMLType
    XMLSchema "http://www.oracle.com/dept_complex.xsd" ELEMENT "Department"
    NESTED TABLE XMLDATA."EMPS" STORE AS dept_xml_tab_tab1;

CREATE OR REPLACE VIEW dallas_dept_view OF XMLType
    XMLSchema "http://www.oracle.com/dept.xsd" ELEMENT "Department"
        AS SELECT OBJECT_VALUE FROM dept_xml_tab
           WHERE extractValue(OBJECT_VALUE, '/Department/Location') = 'DALLAS';
```

Here, `dallas_dept_view` restricts the `XMLType` table rows to those departments whose location is Dallas.

Example 19–18 shows how you can create an `XMLType` view by transforming XML data using a style sheet.

Example 19–18 Creating an XMLType View by Transforming an XMLType Table

```
CREATE OR REPLACE VIEW hr_po_tab OF XMLType
  ELEMENT "PurchaseOrder"
  WITH OBJECT ID DEFAULT
```

```
  AS SELECT XMLtransform(OBJECT_VALUE, x.col1)
       FROM purchaseorder p, xsl_tab x;
```

Referencing XMLType View Objects Using SQL Function REF

You can reference an XMLType view object using SQL function ref:

```
SELECT ref(d) FROM dept_xml_tab d;
```

An XMLType view reference is based on one of the following object IDs:

- System-generated OID — for views on XMLType tables or object views
- Primary key based OID -- for views with OBJECT ID expressions

These REFs can be used to fetch OCIXMLType instances in the OCI Object cache, or they can be used in SQL queries. These REFs act the same as REFs to object views.

DML (Data Manipulation Language) on XMLType Views

An XMLType view may not be inherently updatable. This means that you have to write INSTEAD-OF TRIGGERS to handle all data manipulation (DML). You can identify cases where the view is implicitly updatable, by analyzing the underlying view query.

Example 19–19 Identifying When a View is Implicitly Updatable

One way to identify when an XMLType view is implicitly updatable is to use an XMLType view query to determine if the view is based on an object view or an object constructor that is itself inherently updatable, as follows:

```
CREATE TYPE dept_t AS OBJECT
      (deptno NUMBER(4),
       dname VARCHAR2(30),
       loc NUMBER(4));
/
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/dept.xsd', 4);
END;
/
COMMIT;

BEGIN
  DBMS_XMLSCHEMA.registerSchema('http://www.oracle.com/dept_t.xsd',
    '<?xml version="1.0"?>
     <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xmlns:xdb="http://xmlns.oracle.com/xdb"
                 xsi:schemaLocation="http://xmlns.oracle.com/xdb
                                     http://xmlns.oracle.com/xdb/XDBSchema.xsd">
     <xsd:element name="Department" type="DEPT_TType" xdb:SQLType="DEPT_T"
                    xdb:SQLSchema="HR"/>
     <xsd:complexType name="DEPT_TType" xdb:SQLType="DEPT_T" xdb:SQLSchema="HR"
                      xdb:maintainDOM="false">
         <xsd:sequence>
           <xsd:element name="DEPTNO" type="xsd:double" xdb:SQLName="DEPTNO"
                      xdb:SQLType="NUMBER"/>
           <xsd:element name="DNAME" xdb:SQLName="DNAME" xdb:SQLType="VARCHAR2">
             <xsd:simpleType>
```

```
              <xsd:restriction base="xsd:string">
                <xsd:maxLength value="30"/>
              </xsd:restriction>
            </xsd:simpleType>
          </xsd:element>
          <xsd:element name="LOC" type="xsd:double" xdb:SQLName="LOC"
               xdb:SQLType="NUMBER"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:schema>',
    TRUE,
    FALSE,
    FALSE);
END;
/
CREATE OR REPLACE VIEW dept_xml of XMLType
  XMLSchema "http://www.oracle.com/dept_t.xsd" element "Department"
  WITH OBJECT ID (OBJECT_VALUE.extract('/Department/DEPTNO').getnumberval()) AS
  SELECT dept_t(d.department_id, d.department_name, d.location_id)
    FROM departments d;

INSERT INTO dept_xml
  VALUES (
    XMLType.createXML(
      '<Department
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="http://www.oracle.com/dept_t.xsd" >
         <DEPTNO>300</DEPTNO>
         <DNAME>Processing</DNAME>
         <LOC>1700</LOC>
       </Department>'));

UPDATE dept_xml d
 SET d.OBJECT_VALUE = updateXML(d.OBJECT_VALUE, '/Department/DNAME/text()',
                                'Shipping')
   WHERE existsNode(d.OBJECT_VALUE, '/Department[DEPTNO=300]') = 1;
```

XPath Rewrite on XMLType Views

XPath rewrite for `XMLType` views constructed using `XMLType` tables or object types, object views, and SQL function `sys_XMLGen` is the same as for regular `XMLType` table columns. Hence, SQL functions `extract`, `existsNode`, and `extractValue` on view columns get rewritten into underlying relational or object-relational accesses for better performance.

XPath rewrite for `XMLType` views constructed using the SQL/XML generation functions is also supported. Functions `extract`, `existsNode`, and `extractValue` on view columns get rewritten into underlying relational accesses for better performance.

See Also: Chapter 7, "XPath Rewrite"

Views Constructed With SQL/XML Generation Functions

This section describes XML schema-based and non-schema-based XPath rewrite on `XMLType` views constructed with SQL/XML functions.

XPath Rewrite on Non-Schema-Based Views Constructed With SQL/XML

Example 19–20 illustrates XPath rewrite on non-schema-based XMLType views.

Example 19–20 Non-Schema-Based Views Constructed Using SQL/XML

```
CREATE OR REPLACE VIEW emp_view OF XMLType
  WITH OBJECT ID (extract(OBJECT_VALUE, '/Emp/@empno').getnumberval())
  AS SELECT XMLElement("Emp", XMLAttributes(employee_id),
                       XMLForest(e.first_name ||' '|| e.last_name AS "name",
                                 e.hire_date AS "hiredate")) AS "result"
      FROM employees e
      WHERE salary > 15000;
```

- Querying with SQL function `extractValue` to select from `emp_view`:

  ```
  SELECT extractValue(OBJECT_VALUE, '/Emp/name'),
         extractValue(OBJECT_VALUE, '/Emp/hiredate'
    FROM emp_view;
  ```

  This query becomes something like the following:

  ```
   SELECT e.first_name ||' '|| e.last_name, e.hire_date FROM employees e
     WHERE e.salary > 15000;
  ```

  The rewritten query is a simple relational query. The `extractValue` expression is rewritten down to the relational column access as defined in view `emp_view`.

- Querying with SQL function `extractValue` followed by method `getNumberVal()` to select from `emp_view`:

  ```
  SELECT (extract(OBJECT_VALUE, '/Emp/@empno').getnumberval()) FROM emp_view;
  ```

  This query becomes something like the following:

  ```
  SELECT e.employee_id FROM employees e WHERE e.salary > 15000;
  ```

  The rewritten query is a simple relational query. The `extract` expression followed by `getNumberVal()` is rewritten down to the relational column access as defined in view `emp_view`.

- Querying with SQL function `existsNode` to select from view `emp_view`:

  ```
  SELECT extractValue(OBJECT_VALUE, '/Emp/name'),
         extractValue(OBJECT_VALUE, '/Emp/hiredate')
    FROM emp_view WHERE existsNode(OBJECT_VALUE, '/Emp[@empno=101]') = 1;
  ```

  This query becomes something like the following:

  ```
  SELECT e.first_name ||' '|| e.last_name, e.hire_date
    FROM employees e
    WHERE e.employee_id = 101 AND e.salary > 15000;
  ```

  The rewritten query is a simple relational query. The XPath predicate in the `existsNode` expression is rewritten down to the predicate over relational columns as defined in view `emp_view`.

  If there is an index created on column `employees.empno`, then the query optimizer can use the index to speed up the query.

  Querying with `existsNode` to select from view `emp_view`:

  ```
  SELECT extractValue(OBJECT_VALUE, '/Emp/name'),
         extractValue(OBJECT_VALUE, '/Emp/hiredate'),
  ```

```
      extractValue(OBJECT_VALUE, '/Emp/@empno')
  FROM emp_view
  WHERE existsNode(OBJECT_VALUE, '/Emp[name="Steven King" or @empno = 101] ')
        = 1;
```

This query becomes something like the following:

```
SELECT e.first_name ||' '|| e.last_name, e.hire_date, e.employee_id
  FROM employees e
  WHERE (e.first_name ||' '|| e.last_name = 'Steven King'
         OR e.employee_id = 101)
    AND e.salary > 15000;
```

The rewritten query is a simple relational query. The XPath predicate in the `existsNode` expression is rewritten down to the predicate over relational columns as defined in view `emp_view`.

- Querying with `extract` to select from view `emp_view`:

```
SELECT extract(OBJECT_VALUE, '/Emp/name'),
       extract(OBJECT_VALUE, '/Emp/hiredate')
  FROM emp_view;
```

This query becomes something like the following:

```
SELECT CASE WHEN e.first_name ||' '|| e.last_name IS NOT NULL THEN
       XMLElement("name",e.first_name ||' '|| e.last_name) ELSE NULL END,
       CASE WHEN e.hire_date IS NOT NULL
            THEN XMLElement("hiredate", e.hire_date)
       ELSE NULL END
  FROM employees e WHERE e.salary > 15000;
```

The rewritten query is a simple relational query. The `extract` expression is rewritten to expressions over relational columns.

Note: Since the view uses SQL function `XMLForest` to formulate `name` and `hiredate` elements, the rewritten query uses equivalent `CASE` expression to be consistent with `XMLForest` semantics.

XPath Rewrite on Schema-Based Views Constructed With SQL/XML

Example 19–21 illustrates XPath rewrite on XML-schema-based `XMLType` view constructed with a SQL/XML function.

Example 19–21 XML-Schema-Based Views Constructed With SQL/XML

```
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/emp_simple.xsd', 4);
END;
/

BEGIN
 DBMS_XMLSCHEMA.registerSchema(
   'http://www.oracle.com/emp_simple.xsd',
   '<schema
        xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://www.oracle.com/emp_simple.xsd" version="1.0"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        elementFormDefault="qualified">
```

```
      <element name = "Employee">
        <complexType>
          <sequence>
            <element name = "EmployeeId" type = "positiveInteger"/>
            <element name = "Name" type = "string"/>
            <element name = "Job" type = "string"/>
            <element name = "Manager" type = "positiveInteger"/>
            <element name = "HireDate" type = "date"/>
            <element name = "Salary" type = "positiveInteger"/>
            <element name = "Commission" type = "positiveInteger"/>
            <element name = "Dept">
              <complexType>
                <sequence>
                  <element name = "DeptNo" type = "positiveInteger" />
                  <element name = "DeptName" type = "string"/>
                  <element name = "Location" type = "positiveInteger"/>
                </sequence>
              </complexType>
            </element>
          </sequence>
        </complexType>
      </element>
    </schema>',
   TRUE,
   TRUE,
   FALSE);
END;
/

CREATE OR REPLACE VIEW emp_xml OF XMLType
  XMLSCHEMA "http://www.oracle.com/emp_simple.xsd" ELEMENT "Employee"
  WITH OBJECT ID (extract(OBJECT_VALUE,
                  '/Employee/EmployeeId/text()').getnumberval()) AS
  SELECT
    XMLElement(
      "Employee",
      XMLAttributes('http://www.oracle.com/emp_simple.xsd' AS "xmlns",
                    'http://www.w3.org/2001/XMLSchema-instance' AS "xmlns:xsi",
                    'http://www.oracle.com/emp_simple.xsd
                     http://www.oracle.com/emp_simple.xsd'
                       AS "xsi:schemaLocation"),
      XMLForest(e.employee_id     AS "EmployeeId",
                e.last_name       AS "Name",
                e.job_id          AS "Job",
                e.manager_id      AS "Manager",
                e.hire_date       AS "HireDate",
                e.salary          AS "Salary",
                e.commission_pct  AS "Commission",
                XMLForest(d.department_id    AS "DeptNo",
                          d.department_name  AS "DeptName",
                          d.location_id      AS "Location") AS "Dept"))
   FROM employees e, departments d
   WHERE e.department_id = d.department_id;
```

A query using the SQL function `extractValue` to select from `emp_xml`:

```
SELECT
 extractValue(OBJECT_VALUE, '/Employee/EmployeeId') AS "a1",
 extractValue(OBJECT_VALUE, '/Employee/Name') AS "b1",
 extractValue(OBJECT_VALUE, '/Employee/Job') AS "c1",
 extractValue(OBJECT_VALUE, '/Employee/Manager') AS "d1",
```

```
 extractValue(OBJECT_VALUE, '/Employee/HireDate') AS "e1",
 extractValue(OBJECT_VALUE, '/Employee/Salary') AS "f1",
 extractValue(OBJECT_VALUE, '/Employee/Commission') AS "g1"
FROM emp_xml
WHERE existsNode(OBJECT_VALUE, '/Employee/Dept[Location = 1700]') = 1;
```

This query becomes something like the following:

```
SELECT e.employee_id a1, e.last_name b1, e.job_id c1, e.manager_id d1,
       e.hire_date e1,
       e.salary f1, e.commission_pct g1
  FROM employees e, departments d
  WHERE e.department_id = d.department_id AND d.location_id = 1700;
```

The rewritten query is a simple relational query. The XPath predicate in the `existsNode` expression is rewritten down to the predicate over relational columns as defined in view `emp_view`:

Querying with SQL function `existsNode` to select from view `emp_xml`:

```
SELECT extractValue(OBJECT_VALUE, '/Employee/EmployeeId') as "a1",
       extractValue(OBJECT_VALUE, '/Employee/Dept/DeptNo') as "b1",
       extractValue(OBJECT_VALUE, '/Employee/Dept/DeptName') as "c1",
       extractValue(OBJECT_VALUE, '/Employee/Dept/Location') as "d1"
  FROM emp_xml
  WHERE existsNode(OBJECT_VALUE, '/Employee/Dept[Location = 1700
    AND DeptName="Finance"]') = 1;
```

This query becomes a simple relational query using the XPath rewrite mechanism. The XPath predicate in the `existsNode` expression is rewritten down to the predicate over relational columns as defined in view `emp_view`:

```
SELECT e.employee_id a1, d.department_id b1, d.department_name c1,
       d.location_id d1
  FROM employees e, departments d
  WHERE (d.location_id = 1700 AND d.department_name = 'Finance')
    AND e.department_id = d.department_id;
```

Views Using Object Types, Object Views, and SYS_XMLGEN

The following sections describe XPath rewrite on `XMLType` views using object types, views, and SQL function `sys_XMLGen`.

Non-Schema-Based XMLType Views Using Object Types or Object Views

Non-schema-based `XMLType` views can be created on existing relational and object-relational tables with object types and object views. This provides users with an XML view of the underlying data.

Existing relational data can be transformed into `XMLType` views by creating appropriate object types, and doing a `sys_XMLGen` at the top-level.

Example 19–22 Non-Schema-Based Views Constructed Using SYS_XMLGEN

```
CREATE TYPE emp_t AS OBJECT (empno         NUMBER(6),
                             ename         VARCHAR2(25),
                             job           VARCHAR2(10),
                             mgr           NUMBER(6),
                             hiredate      DATE,
                             sal           NUMBER(8,2),
```

```
                              comm          NUMBER(2,2));
/

CREATE TYPE emplist_t AS TABLE OF emp_t;
/

CREATE TYPE dept_t AS OBJECT (deptno       NUMBER(4),
                              dname        VARCHAR2(30),
                              loc          NUMBER(4),
                              emps         emplist_t);
/

CREATE OR REPLACE VIEW dept_ov OF dept_t
  WITH OBJECT ID (deptno) AS
  SELECT d.department_id, d.department_name, d.location_id,
         CAST(MULTISET(
           SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id,
                        e.hire_date, e.salary, e.commission_pct)
             FROM employees e
             WHERE e.department_id = d.department_id)
             AS emplist_t)
    FROM departments d;

CREATE OR REPLACE VIEW dept_xml OF XMLType
  WITH OBJECT ID (extract(OBJECT_VALUE, '/ROW/DEPTNO').getNumberVal()) AS
  SELECT sys_XMLGen(OBJECT_VALUE) FROM dept_ov;
```

Querying department numbers that have at least one employee making a salary more than $15000:

```
SELECT extractValue(OBJECT_VALUE, '/ROW/DEPTNO')
  FROM dept_xml
  WHERE existsNode(OBJECT_VALUE, '/ROW/EMPS/EMP_T[sal > 15000]') = 1;
```

This query becomes something like the following:

```
SELECT d.department_id
  FROM departments d
  WHERE exists(SELECT NULL FROM employees e
                 WHERE e.department_id = d.department_id
                   AND e.salary > 15000);
```

Example 19–23 Non-Schema-Based Views Constructed Using SYS_XMLGEN on an Object View

For example, the data in the `emp` table can be exposed as follows:

```
CREATE TYPE emp_t AS OBJECT
      (empno         NUMBER(6),
       ename         VARCHAR2(25),
       job           VARCHAR2(10),
       mgr           NUMBER(6),
       hiredate      DATE,
       sal           NUMBER(8,2),
       comm          NUMBER(2,2));
/

CREATE VIEW employee_xml OF XMLType
  WITH OBJECT  ID (OBJECT_VALUE.extract('/ROW/EMPNO/text()').getnumberval()) AS
    SELECT sys_XMLGen(emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id,
                            e.hire_date, e.salary, e.commission_pct))
```

```
      FROM employees e;
```

A major advantage of non-schema-based views is that existing object views can be easily transformed into XMLType views without any additional DDL statements. For example, consider a database that contains the object view employee_ov with the following definition:

```
CREATE VIEW employee_ov OF emp_t
  WITH OBJECT ID (empno) AS
  SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id,
               e.hire_date, e.salary, e.commission_pct)
    FROM employees e;
```

Creating a non-schema-based XMLType view can be achieved by calling sys_XMLGen over the top-level object column. No additional types need to be created.

```
CREATE OR REPLACE VIEW employee_ov_xml OF XMLType
  WITH OBJECT ID (OBJECT_VALUE.extract('/ROW/EMPNO/text()').getnumberval()) AS
  SELECT sys_XMLGen(OBJECT_VALUE) FROM employee_ov;
```

Queries on sys_XMLGen views are rewritten to access the object attributes directly if they meet certain conditions. Simple XPath traversals with SQL functions existsNode, extractValue, and extract are candidates for rewrite. See Chapter 7, "XPath Rewrite", for details on XPath rewrite. For example, a query such as the following:

```
SELECT extract(OBJECT_VALUE, '/ROW/EMPNO')
  FROM employee_ov_xml
  WHERE extractValue(OBJECT_VALUE, '/ROW/ENAME') = 'Smith';
```

This query is rewritten to something like the following:

```
SELECT sys_XMLGen(e.employee_id)
  FROM employees e
  WHERE e.last_name = 'Smith';
```

XML-Schema-Based Views Using Object Types or Object Views

Example 19–24 illustrates XPath rewrite on an XML-schema-based XMLType view using an object type.

Example 19–24 XML-Schema-Based Views Constructed Using Object Types

This example uses the same object types and the same XML schema (emp_complex.xsd) as in section "Creating Schema-Based XMLType Views Over Object Views".

```
CREATE VIEW xmlv_adts OF XMLType
   XMLSchema "http://www.oracle.com/emp_complex.xsd" ELEMENT "Employee"
   WITH OBJECT OID (
          OBJECT_VALUE.extract(
            '/Employee/EmployeeId/text()').getNumberVal()) AS
          SELECT emp_t(e.employee_id, e.last_name, e.job_id, e.manager_id,
                       e.hire_date, e.salary, e.commission_pct,
                       dept_t(d.department_id, d.department_name, d.location_id))
            FROM employees e, departments d
            WHERE e.department_id = d.department_id;
```

A query using SQL function extractValue:

```
SELECT extractValue(OBJECT_VALUE, '/Employee/EMPNO') "EmpID ",
       extractValue(OBJECT_VALUE, '/Employee/ENAME') "Ename ",
```

```
      extractValue(OBJECT_VALUE, '/Employee/JOB') "Job ",
      extractValue(OBJECT_VALUE, '/Employee/MGR') "Manager ",
      extractValue(OBJECT_VALUE, '/Employee/HIREDATE') "HireDate ",
      extractValue(OBJECT_VALUE, '/Employee/SAL') "Salary ",
      extractValue(OBJECT_VALUE, '/Employee/COMM') "Commission ",
      extractValue(OBJECT_VALUE, '/Employee/DEPT/DEPTNO') "Deptno ",
      extractValue(OBJECT_VALUE, '/Employee/DEPT/DNAME') "Deptname ",
      extractValue(OBJECT_VALUE, '/Employee/DEPT/LOC') "Location "
  FROM xmlv_adts
  WHERE existsNode(OBJECT_VALUE, '/Employee[SAL > 15000]') = 1;
```

This query becomes:

```
SELECT e.employee_id "EmpID ", e.last_name "Ename ", e.job_id "Job ",
       e.manager_id "Manager ", e.hire_date "HireDate ", e.salary "Salary ",
       e.commission_pct "Commission ", d.department_id "Deptno ",
       d.department_name "Deptname ", d.location_id "Location "
  FROM employees e, departments d
  WHERE e.department_id = d.department_id AND e.salary > 15000;
```

XPath Rewrite Event Trace

You can disable XPath rewrite for views constructed using a SQL/XML function by using the following event flag:

```
ALTER SESSION SET EVENTS '19027 trace name context forever, level 64';
```

You can disable XPath rewrite for view constructed using object types, object views, and SQL function `sys_XMLGen` by using the following event flag:

```
ALTER SESSION SET EVENTS '19027 trace name context forever, level 1';
```

You can trace why XPath rewrite does not happen by using the following event flag. The trace message is printed in the trace file.

```
ALTER SESSION SET EVENTS '19027 trace name context forever, level 8192';
```

Generating XML Schema-Based XML Without Creating Views

In the preceding examples, the `CREATE VIEW` statement specified the XML schema URL and element name, whereas the underlying view query constructed a non-schema-based `XMLType`. However, there are several scenarios where you may want to avoid the `CREATE VIEW` step, but still must construct XML schema-based XML.

To achieve this, you can use the following XML-generation SQL functions to optionally accept an XML schema URL and element name:

- `createXML`
- `sys_XMLGen`
- `sys_XMLAgg`

See Also: Chapter 17, "Generating XML Data from the Database"

Example 19–25 Generating XML Schema-Based XML Without Creating Views

This example uses the same type and XML schema definitions as in section "Wrapping Relational Department Data with Nested Employee Data as XML". With those definitions, `createXML` creates XML that is XML schema-based.

```
SELECT (XMLTYPE.createXML(
          dept_t(d.department_id, d.department_name, d.location_id,
              CAST(MULTISET(SELECT emp_t(e.employee_id, e.last_name, e.job_id,
                   e.manager_id, e.hire_date, e.salary,
                   e.commission_pct)
                             FROM employees e
                             WHERE e.department_id = d.department_id)
                         AS emplist_t)),
          'http://www.oracle.com/dept_complex.xsd', 'Department'))
  FROM departments d;
```

As `XMLType` has an automatic constructor, `XMLTYPE.createXML` could be replaced by `XMLTYPE` here.

20

Accessing Data Through URIs

This chapter describes how to generate and store URLs in the database and how to retrieve data pointed to by those URLs. Three kinds of URIs are discussed:

- DBUris – addresses to relational data in the database
- XDBUris – addresses to data in Oracle XML DB Repository
- HTTPUris – Web addresses that use the Hyper Text Transfer Protocol (HTTP(S))

This chapter contains these topics:

Overview of Oracle XML DB URL Features

The two main features described in this chapter are these:

- *Using paths as an indirection mechanism* – You can store a path in the database and then access its target *indirectly* by referring to the path. The paths in question are various kinds of Uniform Resource Identifier (URI).
- *Using paths that target database data to produce XML documents* – One kind of URI that you can use for indirection in particular, a *DBUri*, provides a convenient XPath notation for addressing *database data*. You can use a DBUri to construct an *XML document* that contains database data and whose structure reflects the database structure.

URIs and URLs

In developing Web-based XML applications, you often refer to data located on a network using **Uniform Resource Identifiers**, or **URI**s. A **URL**, or **Uniform Resource Locator**, is a URI that accesses an object using an Internet protocol.

A URI has two parts, separated by a number sign (**#**):

- A URL part, that identifies a document.
- A fragment part, that identifies a fragment within the document. The notation for the fragment depends on the document type. For HTML documents, it is an anchor name. For XML documents, it is an XPath expression.

These are typical URIs:

- *For HTML* – `http://www.url.com/document1#some_anchor`, where `some_anchor` is a named anchor in the HTML document.
- *For XML* – `http://www.xml.com/xml_doc#/po/cust/custname`, where:
  - `http://www.xml.com/xml_doc` identifies the location of the XML document.
  - `/po/cust/custname` identifies a fragment within the document. This portion is defined by the W3C XPointer recommendation.

See Also:

- `http://www.w3.org/2002/ws/Activity.html` an explanation of HTTP(S) URL notation
- `http://www.w3.org/TR/xpath` for an explanation of the XML XPath notation
- `http://www.w3.org/TR/xptr/` for an explanation of the XML XPointer notation
- `http://xml.coverpages.org/xmlMediaMIME.html` for a discussion of MIME types

URIType and its Subtypes

Oracle XML DB can represent paths of various kinds as database objects. These are the available path object types:

- **`HTTPURIType`** – An object of this type is called an **HTTPUri** and represents a URL that begins with **`http://`**. With `HTTPURIType`, you can create objects that represent links to remote *Web pages* (or files) and retrieve those Web pages by calling object methods. Applications using `HTTPUriType` must have the proper access privileges. `HTTPUriType` implements the Hyper Text Transfer Protocol (HTTP(S)) for accessing remote Web pages. `HTTPURIType` uses package `UTL_HTTP` to fetch data, so session settings and access control for this package can also be used to influence HTTP fetches.

  See Also:

  - "HTTPURIType Method getContentType()" on page 20-5
  - *Oracle Database Security Guide* for information about managing fine-grained access to external network services

- **`DBURIType`** – An object of this type is called a **DBUri** and represents a URI that targets database data – a table, one or more rows, or a single column. With `DBURIType`, you can create objects that represent links to *database data*, and retrieve such data *as XML* by calling object methods. A DBUri uses a simple form of XPath expression as its URI syntax – for example, the following XPath

expression is a DBUri reference to the row of database table `hr`, column `employees` where column `first_name` has value `Jack`:

```
/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]
```

See Also : DBUris: Pointers to Database Data on page 20-12

- **`XDBURIType`** – An object of this type is called an **XDBUri**, and represents a URI that targets a resource in Oracle XML DB Repository. With `XDBURIType`, you can create objects that represent links to *repository resources*, and retrieve all or part of any resource by calling object methods. The URI syntax for an XDBUri is a repository resource address optionally followed by an XPath expression. For example, `/public/hr/doc1.xml#/purchaseOrder/lineItem` is an XDBUri reference to the `lineItem` child element of the root element `purchaseOrder` in repository file `doc1.xml` in folder `/public/hr`.

See Also : XDBUris: Pointers to Repository Resources on page 20-10

Each of these object types is derived from an *abstract* object type, **`URIType`**. As an abstract type, it has *no* instances (objects); only its subtypes have instances.

Type `URIType` provides the following features:

- *Unified access to data stored inside and outside the server.* Because you can use `URIType` values to store pointers to HTTP(S) and DBUris, you can create queries and indexes without worrying about where the data resides.
- *Mapping of URIs in XML Documents to Database Columns.* When an XML document is broken up and stored in object-relational tables and columns, any URIs contained in the document are mapped to database columns of the appropriate `URIType` subtype.

You can reference data stored in relational columns and expose it to the external world using URIs. Oracle Database provides a standard servlet, DBUriServlet, that interprets DBUris. It also provides PL/SQL package `UTL_HTTP` and Java class `java.net.URL`, which you can use to fetch URL references.

`URIType` columns can be indexed natively in Oracle Database using Oracle Text – no special data store is needed.

See Also:

- "Creating New Subtypes of URIType using Package URIFACTORY" on page 20-20 for information about defining new `URIType` subtypes
- Chapter 5, "Indexing XMLType Data"

DBUris and XDBUris – What For?

The following are typical uses of DBUris and XDBUris:

- You can reference XSLT style sheets from within database-generated Web pages. PL/SQL package `DBMS_METADATA` uses DBUris to reference XSL style sheets. An XDBUri can be used to reference XSLT style sheets stored in Oracle XML DB Repository.
- You can reference HTML text, images and other data stored in the database. URLs can be used to point to data stored in database tables or in repository folders.

- You can improve performance by bypassing the Web server. Replace a global URL in your XML document with a reference to the database, and use a servlet, a DBUri, or an XDBUri to retrieve the targeted content. Using a DBUri or an XDBUri generally provides better performance than using a servlet, because you interact directly with the database rather than through a Web server.
- With a DBUri, you can access an XML document in the database without using SQL.
- Whenever a repository resource is stored in a database table to which you have access, you can use either an XDBUri or a DBUri to access its content.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference*, "DBMS_METADATA package"

URIType Methods

Abstract object type `URIType` includes methods that can be used with each of its subtypes. Each of these methods can be overridden by any of the subtypes. Table 20–1 lists the `URIType` methods. In addition, each of the subtypes has a constructor with the same name as the subtype.

Table 20–1 URIType Methods

URIType Method	Description
`getURL()`	Returns the URL of the `URIType` instance. Use this method instead of referencing a URL directly. `URIType` subtypes override this method to provide the correct URL. For example, `HTTPURIType` stores a URL without prefix `http://`. Method `getURL()` then prepends the prefix and returns the entire URL.
`getExternalURL()`	Similar to `getURL()`, but `getExternalURL()` escapes characters in the URL, to conform with the URL specification. For example, spaces are converted to the escaped value `%20`.
`getContentType()`	Returns the MIME content type for the URI. *HTTPUri:* To return the content type, the URL is followed and the MIME header examined. *DBUri:* The returned content type is either `text/plain` (for a scalar value) or `text/xml` (otherwise). *XDBUri:* The value of the `ContentType` metadata property of the repository resource is returned.
`getCLOB()`	Returns the target of the URI as a `CLOB` value. The database character set is used for encoding the data. *DBUri: XML* data is returned (unless node-test `text()` is used, in which case the targeted data is returned as is). When a `BLOB` column is targeted, the binary data in the column is *translated as hexadecimal character data*.
`getBLOB()`	Returns the target of the URI as a `BLOB` value. No character conversion is performed, and the character encoding is that of the URI target. This method can also be used to fetch binary data. *DBUri:* When applied to a DBUri that targets a `BLOB` column, `getBLOB()` returns the binary data *translated as hexadecimal character data*. When applied to a DBUri that targets *non*-binary data, the data is returned in the database character set.

Table 20–1 (Cont.) URIType Methods

URIType Method	Description
getXML()	Returns the target of the URI as an XMLType instance. Using this, an application that performs operations other than getCLOB() and getBLOB() can use XMLType methods to do those operations. This throws an exception if the URI does not target a well-formed XML document.
createURI()	Constructs an instance of one of the URIType subtypes.

HTTPURIType Method getContentType()

HTTPURIType method getContentType() returns the MIME information for its targeted document. You can use this information to decide whether to retrieve the document as a BLOB value or a CLOB value. For example, you might treat a Web page with a MIME type of x/jpeg as a BLOB value, and one with a MIME type of text/plain or text/html as a CLOB value.

Example 20–1 Using HTTPURIType Method getContentType()

In this example, the HTTP content type is tested to determine whether to retrieve data as a CLOB or BLOB value. The content-type data is the HTTP header, for HTTPURIType, or the metadata of the database column, for DBURIType.

```
DECLARE
  httpuri HTTPURIType;
  y CLOB;
  x BLOB;
BEGIN
  httpuri := HTTPURIType('http://www.oracle.com/object1');
  DBMS_OUTPUT.put_line(httpuri.getContentType());
  IF httpuri.getContentType() = 'text/html'
  THEN
     y := httpuri.getCLOB();
  END IF;
  IF httpuri.getContentType() = 'application-x/bin'
  THEN
     x := httpuri.getBLOB();
  END IF;
END;
/
text/html
```

DBURIType Method getContentType()

Method getContentType() returns the MIME information for a URL. If a DBUri targets a scalar value, then the MIME content type returned is text/plain; otherwise, it is text/xml. For example, consider table dbtab:

```
CREATE TABLE DBTAB(a VARCHAR2(20), b BLOB);
```

DBUris corresponding to the following XPath expressions have content type text/xml, because each targets a complete column of XML data.

- /HR/DBTAB/ROW/A
- /HR/DBTAB/ROW/B

DBUris corresponding to the following XPath expressions have content type text/plain, because each targets a scalar value.

- /HR/DBTAB/ROW/A/text()
- /HR/DBTAB/ROW/B/text()

DBURIType Method getCLOB()

When method getCLOB() is applied to a DBUri, the targeted data is returned as *XML* data, using the targeted column or table name as an XML element name. If the target XPath uses node-test text(), then the data is returned as text without an enclosing XML tag. In both cases, the returned data is in the database character set.

For example: If applied to a DBUri with XPath /HR/DBTAB/ROW/A/text(), where A is a non-binary column, the data in column A is returned as is. Without XPath node-test text(), the result is the data wrapped in XML:

```
<HR><DBTAB><ROW><A>...data_in_column_A...</A></ROW></DBTAB></HR>
```

When applied to a DBUri that targets a *binary* (BLOB) column, the binary data in the column is *translated as hexadecimal character data*.

For example: If applied to a DBUri with XPath /HR/DBTAB/ROW/B/text(), where B is a BLOB column, the targeted binary data is translated to hexadecimal character data and returned. Without XPath node-test text(), the result is the translated data wrapped in XML:

```
<HR><DBTAB><ROW><B>...data_translated_to_hex...</B></ROW></DBTAB></HR>
```

DBURIType Method getBLOB()

When applied to a DBUri that targets a BLOB column, getBLOB() returns the binary data *translated as hexadecimal character data*. When applied to a DBUri that targets *non*-binary data, getBLOB() returns the data (as a BLOB value) in the database character set.

For example, consider table dbtab:

```
CREATE TABLE DBTAB(a VARCHAR2(20), b BLOB);
```

When getBLOB() is applied to a DBUri corresponding to XPath expression /HR/DBTAB/ROW/B, it returns a BLOB value containing an XML document with root element B whose content is the hexadecimal-character translation of the binary data of column B.

When getBLOB() is applied to a DBUri corresponding to XPath expression /HR/DBTAB/ROW/B/text(), it returns a BLOB value containing only the hexadecimal-character translation of the binary data of column B.

When getBLOB() is applied to a DBUri corresponding to XPath expression /HR/DBTAB/ROW/**A**/text(), which targets *non*-binary data, it returns a BLOB value containing the data of column A, in the database character set.

Accessing Data Using URIType Instances

To use instances of URIType subtypes for indirection, you generally store such instances in the database and then use them in queries with a method such as getCLOB() to retrieve the targeted data. This section illustrates how to do this.

You can create database columns using URIType or any of its subtypes, or you can store just the text of each URI as a string and then create the needed URIType instances on demand, when the URIs are accessed. You can store objects of different URIType subtypes in the same URIType database column.

You can also define your own object types that inherit from the URIType subtypes. Deriving new types lets you use custom techniques to retrieve, transform, or filter data.

See Also:

- "Creating New Subtypes of URIType using Package URIFACTORY" on page 20-20 for information about defining new URIType subtypes
- "XSL Transformation and Oracle XML DB" on page 3-71 for information about transforming XML data

Example 20–2 Creating and Querying a URI Column

This example stores an HTTPUri and a DBUri (instances of URIType subtypes HTTPURIType and DBURIType) in the same database column of type URIType. A query retrieves the data addressed by each of the URIs. The first URI is a Web-page URL; the second references data in the employees table of standard schema hr. (For brevity, only the beginning of the Web page is shown.)

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES (HTTPURIType.createURI('http://www.oracle.com'));
1 row created.

INSERT INTO uri_tab VALUES (DBURIType.createURI(
                              '/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
--------------------------------------------------------------------
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Oracle Corporation</TITLE>
. . .

<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>177</EMPLOYEE_ID>
  <FIRST_NAME>Jack</FIRST_NAME>
  <LAST_NAME>Livingston</LAST_NAME>
  <EMAIL>JLIVINGS</EMAIL>
  <PHONE_NUMBER>011.44.1644.429264</PHONE_NUMBER>
  <HIRE_DATE>23-APR-98</HIRE_DATE>
  <JOB_ID>SA_REP</JOB_ID>
  <SALARY>8400</SALARY>
  <COMMISSION_PCT>.2</COMMISSION_PCT>
  <MANAGER_ID>149</MANAGER_ID>
  <DEPARTMENT_ID>80</DEPARTMENT_ID>
 </ROW>

2 rows selected.
```

To use URIType method createURI(), you must know the particular URIType subtype to use. Method getURI() of package URIFACTORY lets you instead use the flexibility of late binding, determining the particular type information at runtime.

`URIFACTORY.getURI()` takes as argument a URI string; it returns a `URIType` instance of the appropriate subtype (`HTTPURIType`, `DBURIType`, or `XDBURIType`), based on the form of the URI string:

- If the URI starts with `http://`, then `getURI()` creates and returns an HTTPUri.
- If the URI starts with either `/oradb/` or `/dburi/`, then `getURI()` creates and returns a DBUri.
- Otherwise, `getURI()` creates and returns an XDBUri.

Example 20–3 Using Different Kinds of URI, Created in Different Ways

This example is similar to Example 20–2. However, it uses two different ways to obtain documents targeted by URIs:

- Method `SYS.URIFACTORY.getURI()` with *absolute* URIs:
  - an HTTPUri that targets HTTP address `http://www.oracle.com`
  - a DBUri that targets database address `/oradb/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]`
- Constructor `SYS.HTTPURIType()` with a *relative* URL (no `http://`). The same HTTPUri is used as for the absolute URI: the Oracle home page.

In this example, the URI strings passed to `getURI()` are hard-coded, but they could just as easily be string values that are obtained by an application at runtime.

```
CREATE TABLE uri_tab (docUrl SYS.URIType, docName VARCHAR2(200));
Table created.

-- Insert an HTTPUri with absolute URL into SYS.URIType using URIFACTORY.
-- The target is Oracle home page.
INSERT INTO uri_tab VALUES
  (SYS.URIFACTORY.getURI('http://www.oracle.com'), 'AbsURL');
1 row created.

-- Insert an HTTPUri with relative URL using constructor SYS.HTTPURIType.
-- Note the absence of prefix http://. The target is the same.
INSERT INTO uri_tab VALUES (SYS.HTTPURIType('www.oracle.com'), 'RelURL');
1 row created.

-- Insert a DBUri that targets employee data from database table hr.employees.
INSERT INTO uri_tab VALUES
  (SYS.URIFACTORY.getURI('/oradb/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]'), 'Emp200');
1 row created.

-- Extract all of the documents.
SELECT e.docUrl.getCLOB(), docName FROM uri_tab e;

E.DOCURL.GETCLOB()
------------------
DOCNAME
-----------------------------------
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<HTML>
<HEAD>
<TITLE>Oracle Corporation</TITLE>
. . .
AbsURL

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
```

```
<HTML>
<HEAD>
<TITLE>Oracle Corporation</TITLE>
. . .
RelURL

<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-87</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>
Emp200

3 rows selected.

-- In PL/SQL
CREATE OR REPLACE FUNCTION returnclob
RETURN CLOB
IS
  a SYS.URIType;
BEGIN
  SELECT docUrl INTO a FROM uri_Tab WHERE docName LIKE 'Emp200%';
  RETURN a.getCLOB;
END;
/
Function created.

SELECT returnclob() FROM DUAL;

RETURNCLOB()
--------------------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-87</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>

1 row selected.
```

XDBUris: Pointers to Repository Resources

XDBURIType is a subtype of URIType that provides a way to expose resources in Oracle XML DB Repository using URIs. Instances of type XDBURIType are called **XDBUris**.

XDBUri URI Syntax

The URL portion of an XDBUri URI is the hierarchical address of the targeted repository resource – it is a *repository* path (*not* an XPath expression).

The optional fragment portion of the URI uses the XPath syntax, and is separated from the URL part by a number-sign (#). It is appropriate only if the targeted resource is an *XML* document, in which case the fragment portion targets one or more parts of the XML document. If the targeted resource is not an XML document, then omit the fragment and number-sign.

The following are examples of XDBUri URIs:

- /public/hr/image27.jpg
- /public/hr/doc1.xml#/PurchaseOrder/LineItem

Based on the form of these URIs, we can determine the following:

- /public/hr is a folder resource in Oracle XML DB Repository.
- image27.jpg and doc1.xml are resources in folder /public/hr.
- Resource doc1.xml is a file resource, and it contains an XML document.
- The XPath expression /PurchaseOrder/LineItem refers to the LineItem child element in element PurchaseOrder of XML document doc1.xml.

You can create an XDBUri using method getURI() of package URIFACTORY.

XDBURIType is the *default* URIType used when generating instances using URIFACTORY method getURI(), unless the URI has one of the recognized prefixes http://, /dburi, or /oradb.

For example, if resource doc1.xml is present in repository folder /public/hr, then the following query will return an XDBUri that targets that resource.

```
SELECT SYS.URIFACTORY.getURI('/public/hr/doc1.xml') FROM DUAL;
```

It is the lack of a special prefix that determines that the type is XDBURIType, not any particular resource file extension or the presence of # followed by an XPath expression; if the resource were named foo.bar instead of doc1.xml, the returned URIType instance would still be an XDBUri.

XDBUri Examples

Example 20–4 Using an XDBUri to Access a Repository Resource by URI

This example creates an XDBUri, inserts values into a purchase-order table, and then selects all of the purchase orders. Because there is no special prefix used in the URI passed to URIFACTORY.getURI(), the created URIType instance is an XDBUri.

```
DECLARE
res BOOLEAN;
postring VARCHAR2(100):= '<?xml version="1.0"?>
<ROW>
<PO>999</PO>
```

```
</ROW>';
BEGIN
res:=DBMS_XDB.createFolder('/public/orders/');
res:=DBMS_XDB.createResource('/public/orders/po1.xml', postring);
END;
/
PL/SQL procedure successfully completed.

CREATE TABLE uri_tab (poUrl SYS.URIType, poName VARCHAR2(1000));
Table created.

-- We create an abstract type column so any type of URI can be used
-- Insert an absolute URL into poUrl.
-- The factory will create an XDBURIType because there is no prefix.
-- Here, po1.xml is an XML file that is stored in /public/orders/
-- of the XML repository.
INSERT INTO uri_tab VALUES
  (URIFACTORY.getURI('/public/orders/po1.xml'), 'SomePurchaseOrder');
1 row created.

-- Get all the purchase orders
SELECT e.poUrl.getCLOB(), poName FROM uri_tab e;

E.POURL.GETCLOB()
-----------------
PONAME
------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>
SomePurchaseOrder

1 row selected.

-- Using PL/SQL, you can access table uri_tab as follows:
CREATE OR REPLACE FUNCTION returnclob
RETURN CLOB
IS
  a URIType;
BEGIN
  -- Get absolute URL for purchase order named like 'Some%'
   SELECT poUrl INTO a FROM uri_tab WHERE poName LIKE 'Some%';
   RETURN a.getCLOB();
END;
/
Function created.

SELECT returnclob() FROM DUAL;

RETURNCLOB()
--------------------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>

1 row selected.
```

Example 20–5 Using Method getXML() with EXTRACTVALUE

Because method `getXML()` returns an `XMLType` instance, you can use it with SQL functions like `extractValue`. This query retrieves all purchase orders numbered 999:

```
SELECT e.poUrl.getCLOB() FROM uri_tab e
   WHERE extractValue(e.poUrl.getXML(), '/ROW/PO') = '999';

E.POURL.GETCLOB()
--------------------
<?xml version="1.0"?>
<ROW>
<PO>999</PO>
</ROW>

1 row selected.
```

DBUris: Pointers to Database Data

A DBUri is a URI that targets *database data*. As for all instances of `URIType` subtypes, a DBUri provides an indirection mechanism for accessing data. In addition, `DBURIType` lets you do the following:

- Address database data using XPath notation. This, in effect, lets you visualize and access the database as if it were XML data.

  For example, a DBUri can use an expression such as `/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]` to target the row of database table `hr`, column `employees` where column `first_name` has value `Jack`.

- *Construct an XML document* that contains database data targeted by a DBUri and whose structure reflects the database structure.

  For example: A DBUri with XPath `/HR/DBTAB/ROW/A` can be used to construct an XML document that wraps the data of column `A` in XML elements that reflect the database structure and are named accordingly:

  ```
  <HR><DBTAB><ROW><A>...data_in_column_A...</A></ROW></DBTAB></HR>
  ```

A DBUri does not reference a global location as does an HTTPUri. You can, however, also access objects addressed by a DBUri in a global manner, by appending the DBUri to an HTTPUri that identifies a servlet that handles DBUris – see "DBUriServlet" on page 20-25.

Viewing the Database as XML Data

You can only access those database schemas to which you have been granted access privileges. This portion of the database is, in effect, your own view of the database.

Using `DBURIType`, you can have corresponding *XML* views of the database, which are portions of the database to which you have access, presented *in the form of XML data*. This means all kinds database data, not just data that is stored as XML. When visualized this way, the database data is effectively wrapped in XML elements, resulting in one or more XML documents.

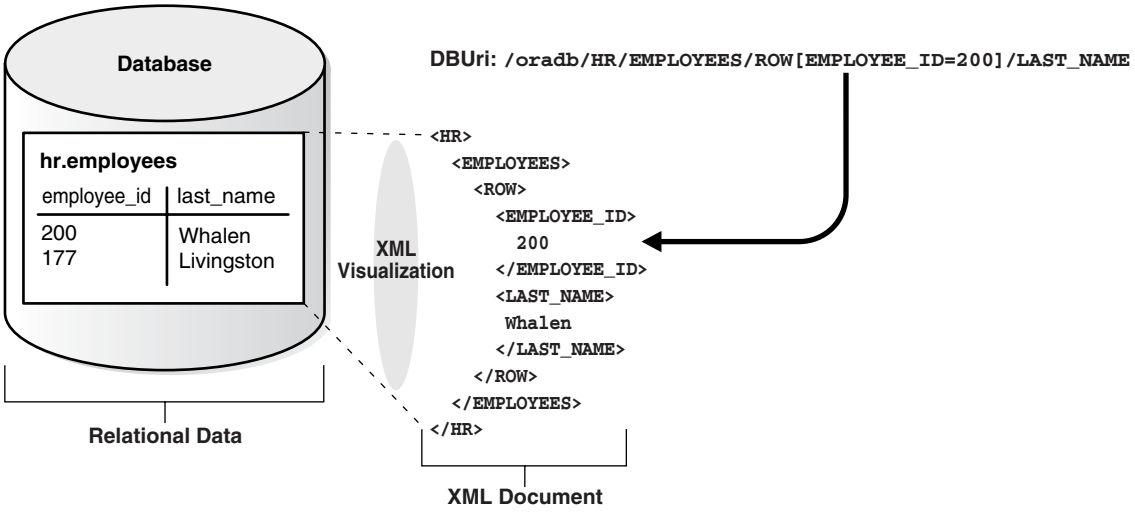
Such "XML views" are not database views, in the technical sense of the term; "view" here means only an abstract perspective that can be useful for understanding `DBURIType`. You can think of `DBURIType` as providing a way to visualize and access the database *as if it were* XML data.

However, DBURIType does not just provide an exercise in visualization and an additional means to access database data. Each "XML view" can be realized as an XML document – that is, you can use DBURIType to generate XML documents using database data.

All of this is another way of saying that DBURIType lets you use XPath notation to 1) address and access any database data to which you have access and 2) construct XML representations of that data.

Figure 20–1 illustrates the relation between a relational table, hr.employees, a corresponding "XML view" of a portion of that table, and the corresponding DBUri URI (a simple XPath expression). In this case, the portion of the data exposed as XML is the row where employee_id is 200. The URI can be used to access the data and construct an XML document that reflects the "XML view".

Figure 20–1 A DBUri Corresponds to an XML Visualization of Relational Data



The XML elements in the "XML view" and the steps in the URI XPath expression both reflect the database table and column names. Note the use of **ROW** to indicate a row in the database table – both in the "XML view" and in the URI XPath expression.

Note also that the XPath expression contains a root-element step, **oradb**. This is used to indicate that the URI corresponds to a DBUri, not an HTTPUri or an XDBUri. Whenever this correspondence is understood from context, this XPath step can be skipped. For example, if it is known that the path in question is a path to database data, the following URIs are equivalent:

- **/oradb**/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME
- /HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME

Whenever the URI context is not clear, however, you must use the prefix /oradb to distinguish a URI as corresponding to a DBUri. In particular, you must supply the prefix to URIFACTORY methods and to DBUriServlet.

See Also:

- "Creating New Subtypes of URIType using Package URIFACTORY" on page 20-20
- "DBUriServlet" on page 20-25
- Chapter 17, "Generating XML Data from the Database" for other ways to generate XML from database data

DBUri URI Syntax

An XPath expression is a path into XML data that addresses one or more XML nodes. A DBUri exploits the notion of a virtual XML user visualization of the database to use a *simple form* of XPath expression as a URI to address database data. This is so, regardless of the type of data, in particular, whether or not the data is XML.

Thus, for `DBURIType`, Oracle Database does not support the full XPath or XPointer syntax; only a subset is allowed. There are no syntax restrictions for ***X***DBUri XPath expressions. There is also an exception in the DBUri case: data in `XMLType` tables. For an `XMLType` table, the simple XPath form is used to address the table itself within the database. Then, to address particular XML data in the table, the remainder of the XPath expression can use the full XPath syntax. This exception applies only to `XMLType` *tables*, not to `XMLType` columns.

In any case, unlike an XDBUri, a DBUri URI does not use a number-sign (`#`) to separate the URL portion of a URI from a fragment (XPath) portion. `DBURIType` does not use URI fragments; the entire URI is treated as a (simple) XPath expression.

You can create DBUris to any database data to which you have access. XPath expressions such as the following are allowed:

- */database_schema/table*
- */database_schema/table/*ROW[*predicate_expression*]*/column*
- */database_schema/table/*ROW[*predicate_expression*]*/object_column/attribute*
- */database_schema/**XMLType_table***/ROW/*XPath_expression*

In the last case, *XMLType_table* is an `XMLType` table, and *XPath_expression* is *any* XPath expression. For tables that are *not* `XMLType`, a DBUri XPath expression must end at a column; it cannot address specific data inside a column. This restriction includes `XMLType` columns, LOB columns, and `VARCHAR2` columns that contain XML data.

A DBUri XPath expression can do any of the following:

- Target an entire table.

  For example, `/HR/EMPLOYEES` targets table `employees` of database schema `hr`.

- Include XPath predicates at any step in the path, except the database schema and table steps.

  For example, `/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/EMAIL` targets the `email` column of table `hr.employees`, where `employee_id` is `200`.

- Use the `text()` XPath node test on data with scalar content. This is the *only* node test that can be used, and it cannot be used with the table or row step.

The following can be used in DBUri (XPath) *predicate* expressions:

- Boolean operators `and`, `or`, and `not`

- Relational operators `<`, `>`, `<=`, `!=`, `>=`, `=`, `mod`, `div`, `*` (multiply)

A DBUri XPath expression *must* do all of the following:

- Use only the *child* XPath axis – other axes, such as parent, are not allowed.
- Either specify a database schema or specify `PUBLIC` to resolve the table name without a specific schema.
- Specify a database view or table name.
- Include a `ROW` step, if a database column is targeted.
- Identify a *single* data value, which can be an object-type instance or a collection.
- Result in well-formed XML when it is used to generate XML data using database data.

  An example of a DBUri that does *not* result in well-formed XML is `/HR/EMPLOYEES/ROW/LAST_NAME`. It returns more than one `<LAST_NAME>` element fragment, with no single root element.
- Use *none* of the following:
  - `*` (wildcard)
  - `.` (self)
  - `..` (parent)
  - `//` (descendant or self)
  - XPath functions, such as `count`

A DBUri XPath expression can optionally be prefixed by **`/oradb`** or **`/dburi`** (the two are equivalent) to distinguish it. This prefix is case-insensitive. However, the rest of the DBUri XPath expression is *case-sensitive*, as are XPath expressions generally. Thus, for example, to specify database column `hr.employees` as a DBUri XPath expression, you must use `HR/EMPLOYEES`, not `hr/employees` (or a mixed-case combination), because table and column names are uppercase, by default.

See Also: `http://www.w3.org/TR/xpath` on XPath notation

DBUris are Scoped to a Database and Session

The content of the "XML views" you have of the database, and hence of the XML documents that you can construct, reflects the permissions you have to access particular database data at a given time. That is, a DBUri is scoped to a given database session, so the same DBUri can give different results in the same query, depending on the session context (which user is connected and what privileges the user has).

To complicate things a bit, there is also an XML element `PUBLIC`, under which database data is accessible without any database-schema qualification. This is a convenience feature, but it can also lead to some confusion if you forget that the XML views of the database for a given user depend on the specific access the user has to the database at a given time.

XML element `PUBLIC` corresponds to the use of a *public synonym*. For example, when queried by user `quine`, the following query tries to match table `foo` under database schema `quine`, but if no such table exists, it tries to match a public synonym named `foo`.

```
SELECT * FROM foo;
```

In the same way, XML element PUBLIC contains all of the database data visible to a given user, as well as all of the data visible to that user through public synonyms. So, the same DBUri URI /PUBLIC/FOO can resolve to quine.foo when user quine is connected, and resolve to curry.foo when user curry is connected.

DBUri Examples

A DBUri can identify a table, a row, a column in a row, or an attribute of an object column. The following sections describe how to target different object types.

Targeting a Table

You can target a complete database table, using this syntax:

/database_schema/table

Example 20–6 Using a DBUri to Target a Complete Table

In this example, a DBUri targets a complete table. An XML document is returned that corresponds to the table contents. The top-level XML element is named for the table. The values of each row are enclosed in a ROW element.

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
---------------
<?xml version="1.0"?>
<EMPLOYEES>
 <ROW>
  <EMPLOYEE_ID>100</EMPLOYEE_ID>
  <FIRST_NAME>Steven</FIRST_NAME>
  <LAST_NAME>King</LAST_NAME>
  <EMAIL>SKING</EMAIL>
  <PHONE_NUMBER>515.123.4567</PHONE_NUMBER>
  <HIRE_DATE>17-JUN-87</HIRE_DATE>
  <JOB_ID>AD_PRES</JOB_ID>
  <SALARY>24000</SALARY>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 <ROW>
  <EMPLOYEE_ID>101</EMPLOYEE_ID>
  <FIRST_NAME>Neena</FIRST_NAME>
  <LAST_NAME>Kochhar</LAST_NAME>
  <EMAIL>NKOCHHAR</EMAIL>
  <PHONE_NUMBER>515.123.4568</PHONE_NUMBER>
  <HIRE_DATE>21-SEP-89</HIRE_DATE>
  <JOB_ID>AD_VP</JOB_ID>
  <SALARY>17000</SALARY>
  <MANAGER_ID>100</MANAGER_ID>
  <DEPARTMENT_ID>90</DEPARTMENT_ID>
 </ROW>
 . . .
```

```
1 row selected.
```

Targeting a Row in a Table

You can target one or more specific rows of a table, using this syntax:

/database_schema/table/ROW[*predicate_expression*]

Example 20–7 Using a DBUri to Target a Particular Row in a Table

In this example, a DBUri targets a single table row. The XPath predicate expression identifies the single table row that corresponds to employee number 200. The result is an XML document with `ROW` as the top-level element.

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
--------------------------------------------------------
<?xml version="1.0"?>
 <ROW>
  <EMPLOYEE_ID>200</EMPLOYEE_ID>
  <FIRST_NAME>Jennifer</FIRST_NAME>
  <LAST_NAME>Whalen</LAST_NAME>
  <EMAIL>JWHALEN</EMAIL>
  <PHONE_NUMBER>515.123.4444</PHONE_NUMBER>
  <HIRE_DATE>17-SEP-87</HIRE_DATE>
  <JOB_ID>AD_ASST</JOB_ID>
  <SALARY>4400</SALARY>
  <MANAGER_ID>101</MANAGER_ID>
  <DEPARTMENT_ID>10</DEPARTMENT_ID>
 </ROW>

1 row selected.
```

Targeting a Column

You can target a specific column, using this syntax:

/database_schema/table/ROW[*predicate_expression*]/*column*

You can target a specific attribute of an object column, using this syntax:

/database_schema/table/ROW[*predicate_expression*]/*object_column/attribute*

You can target a specific object column whose attributes have specific values, using this syntax:

/database_schema/table/ROW[*predicate_expression_with_attributes*]/*object_column*

Example 20–8 Using a DBUri to Target a Specific Column

In this example, a DBUri targets column `last_name` for the same employee as in Example 20–7. The top-level XML element is named for the targeted column.

```
CREATE TABLE uri_tab (url URIType);
```

```
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI('/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
------------------------------
<?xml version="1.0"?>
 <LAST_NAME>Whalen</LAST_NAME>

1 row selected.
```

Example 20–9 Using a DBUri to Target an Object Column with Specific Attribute Values

In this example, a DBUri targets a `CUST_ADDRESS` object column containing city and postal code attributes with certain values. The top-level XML element is named for the column, and it contains child elements for each of the object attributes.

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
  (DBURIType.createURI(
     '/OE/CUSTOMERS/ROW[CUST_ADDRESS/CITY="Poughkeepsie" and
                        CUST_ADDRESS/POSTAL_CODE=12601]/CUST_ADDRESS'));
1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
---------------
<?xml version="1.0"?>
 <CUST_ADDRESS>
  <STREET_ADDRESS>33 Fulton St</STREET_ADDRESS>
  <POSTAL_CODE>12601</POSTAL_CODE>
  <CITY>Poughkeepsie</CITY>
  <STATE_PROVINCE>NY</STATE_PROVINCE>
  <COUNTRY_ID>US</COUNTRY_ID>
 </CUST_ADDRESS>

1 row selected.
```

The DBUri identifies the object that has a `CITY` attribute with `Poughkeepsie` as value and a `POSTAL_CODE` attribute with `12601` as value.

Retrieving the Text Value of a Column

In many cases, it can be useful to retrieve only the text values of a column and not the enclosing tags. For example, if XSLT style sheets are stored in a `CLOB` column, you can retrieve the document text without having any enclosing column-name tags. You can use the `text()` XPath node test for this. It specifies that you want only the text value of the node. Use the following syntax:

`/oradb/`*`database_schema`*`/`*`table`*`/ROW[`*`predicate_expression`*`]/`*`column`*`/`**`text()`**

Example 20–10 Using a DBUri to Retrieve Only the Text Value of a Node

This example retrieves the text value of the employee `last_name` column for employee number 200, without the XML tags.

```
CREATE TABLE uri_tab (url URIType);
Table created.

INSERT INTO uri_tab VALUES
       (DBURIType.createURI(
          '/HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME/text()'));

1 row created.

SELECT e.url.getCLOB() FROM uri_tab e;

E.URL.GETCLOB()
---------------
Whalen

1 row selected.
```

Targeting a Collection

You can target a database collection, such as an ordered collection table. You must, however, target the entire collection – you cannot target individual members of a collection. When a collection is targeted, the XML document produced by the DBUri contains each collection member as an XML element, with all such elements enclosed in a element named for the *type* of the collection.

Example 20–11 Using a DBUri to Target a Collection

In this example, a DBUri targets a collection of numbers. The top-level XML element is named for the collection, and its children are named for the collection *type* (`NUMBER`).

```
CREATE TYPE num_collection AS VARRAY(10) OF NUMBER;
/
Type created.

CREATE TABLE orders (item VARCHAR2(10), quantities num_collection);
Table created.

INSERT INTO orders VALUES ('boxes', num_collection(3, 7, 4, 9));
1 row created.

SELECT * FROM orders;

ITEM
----
QUANTITIES
----------
boxes
NUM_COLLECTION(3, 7, 4, 9)

1 row selected.

SELECT DBURIType('/HR/ORDERS/ROW[ITEM="boxes"]/QUANTITIES').getCLOB() FROM DUAL;

DBURITYPE('/HR/ORDERS/ROW[ITEM="BOXES"]/QUANTITIES').GETCLOB()
--------------------------------------------------------------
<?xml version="1.0"?>
```

```
 <QUANTITIES>
  <NUMBER>3</NUMBER>
  <NUMBER>7</NUMBER>
  <NUMBER>4</NUMBER>
  <NUMBER>9</NUMBER>
 </QUANTITIES>

1 row selected.
```

Creating New Subtypes of URIType using Package URIFACTORY

You can use PL/SQL package `URIFACTORY` to do more than create `URIType` instances. Additional methods are listed in Table 20–2.

Table 20–2 URIFACTORY Methods

Method	Description
`getURI()`	Returns the URL of the `URIType` instance.
`escapeURI()`	Escapes the URI string by replacing characters that are not permitted in URIs by their equivalent escape sequence.
`unescapeURI()`	Unescapes a given URI.
`registerURLHandler()`	Registers a particular type name for handling a particular URL. This is called by `getURI()` to generate an instance of the type. A Boolean argument can be used to indicate that the prefix must be stripped off before calling the appropriate type constructor.
`unregisterURLHandler()`	Unregisters a URL handler.

Of particular note is that you can use package `URIFACTORY` to define new subtypes of type `URIType`. You can then use those subtypes to provide specialized processing of URIs. In particular, you can define `URIType` subtypes that correspond to particular protocols – `URIFACTORY` will then recognize and process instances of those subtypes accordingly.

Defining new types and creating database columns specific to the new types has these advantages:

- It provides an implicit *constraint* on the columns to contain only instances of those types. This can be useful for implementing specialized indexes on a column for specific protocols. For a DBUri, for instance, you can implement specialized indexes that fetch data directly from disk blocks, rather than executing SQL queries.
- You can have different constraints on different columns, based on the type. For a HTTPUri, for instance, you can define proxy and firewall constraints on a column, so that any access through the HTTP uses the proxy server.

Registering New URIType Subtypes with Package URIFACTORY

To provide specialized processing of URIs, you define and register a new URIType subtype, as follows:

1. Create the new type using SQL statement `CREATE TYPE`. The type must implement method `createURI()`.
2. Optionally override the default methods, to perform specialized processing when retrieving data or to transform the XML data before displaying it.

3. Choose a new URI prefix, to identify URIs that use this specialized processing.
4. Register the new prefix using method `registerURLHandler()`, so that package `URIFACTORY` can create an instance of your new subtype when it receives a URI starting with the new prefix you defined.

After the new subtype is defined, a URI with the new prefix will be recognized by `URIFACTORY` methods, and you can create and use instances of the new type.

For example, suppose that you define a new protocol prefix, `ecom://`, and define a subtype of `URIType` to handle it. Perhaps the new subtype implements some special logic for method `getCLOB()`, or perhaps it makes some changes to XML tags or data in method `getXML()`. After you register prefix `ecom://` with `URIFACTORY`, a call to `getURI()` will generate an instance of the new `URIType` subtype for a URI with that prefix.

Example 20–12 URIFACTORY: Registering the ECOM Protocol

This example creates a new type, `ECOMURIType`, to handle a new protocol, `ecom://`. The example stores three different kinds of URIs in a single table: an HTTPUri, a DBUri, and an instance of the new type, `ECOMURIType`. To run this example, you would need to define each of the `ECOMURIType` member functions.

```
CREATE TABLE url_tab (urlcol varchar2(80));
Table created.

-- Insert an HTTP URL reference
INSERT INTO url_tab VALUES ('http://www.oracle.com/');
1 row created.

-- Insert a DBUri
INSERT INTO url_tab VALUES ('/oradb/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]');
1 row created.

-- Create a new type to handle a new protocol called ecom://
-- This is just an example template. For this to run, the implementations
-- of these functions needs to be specified.
CREATE OR REPLACE TYPE ECOMURIType UNDER SYS.URIType (
  OVERRIDING MEMBER FUNCTION getCLOB RETURN CLOB,
  OVERRIDING MEMBER FUNCTION getBLOB RETURN BLOB,
  OVERRIDING MEMBER FUNCTION getExternalURL RETURN VARCHAR2,
  OVERRIDING MEMBER FUNCTION getURI RETURN VARCHAR2,
  -- Must have this for registering with the URL handler
  STATIC FUNCTION createURI(url IN VARCHAR2) RETURN ECOMURIType);
/
-- Register a new handler for the ecom:// prefixes
BEGIN
  -- The handler type name is ECOMURIType; schema is HR
  -- Ignore the prefix case, so that URIFACTORY creates the same subtype
  -- for URIs beginning with ECOM://, ecom://, eCom://, and so on.
  -- Strip the prefix before calling method createURI(),
  -- so that the string 'ecom://' is not stored inside the
  -- ECOMURIType object. It is added back automatically when
  -- you call ECOMURIType.getURI().
  URIFACTORY.registerURLHandler (prefix => 'ecom://',
                                 schemaname => 'HR',
                                 typename => 'ECOMURITYPE',
                                 ignoreprefixcase => TRUE,
                                 stripprefix => TRUE);
END;
/
```

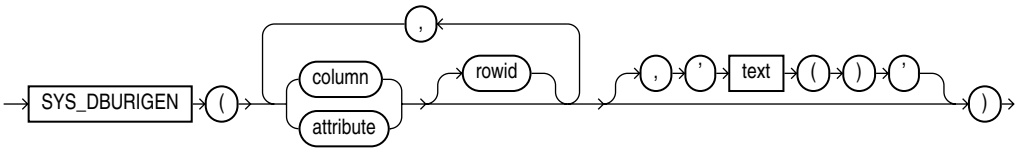
```
PL/SQL procedure successfully completed.

-- Insert this new type of URI into the table
INSERT INTO url_tab VALUES ('ECOM://company1/company2=22/comp');
1 row created.

-- Use the factory to generate an instance of the appropriate
-- subtype for each URI in the table.

-- You would need to define the member functions for this to work:
SELECT urifactory.getURI(urlcol) FROM url_tab;

-- This would generate:
HTTPURIType('www.oracle.com'); -- an HTTPUri
DBURIType('/oradb/HR/EMPLOYEES/ROW[FIRST_NAME="Jack"]', null); -- a DBUri
ECOMURIType('company1/company2=22/comp'); -- an ECOMURIType instance
```

SYS_DBURIGEN SQL Function

You can create a DBUri by providing an XPath expression to constructor `DBURIType` or to appropriate `URIFACTORY` methods. With SQL function `sys_DburiGen`, you can alternatively create a DBUri with an *XPath that is composed* from database columns and their values.

SQL function `sys_DburiGen` takes as its argument one or more database columns or attributes, and optionally a rowid, and generates a DBUri that targets a particular column or row object. Function `sys_DburiGen` takes an additional parameter that indicates whether the text value of the node is needed. See Figure 20–2.

Figure 20–2 SYS_DBURIGEN Syntax



All columns or attributes referenced must reside in the same table. They must each reference a unique value. If you specify multiple columns, then the initial columns identify the row, and the last column identifies the column within that row. If you do not specify a database schema, then the table name is interpreted as a public synonym.

See Also: *Oracle Database SQL Language Reference*

Example 20–13 SYS_DBURIGEN: Generating a DBUri that Targets a Column

This example uses SQL function `sys_DburiGen` to generate a DBUri that targets column `email` of table `hr.employees` where `employee_id` is `206`:

```
SELECT sys_DburiGen(employee_id, email)
  FROM employees
  WHERE employee_id = 206;

SYS_DBURIGEN(EMPLOYEE_ID,EMAIL)(URL, SPARE)
--------------------------------------------------------------------
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID = "206"]/EMAIL', NULL)

1 row selected.
```

Rules for Passing Columns or Object Attributes to SYS_DBURIGEN

A column or attribute passed to SQL function `sys_DburiGen` must obey the following rules:

- *Same table:* All columns referenced in function `sys_DburiGen` must come from the same table or view.
- *Unique mapping:* The column or object attribute must be uniquely mappable back to the table or view from which it came. The only virtual columns allowed are those produced with `value` or `ref`. The column can come from a subquery with SQL function `table` or from an inline view (as long as the inline view does not rename the columns).
- *Key columns:* Either the rowid or a set of key columns must be specified. The list of key columns is not required to be declared as a unique or primary key, as long as the columns uniquely identify a particular row in the result.
- **`PUBLIC`** *element:* If the table or view targeted by the rowid or key columns does not specify a database schema, then the `PUBLIC` keyword is used. When a DBUri is accessed, the table name resolves to the same table, synonym, or database view that was visible by that name when the DBUri was created.
- *Optional* **`text()`** *argument:* By default, `DBURIType` constructs an XML document. Use `text()` as the third argument to `sys_DburiGen` to create a DBUri that targets a text node (no XML elements). For example:

  ```
  SELECT sys_DburiGen(employee_id, last_name, 'text()') FROM hr.employees,
    WHERE employee_id=200;
  ```

  This will construct a DBUri with the following URI:

  ```
  /HR/EMPLOYEES/ROW[EMPLOYEE_ID=200]/LAST_NAME/text()
  ```

- *Single-column argument:* If there is a single-column argument, then the column is used as both the key column to identify the row and the referenced column.

Example 20–14 Passing Columns With Single Arguments to SYS_DBURIGEN

This query uses `employee_id` as both the key column and the referenced column. It generates a DBUri that targets the row with `employee_id` 200.

```
SELECT sys_DburiGen(employee_id) FROM employees
  WHERE employee_id=200;

SYS_DBURIGEN(EMPLOYEE_ID)(URL, SPARE)
-------------------------------------
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID=''200'']/EMPLOYEE_ID', NULL)

1 row selected.
```

SYS_DBURIGEN SQL Function: Examples

Example 20–15 Inserting Database References Using SYS_DBURIGEN

```
CREATE TABLE doc_list_tab(docno NUMBER PRIMARY KEY, doc_ref SYS.DBURIType);
Table created.

-- Insert a DBUri that targets the row with employee_id=177
INSERT INTO doc_list_tab VALUES(1001, (SELECT sys_DburiGen(rowid, employee_id)
                                         FROM employees WHERE employee_id=177));
```

```
1 row created.

-- Insert a DBUri that targets the last_name column of table employees
INSERT INTO doc_list_tab VALUES(1002,
                                (SELECT sys_DburiGen(employee_id, last_name)
                                   FROM employees WHERE employee_id=177));
1 row created.

SELECT * FROM doc_list_tab;

     DOCNO
----------
DOC_REF(URL, SPARE)
--------------------------------------------------
      1001
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[ROWID=''AAAL3LAAFAAAABSABN'']/EMPLOYEE_ID', NULL)

      1002
DBURITYPE('/PUBLIC/EMPLOYEES/ROW[EMPLOYEE_ID=''177'']/LAST_NAME', NULL)

2 rows selected.
```

Returning Partial Results

When selecting from a large column, you might sometimes want to retrieve only a portion of the result, and create a URL to the column instead. For example, consider the case of a travel story Web site. If travel stories are stored in a table, and users search for a set of relevant stories, then you do not want to list each entire story in the search-result page. Instead, you might show just the first 20 characters of each story, to represent the gist, and then return a URL to the full story. This can be done as follows:

Example 20–16 Returning a Portion of the Results By Creating a View and Using SYS_DBURIGEN

Assume that the travel story table is defined as follows:

```
CREATE TABLE travel_story (story_name VARCHAR2(100), story CLOB);
Table created.

INSERT INTO travel_story
  VALUES ('Egypt', 'This is the story of my time in Egypt....');
1 row created.
```

We create a function that returns only the first 20 characters from the story:

```
CREATE OR REPLACE FUNCTION charfunc(clobval IN CLOB) RETURN VARCHAR2 IS
  res VARCHAR2(20);
  amount NUMBER := 20;
BEGIN
  DBMS_LOB.read(clobval, amount, 1, res);
  RETURN res;
END;
/
Function created.
```

We next create a view that selects only the first twenty characters from the story, and returns a DBUri to the story column.

```
CREATE OR REPLACE VIEW travel_view AS
  SELECT story_name, charfunc(story) short_story,
         sys_DburiGen(story_name, story, 'text()') story_link
```

```
  FROM travel_story;
View created.

SELECT * FROM travel_view;

STORY_NAME
----------
SHORT_STORY
-----------
STORY_LINK(URL, SPARE)
----------------------
Egypt
This is the story of
DBURITYPE('/PUBLIC/TRAVEL_STORY/ROW[STORY_NAME=''Egypt'']/STORY/text()', NULL)

1 row selected.
```

RETURNING URLs to Inserted Objects

You can use SQL function `sys_DburiGen` in the `RETURNING` clause of DML statements to retrieve the URL of an object as it is inserted.

Example 20–17 Using SYS_DBURIGEN in the RETURNING Clause to Retrieve a URL

In this example, whenever a document is inserted into table `clob_tab`, its URL is inserted into table `uri_tab`. This is done using SQL function `sys_DburiGen` in the `RETURNING` clause of the `INSERT` statement.

```
CREATE TABLE clob_tab (docid NUMBER, doc CLOB);
Table created.
CREATE TABLE uri_tab (docs SYS.DBURIType);
Table created.
```

In PL/SQL, we specify the storage of the URL of the inserted document as part of the insertion operation, using the `RETURNING` clause and `EXECUTE IMMEDIATE`:

```
DECLARE
  ret SYS.DBURIType;
BEGIN
  -- execute the insert operation and get the URL
  EXECUTE IMMEDIATE
    'INSERT INTO clob_tab VALUES (1, ''TEMP CLOB TEST'')
       RETURNING sys_DburiGen(docid, doc, ''text()'') INTO :1'
    RETURNING INTO ret;
  -- Insert the URL into uri_tab
  INSERT INTO uri_tab VALUES (ret);
END;
/

SELECT e.docs.getURL() FROM hr.uri_tab e;
E.DOCS.GETURL()
------------------------------------------------
/ORADB/PUBLIC/CLOB_TAB/ROW[DOCID='1']/DOC/text()

1 row selected.
```

DBUriServlet

Oracle XML DB Repository resources can be retrieved using the HTTP server that is incorporated in Oracle XML DB. Oracle Database also includes a servlet,

DBUriServlet, that makes any kind of database data available through HTTP(S) URLs. The data can be returned as plain text, HTML, or XML.

A Web client or application can access such data without using SQL or a specialized database API. You can retrieve the data by linking to it on a Web page or by requesting it through HTTP-aware APIs of Java, PL/SQL, and Perl. You can display or process the data using an application such as a Web browser or an XML-aware spreadsheet. DBUriServlet can generate content that is XML data or not, and it can transform the result using XSLT style sheets.

You make database data Web-accessible by using a URI that is composed of a servlet address (URL) plus a DBUri URI that specifies which database data to retrieve. This is the syntax, where `http://server:port` is the URL of the servlet (server and port), and `/oradb/database_schema/table` is the DBUri URI (any DBUri URI can be used):

```
http://server:port/oradb/database_schema/table
```

When using XPath notation in a URL for the servlet, you might need to escape certain characters. You can use `URIType` method `getExternalURL()` to do this.

You can either use DBUriServlet, which is pre-installed as part of Oracle XML DB, or write your own servlet that runs on a servlet engine. The servlet reads the URI portion of the invoking URL, creates a DBUri using that URI, calls `URIType` methods to retrieve the data, and returns the values in a form such as a Web page, an XML document, or a plain-text document.

The MIME type to use is specified to the servlet through the URI:

- By default, the servlet produces MIME types `text/xml` and `text/plain`. If the DBUri path ends in `text()`, then `text/plain` is used; otherwise, an XML document is generated with MIME type `text/xml`.
- You can override the default MIME type, setting it to `binary/x-jpeg` or some other value, by using the `contenttype` argument to the servlet.

> **See Also:** Chapter 32, "Writing Oracle XML DB Applications in Java", for information about Oracle XML DB servlets

Example 20–18 Using a URL to Override the MIME Type

To retrieve the `employee_id` column of the `employee` table, you can use a URL such as one of the following, where computer *`server.oracle.com`* is running Oracle Database with a Web service listening to requests on port 8080. Step `oradb` is the virtual path that maps to the servlet.

```
-- Produces a content type of text/plain
http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C/text()

-- Produces a content type of text/xml
http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C
```

To override the content type, you can use a URL that passes `text/html` to the servlet as the `contenttype` parameter:

```
-- Produces a content type of text/html
http://server.oracle.com:8080/oradb/QUINE/A/ROW[B=200]/C?contenttype=text/html
```

Table 20–3 describes each of the optional URL parameters you can pass to DBUriServlet to customize its output.

Table 20–3 DBUriServlet: Optional Arguments

Argument	Description
rowsettag	Changes the default root tag name for the XML document. For example: http://*server*:8080/oradb/HR/EMPLOYEES**?rowsettag=OracleEmployees** This can also be used to put a tag around a URI that points to multiple rows. For example:
contenttype	Specifies the MIME type of the generated document. For example: http://*server*:8080/oradb/HR/EMPLOYEES**?contenttype=text/plain**
transform	Passes a URL to URIFACTORY, which retrieves the XSL style sheet at that location. This style sheet is then applied to the XML document being returned by the servlet. For example: http://*server*:8080/oradb/HR/EMPLOYEES**?transform=/oradb/QUINE/XSLS/DOC/text()**&contenttype=text/html

Customizing DBUriServlet

DBUriServlet is built into the database – to customize the servlet, you must edit the Oracle XML DB configuration file, xdbconfig.xml. You can edit it with database schema (user account) XDB, using WebDAV, FTP, Oracle Enterprise Manager, or PL/SQL. To update the file using FTP or WebDAV, download the document, edit it, and save it back into the database.

See Also:

- Chapter 32, "Writing Oracle XML DB Applications in Java"
- Chapter 34, "Administering Oracle XML DB"
- *Oracle Database 2 Day + Security Guide* for information about database schema XDB

DBUriServlet is installed at /oradb/*, which is the address specified in the servlet-pattern tag of xdbconfig.xml. The asterisk (*) is necessary to indicate that any path following oradb is to be mapped to the same servlet. oradb is published as the virtual path. You can change the path that will be used to access the servlet.

Example 20–19 Changing the Installation Location of DBUriServlet

In this example, the configuration file is modified to install DBUriServlet under /dburi/*.

```
DECLARE
  doc XMLType;
  doc2 XMLType;
BEGIN
  doc := DBMS_XDB.cfg_get();
  SELECT
    updateXML(doc,
'/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/
servlet-mappings/servlet-mapping[servlet-name="DBUriServlet"]/servlet-pattern/
text()',
              '/dburi/*')
    INTO doc2 FROM DUAL;
  DBMS_XDB.cfg_update(doc2);
  COMMIT;
END;
```

```
/
```

Security parameters, the servlet display-name, and the description can also be customized in configuration file `xdbconfig.xml`. The servlet can be removed by deleting its servlet-pattern. This can also be done using SQL function `updateXML` to update the servlet-mapping element to `NULL`.

DBUriServlet Security

Servlet security is handled by Oracle Database using roles. When users log in to the servlet, they use their database username and password. The servlet checks to ensure that the user logging has one of the roles specified in the configuration file using parameter `security-role-ref`). By default, the servlet is available to role `authenticatedUser`, and any user who logs into the servlet with a valid database password has this role.

The role parameter can be changed to restrict access to any specific database roles. To change from the default `authenticated-user` role to a role that you have created, you modify the Oracle XML DB configuration file.

Example 20–20 Restricting Servlet Access to a Database Role

This example changes the default `authenticated-user` role to role `servlet-users` (which it is assumed you have created).

```
DECLARE
  doc  XMLType;
  doc2 XMLType;
  doc3 XMLType;
BEGIN
  doc := DBMS_XDB.cfg_get();
  SELECT updateXML(doc,
'/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/
servlet-list/servlet[servlet-name="DBUriServlet"]/security-role-ref/role-name/
text()',
                   'servlet-users')
    INTO doc2 FROM DUAL;
  SELECT updateXML(doc2,
'/xdbconfig/sysconfig/protocolconfig/httpconfig/webappconfig/servletconfig/
servlet-list/servlet[servlet-name="DBUriServlet"]/security-role-ref/role-link/
text()',
                   'servlet-users')
    INTO doc3 FROM DUAL;
  DBMS_XDB.cfg_update(doc3);
  COMMIT;
END;
/
```

Configuring Package URIFACTORY to Handle DBUris

A URL such as `http://server/servlets/oradb` is handled by DBUriServlet (or by a custom servlet). When a URL such as this is stored as a `URIType` instance, it is generally desirable to use subtype `DBURIType`, since this URI targets database data.

However, if a `URIType` instance is created using methods of package `URIFACTORY` such as `getURI()`, then by default the subtype used is `HTTPURIType`, not `DBURIType`. This is because `URIFACTORY` looks only at the URI prefix, sees `http://`, and assumes that the URI targets a Web page. This results in unnecessary layers of communication and perhaps extra character conversions.

To make things more efficient, you can teach URIFACTORY that URIs of the given form represent database accesses and so should be realized as DBUris, not HTTPUris. You do this by registering a handler for this URI as a prefix, specifying DBURIType as the type of instance to generate.

Example 20–21 Registering a Handler for a DBUri Prefix

This example effectively tells URIFACTORY that any URI string starting with http://*server*/*servlets*/oradb corresponds to a database access.

```
BEGIN
  URIFACTORY.registerURLHandler('http://server/servlets/oradb',
                                'SYS', 'DBURIType', true, true);
END;
/
```

After you execute this code, all getURI() calls in the same session automatically create DBUris for any URI strings with prefix http://*server*/*servlets*/oradb.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about URIFACTORY functions

Part V

Oracle XML DB Repository

Part V of this manual describes Oracle XML DB repository. It includes how to version your data, implement and manage security, and how to use the associated Oracle XML DB APIs to access and manipulate repository data.

Part V contains the following chapters:

21

Accessing Oracle XML DB Repository Data

This chapter describes how to access data in Oracle XML DB Repository using standard protocols such as FTP and HTTP(S)/WebDAV, and other Oracle XML DB resource Application Program Interfaces (APIs). It also introduces you to using `RESOURCE_VIEW` and `PATH_VIEW` as the SQL mechanism for accessing and manipulating repository data. It includes a table for comparing repository operations through the various resource APIs.

This chapter contains these topics:

Overview of Oracle XML DB Foldering

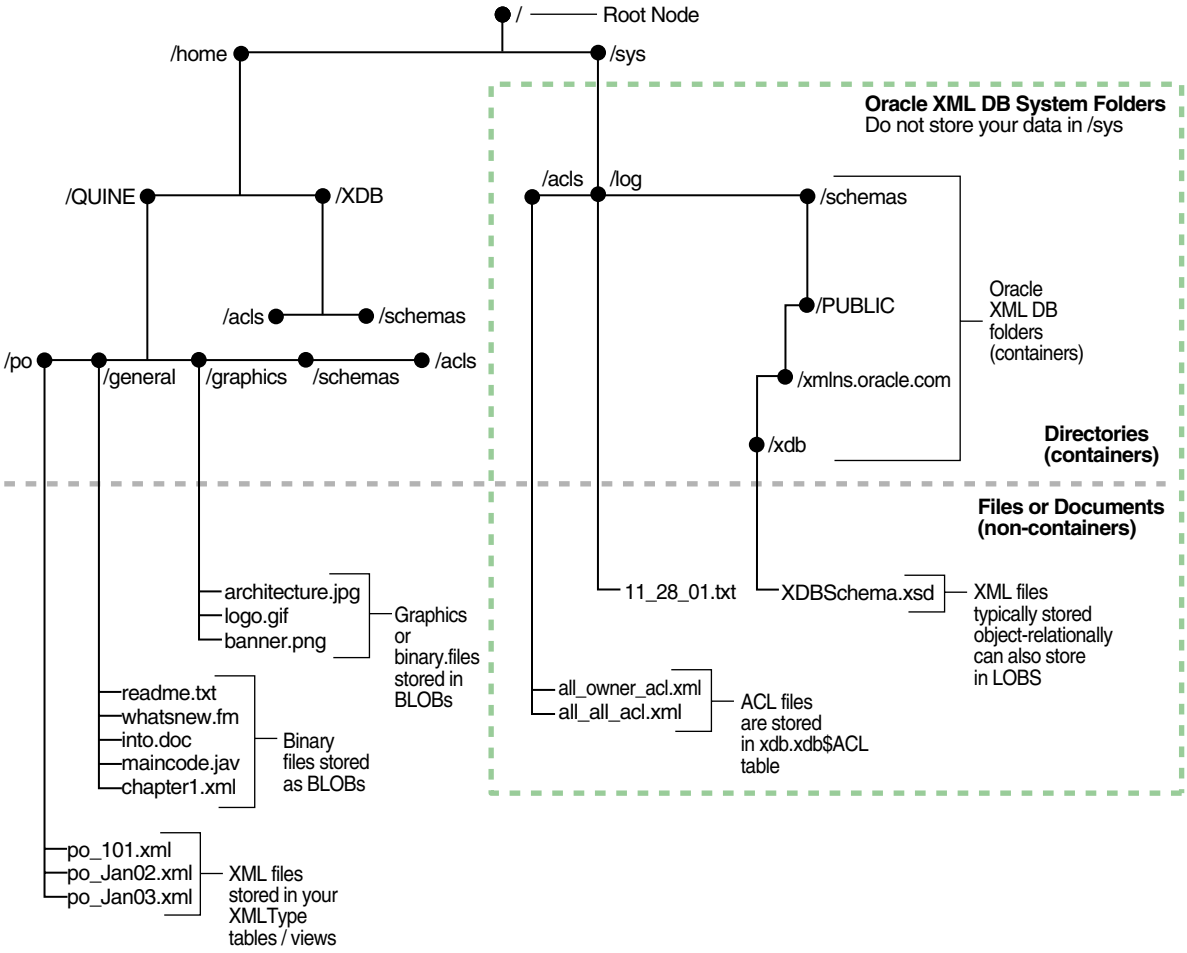
Using the foldering feature in Oracle XML DB you can store content in the database in hierarchical structures, as opposed to traditional relational database structures.

Figure 21–1 is an example of a hierarchical structure that shows a typical tree of folders and files in Oracle XML DB Repository. The top of the tree shows '/', the root folder.

Foldering lets applications access hierarchically indexed content in the database using the FTP, HTTP(S), and WebDAV protocol standards as if the database content were stored in a file system.

This chapter provides an overview of how to access data in Oracle XML DB Repository folders using the standard protocols. It discusses APIs that you can use to access the repository object hierarchy using Java, SQL, and PL/SQL.

Figure 21–1 A Folder Tree, Showing Hierarchical Structures in the Repository



Note: Folder `/sys` is used by Oracle XML DB to maintain *system-defined* XML schemas, access control lists (ACLs), and so on. Do *not* add or modify any data in folder `/sys`.

See Also:

- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 26, "Using PL/SQL to Access the Repository"
- Chapter 28, "Using Protocols to Access the Repository"

Repository Terminology and Supplied Resources

Oracle XML DB Repository is the set of database objects, across all XML and database schemas, that are mapped to path names. It is a connected, directed, acyclic[1] graph of resources, with a single root node (`/`). Each resource in the graph has one or more

[1] The graph is established by the hard links that define the repository structure, and cycles are not permitted using hard links. You can, however, introduce cycles using weak links. See "Hard Links and Weak Links" on page 21-7.

associated path names: the repository supports multiple links to a given resource. The repository can be thought of as a file system of objects rather than files.

Repository Terminology

The following list describes terms used in Oracle XML DB Repository:

- **resource** – Any object or node in the repository hierarchy. Resources are identified by URLs.

  See Also:

  "Overview of Oracle XML DB Repository" on page 1-7

  "Oracle XML DB Resources" on page 21-4

- **folder** – A resource that can contain other resources. Sometimes called a **directory**.
- **path name** – A hierarchical name representing an absolute path to a resource. It is composed of a slash (`/`) representing the repository root, followed by zero or more **path components** separated by slashes. A path component cannot be only `.` or `..`, but a period (`.`) can otherwise be used in a path component. A path component is composed of any characters in the database character set *except* slash (`/`), backslash (`\`), and those characters specified in the Oracle XML DB configuration file, `/xdbconfig.xml`, by configuration parameter `/xdbconfig/sysconfig/invalid-pathname-chars`.
- **resource name** (or **link name**) – The name of a resource within its parent folder. This is the rightmost path component of a path name. Resource names must be unique within their immediately containing folder, and they are case-sensitive.
- **resource content** – The body, or data, of a resource. This is what you get when you treat the resource as a file and ask for its content. This is always of type `XMLType`.
- **XDBBinary element** – An XML element that contains binary data. It is defined by the Oracle XML DB XML schema. `XDBBinary` elements are stored in the repository whenever unstructured binary data is uploaded into Oracle XML DB.
- **access control list** (ACL) – A set of principals (users or roles) that are allowed access to one or more specific resources.

  See Also: Chapter 27, "Repository Resource Security"

Many terms used by Oracle XML DB have common synonyms used in other contexts, as shown in Table 21–1.

Table 21–1 Synonyms for Oracle XML DB Foldering Terms

Synonym	Foldering Term	Usage
collection	folder	WebDAV
directory	folder	operating systems
privilege	privilege	permission
right	privilege	various
WebDAV folder	folder	Web folder
role	group	access control
revision	version	RCS, CVS
file system	repository	operating systems

Table 21–1 (Cont.) Synonyms for Oracle XML DB Foldering Terms

Synonym	Foldering Term	Usage
hierarchy	repository	various
file	resource	operating systems
binding	link	WebDAV

Supplied Files and Folders

The list of supplied Oracle XML DB Repository files and folders is as follows. In addition to using these, you can create your own folders and files wherever you want.

```
/public
/sys
/sys/acls
/sys/acls/all_all_acl.xml
/sys/acls/all_owner_acl.xml
/sys/acls/bootstrap_acl.xml
/sys/acls/ro_all_acl.xml
/sys/apps
/sys/asm
/sys/log
/sys/schemas
/sys/schemas/PUBLIC
/sys/schemas/PUBLIC/www.w3.org
/sys/schemas/PUBLIC/www.w3.org/2001
/sys/schemas/PUBLIC/www.w3.org/2001/xml.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBFolderListing.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResource.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBStandard.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/dav.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/ftplog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/httplog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/xdblog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/stats.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/xdbconfig.xsd
/xdbconfig.xml
```

Oracle XML DB Resources

Oracle XML DB Repository resources conform to the Oracle XML DB XML schema `XDBResource.xsd`. The elements in a resource include those needed to persistently store WebDAV-defined properties, such as creation date, modification date, WebDAV locks, owner, ACL, language, and character set.

> **See Also:** "XDBResource.xsd: XML Schema for Oracle XML DB Resources" on page A-1

Contents Element in Resource Index

A resource index has a special element called **`Contents`** that contains the contents of the resource.

any Element

The XML schema for a resource also defines an **`any`** element, with `maxoccurs` attribute unbounded. An `any` element can contain any element outside of the Oracle XML DB XML namespace. Arbitrary instance-defined properties can be associated with the resource.

Where Is Repository Data Stored?

Oracle XML DB stores Oracle XML DB Repository data in a set of tables and indexes to which you have access. If you register an XML schema and request that the tables be generated by Oracle XML DB, then the tables are created in your database schema. You are then able to see or modify them. Other users will not be able to see your tables unless you grant them permission to do so.

Names of Generated Tables

The names of the generated tables are assigned by Oracle XML DB, and can be obtained by finding the `xdb:defaultTable` attribute in your XML schema document (or in the default XML schema document). When you register an XML schema, you can alternatively provide your own table name, instead of using the default name supplied by Oracle XML DB. If the table specifies binary XML storage, then a document is encoded in binary XML format before storing it in the table.

> **See Also:** "Default Tables Created During XML Schema Registration" on page 6-10

Defining Structured Storage for Resources

Applications that need to define structured storage for resources can do so in one of these ways:

- Subclass the Oracle XML DB resource type. Subclassing Oracle XML DB resources requires privileges on the table `XDB$RESOURCE`.
- Store data that conforms to a visible, registered XML schema.

> **See Also:** Chapter 6, "XML Schema Storage and Query: Basic"

ASM Virtual Folder

The ASM virtual folder, `/sys/asm`, is an exception to the description of the previous sections: its contents are ASM files and folders that are managed automatically by Oracle Automatic Storage Management (ASM).

> **See Also:**
>
> - "Accessing ASM Files Using Protocols and Resource APIs – For DBAs" on page 21-12
> - *Oracle Database Storage Administrator's Guide*

Path-Name Resolution

The data relating a folder to its contents is managed by the Oracle XML DB hierarchical repository index. This provides a fast mechanism for evaluating path names, similar to the directory mechanisms used by operating-system file systems.

Resources that are folders have the `Container` attribute set to `TRUE`.

To resolve a resource name in a folder, the current user must have the following privileges:

- `resolve` privilege on the folder
- `read-properties` on the resource in that folder

If the user does not have these privileges, then the user receives an `access denied` error. Folder listings and other queries will not return a row when the `read-properties` privilege is denied on its resource.

Caution: Error handling in path-name resolution differentiates between invalid resource names and resources that are not folders, for compatibility with file systems. Because Oracle XML DB resources are accessible from outside Oracle XML DB Repository (using SQL), denying read access on a folder that contains a resource does *not prevent* read access to that resource.

Managing and Controlling Access to Resources

You can control access to particular Oracle XML DB resources, both folders and files.

See Also:

- Chapter 27, "Repository Resource Security" for more detail on using access control on Oracle XML DB folders
- *Oracle Database PL/SQL Packages and Types Reference*

Link Types

Links in Oracle XML DB can be repository links or document links. Repository links can be hard links or weak links. Document links can also be hard links or weak links, when their targets are repository resources. These terms are explained further in the following sections.

Repository and Document Links

In addition to containing resources, a folder resource can contain links to other resources (files or folders). These **repository links**, sometimes called **folder links**, are not to be confused with **document links**, which correspond to the links provided by the XLink and XInclude standards, and which are also supported by Oracle XML DB. Repository links are navigational, folder–child links among repository resources; document links are arbitrary links among documents that are not necessarily repository resources.

Repository links represent repository hierarchical relationships; document links represent arbitrary relationships whose semantics derive from the applications that use them. Because they represent repository hierarchical relationships, repository links can be navigated using file system-related protocols; this is not true of document links. Because document links can represent arbitrary relationships, they can also represent repository relationships. When document links thus target resources, they can also be hard or weak.

See Also: Chapter 23, "Using XLink and XInclude With Oracle XML DB" for information about document links

Hard Links and Weak Links

Links that target repository resources can be **hard links** or **weak links**. Both hard and weak links are references, or pointers, to physical data—(internal) repository resource identifiers; they do not point to symbolic names or paths to other links. Their targets are resolved at the time of link creation. Because they point directly to resource identifiers, hard and weak links cannot dangle: they remain valid even when their targets are renamed or moved. You need the same privileges to create or delete hard and weak links.

The difference between hard and weak links lies in their relationship to target resource deletion. A target resource is dependent on its hard links, in the sense that it cannot be deleted as long as it remains the target of a hard link. Deletion of a hard link also deletes the resource targeted by the link, if the following are both true:

- The resource is not versioned.
- The hard link that was deleted was the last (that is, the only) hard link to the resource.

A weak link has no such hold on a resource: you can delete a resource, even if it is the target of a weak link (as long as it is not the target of a hard link). Because of this, weak links can be used as shortcuts to frequently accessed resources, without impacting deletion of those resources.

There is a dependency in the other direction, however: If you delete a resource that is the target of one or more weak links, then those links are automatically deleted, as well. In this sense, too, weak links cannot dangle. Both hard and weak links provide referential integrity: if a link exists, then so does its target.

Another difference between hard and weak links is this: Hard links to ancestor folders are not permitted, because they introduce cycles. There is no such restriction for weak links: a weak link can target any folder, possibly creating a cycle. It is the set of hard links that define the (acyclic) structure of Oracle XML DB Repository. Weak links represent an additional mapping on top of that basic structure.

You can query the repository path view, `PATH_VIEW`, to determine the type of a repository link: the link information contains the link type. `XMLType` column `LINK` of `PATH_VIEW` contains this information in element `LinkType`, which is a child of the root element, `LINK`. Example 21–1 illustrates this. You can also determine the type of a repository link by using the `getLink()` callback function on an event handler (`LinkIn`, `LinkTo`, `UnlinkIn`, or `UnlinkFrom`).

Example 21–1 Querying PATH_VIEW to Determine Link Type

```
SELECT RESID, extractValue(LINK, '/LINK/LinkType') link_type
  FROM PATH_VIEW WHERE equals_path(RES, '/home/QUINE/purchaseOrder.xml') = 1;

RESID                            LINK_TYPE
-------------------------------- ---------
DF9856CF2FE0829EE030578CCE0639C5 Weak
```

See Also:

- "Deleting Repository Resources: Examples" on page 25-14
- "Query-Based Access" on page 21-13 for information about `PATH_VIEW`
- Chapter 30, "Oracle XML DB Repository Events" for information on method `getLink()`

Creating a Weak Link Without Knowledge of Folder Hierarchy

Suppose that you want to read a file resource that belongs to one of your colleagues. You cannot create a hard link to that resource, to make it accessible for your use, unless you have the privilege `<xdb:resolve>` on *all* of the ancestor folders of that file. Having that privilege would mean that you could see all of your colleague's folder names and the structure of the hierarchy down to the target resource.

However, because weak links represent, essentially, a mapping on top of the real repository structure, which structure is determined by the set of hard links, you can create a weak link to a resource using just its OID, rather than its full, named path (URL). This means that your colleague can determine the OID path to the file, send you that instead of the named path, and you can create a weak link to the document using that OID path. Example 21–2 and Example 21–3 illustrate this.

Example 21–2 Obtaining the OID Path of a Resource

This example prints the OID path for the file resource `/home/QUINE/purchaseOrder.xml`. User `quine` can use this to obtain the OID path to the resource, and then send that path to user `curry`, who can create a weak link to the resource (Example 21–3).

```
DECLARE
  resoid  RAW(16);
  oidpath VARCHAR2(100);
BEGIN
  SELECT RESID INTO :resoid FROM RESOURCE_VIEW
    WHERE equals_path(RES, '/home/QUINE/purchaseOrder.xml') = 1;
    oidpath := DBMS_XDB.createOIDPath(resoid)
  DBMS_OUTPUT.put_line(oidpath);
END;
```

Example 21–3 Creating a Weak Link Using an OID Path

Here, user `curry` creates a weak link named `quinePurchaseOrder.xml` in folder `/home/CURRY`. The target of the link is the OID path that corresponds to the URL `/home/QUINE/purchaseOrder.xml` (Example 21–3). User `curry` need not be aware of the repository structure that is visible to user `quine`.

```
CALL DBMS_XDB.Link(/sys/oid/1BDCB46477B59C20E040578CCE0623D3
                   '/home/CURRY', 'quinePurchaseOrder.xml',
                   DBMS_XDB.LINK_TYPE_WEAK);
```

Restricting Multiple Hard Links

Sometimes, it is useful to restrict the creation of hard links, disallowing multiple hard links to folders or files (or both). In particular, allowing multiple hard links to file resources, but disallowing multiple hard links to folder resources, provides behavior that is similar to that for some file systems, including Unix and Linux. This can simplify application design, by, in effect, ensuring that each file resource has a unique, canonical hard-link path to it. In addition, preventing multiple hard links to a resource can lead to query performance improvements.

You can configure the prevention of multiple hard links using the following Boolean parameters in configuration file `xdbconfig.xml`. The default value of each parameter is `true`, meaning that multiple hard links can be created.

- `folder-hard-links` – Prevent the creation of multiple hard links to a folder resource, if `false`.

- `non-folder-hard-links` – Prevent the creation of multiple hard links to a file resource, if `false`.

  See Also: "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5

Accessing Oracle XML DB Repository Resources

There are two ways to access Oracle XML DB Repository resources:

- Navigational or path-based access. This uses a hierarchical index of resources. Each resource has one or more unique path names that reflect its location in the hierarchy. You can navigate, using XPath expressions, to any repository resource.

  A repository resource can be physically present in the repository, or it can be created as a reference to an existing `XMLType` object in the database. In particular, this means that you can navigate to any such database object using XPath. See *"Navigational or Path Access"* on page 21-9.

- SQL access to the repository. This is done using special views that expose resource properties and path names, and map hierarchical access operators onto the Oracle XML DB schema. See *"Query-Based Access" on page 21-13*.

  See Also:

  - "How Structured Is Your Data?" on page 2-4 for guidance on selecting an access method
  - Table 21–3, " Accessing Oracle XML DB Repository: API Options" for a summary comparison of the access methods

A Uniform Resource Locator (URL) is used to access an Oracle XML DB resource. A URL includes the host name, protocol information, path name, and resource name of the object.

Navigational or Path Access

Oracle XML DB Repository folders support the same protocol standards used by many operating systems. This lets a repository folder act like a native folder (directory) in supported operating-system environments. For example, you can:

- Use Windows Explorer to open and access Oracle XML DB folders and resources the same way you access other directories or resources in the Windows NT file system, as shown in Figure 21–2.
- Access Oracle XML DB Repository data using HTTP(S)/WebDAV from an Internet Explorer browser, such as when viewing Web Folders, as shown in Figure 21–3. Figure 21–3 shows a Web browser visiting URL `http://xdbdemo:8080/`: the server it is connected to is `xdbdemo`, and its HTTP port number is `8080`.

  See Also: "Configuring Protocol Server Parameters" on page 28-3 for information about configuring the HTTP port number

Figure 21–2 Oracle XML DB Folders in Windows Explorer

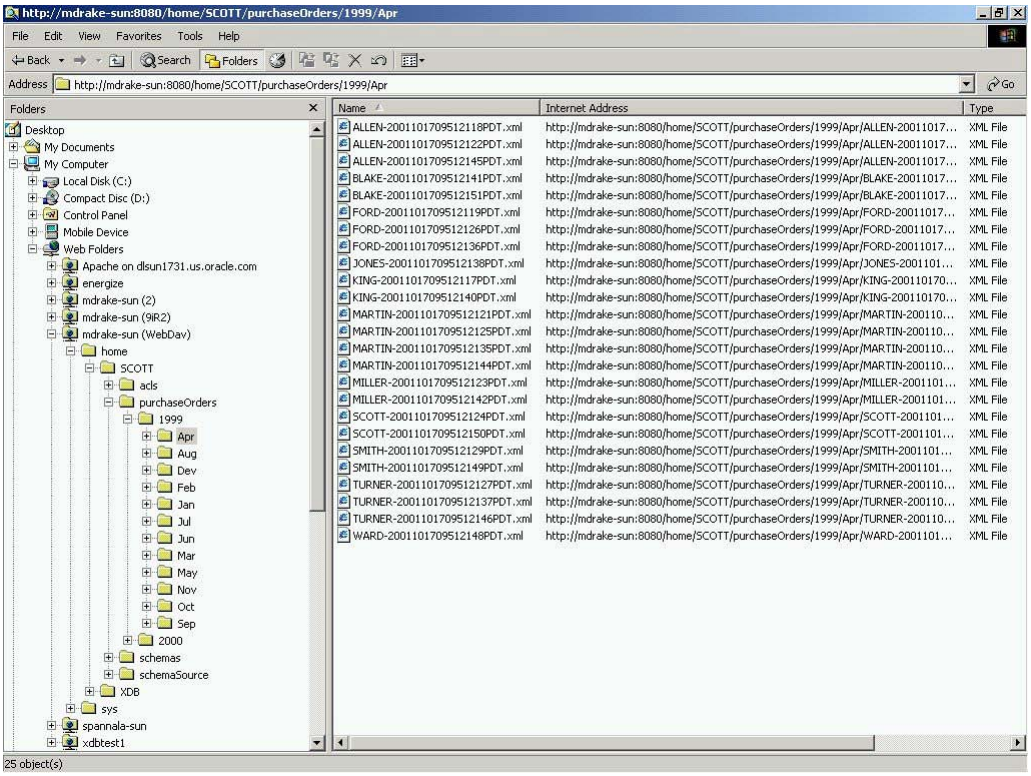
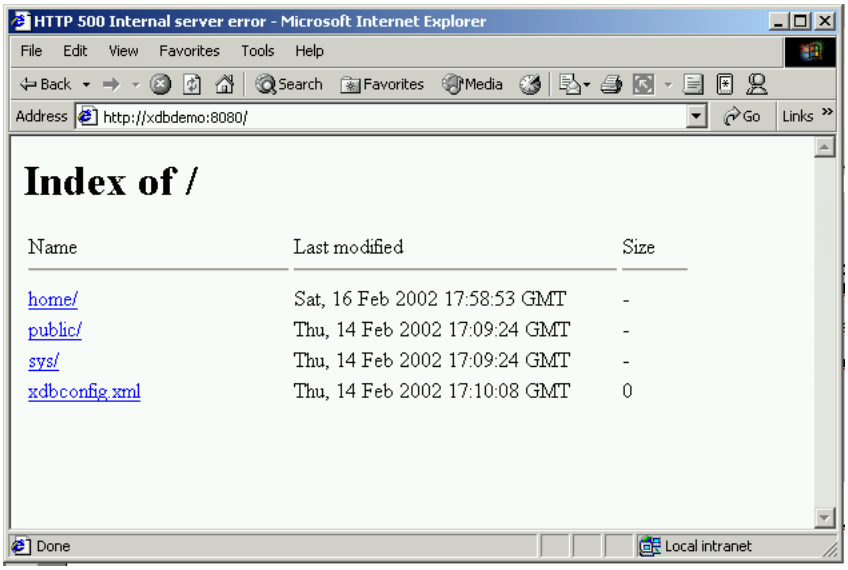


Figure 21–3 Accessing Repository Data Using HTTP(S)/WebDAV and Navigational Access From IE Browser: Viewing Web Folders



Accessing Oracle XML DB Resources Using Internet Protocols

Oracle Net Services provides one way of accessing database resources. Oracle XML DB support for Internet protocols provides another way of accessing database resources.

Where You Can Use Oracle XML DB Protocol Access

Oracle Net Services is optimized for record-oriented data. Internet protocols are designed for stream-oriented data, such as binary files or XML text documents. Oracle XML DB protocol access is a valuable alternative to Net Services in the following scenarios:

- Direct database access from file-oriented applications using the database like a file system
- Heterogeneous application server environments that require a uniform data access method (such as XML over HTTP, which is supported by most data servers, including MS SQL Server, Exchange, Notes, many XML databases, stock quote services and news feeds)
- Application server environments that require data in the form of XML text
- Web applications that use client-side XSL to format datagrams that do not need much application processing
- Web applications that use Java servlets that run inside the database
- Web access to XML-oriented stored procedures

Using Protocol Access

Accessing Oracle XML DB using a protocol proceeds as follows:

1. A connection object is established, and the protocol might read part of the request.
2. The protocol decides whether the user is already authenticated and wants to reuse an existing session or the connection must be re-authenticated (the latter is more common).
3. An existing session is pulled from the session pool, or else a new one is created.
4. If authentication has not been provided, and the request is HTTP `get` or `head`, then the session is run as the `ANONYMOUS` user. If the session has already been authenticated as the `ANONYMOUS` user, then there is no cost to reuse the existing session. If authentication has been provided, then the database re-authentication routines are used to authenticate the connection.
5. The request is parsed.
6. (HTTP only) If the requested path name maps to a servlet, then the servlet is invoked using Java Virtual Machine (VM). The servlet code writes the response to a response stream or asks `XMLType` instances to do so.

Retrieving Oracle XML DB Resources

When the protocol indicates that a resource is to be retrieved, the path name to the resource is resolved. Resources being fetched are always streamed out as XML, with the exception of resources containing the `XDBBinary` element, an element defined to be the XML binary data type, which have their contents streamed out in RAW form.

Storing Oracle XML DB Resources

When the protocol indicates that a resource must be stored, Oracle XML DB checks the document file name extension for `.xml`, `.xsl`, `.xsd`, and so on. If the document is XML, then a pre-parse step is done, whereby enough of the resource is read to determine the XML `schemaLocation` and `namespace` of the root element in the document. If a registered schema is located at the `schemaLocation` URL, and it has a

definition for the root element of the current document, then the default table specified for that root element is used to store the contents of the resource.

Using Internet Protocols and XMLType: XMLType Direct Stream Write

Oracle XML DB supports Internet protocols at the `XMLType` level by using the `writeToStream()` Java method on `XMLType`. This method is natively implemented, and writes `XMLType` data directly to the protocol request stream. This avoids Java VM execution costs and the overhead of converting database data through Java data types and creating Java objects, resulting in significantly higher performance. Performance is further enhanced if the Java code deals only with XML element trees that are close to the root, and does not traverse too many of the leaf elements, so that relatively few Java objects are created.

See Also: Chapter 28, "Using Protocols to Access the Repository"

Accessing ASM Files Using Protocols and Resource APIs – For DBAs

Automatic Storage Management (ASM) organizes database files into *disk groups* for simplified management and added benefits such as database mirroring and I/O balancing.

Repository access using protocols and resource APIs (such as `DBMS_XDB`) extends to Automatic Storage Management (ASM) files. ASM files are accessed in the *virtual* repository folder `/sys/asm`. However, this access is reserved for DBAs; it is *not* intended for developers.

A typical use of such access is to copy ASM files from one database instance to another. For example, a DBA can view folder `/sys/asm` in a graphical user interface using the WebDAV protocol, and then drag-and-drop a copy of a data-pump dump set from an ASM disk group to an operating-system file system.

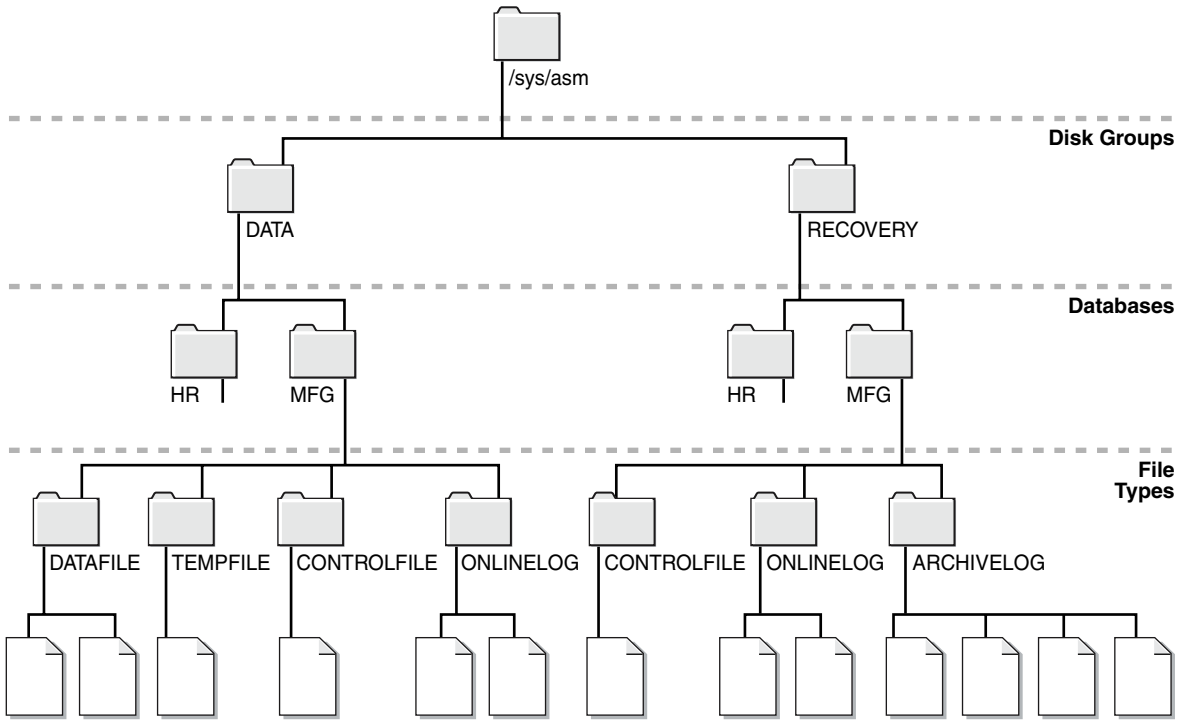
Virtual folder `/sys/asm` is created by default during Oracle XML DB installation. If the database is not configured to use ASM, the folder is empty and no operations are permitted on it.

Folder `/sys/asm` contains folders and subfolders that follow the hierarchy defined by the structure of an ASM *fully qualified filename*:

- It contains a subfolder for each mounted *disk group*.
- A disk-group folder contains a subfolder for each *database* that uses that disk group. In addition, a disk-group folder may contain files and folders corresponding to ASM *aliases* created by the administrator.
- A database folder contains file-type folders.
- A file-type folder contains ASM files, which are binary.

This hierarchy is shown in Figure 21–4, which omits directories created for aliases, for simplicity.

Figure 21–4 ASM Virtual Folder Hierarchy



The following usage restrictions apply to virtual folder `/sys/asm`. You *cannot*:

- *query* `/sys/asm` using SQL
- put regular files under `/sys/asm` (you can put only ASM files there)
- *move* (rename) an ASM file to a different ASM disk group or to a folder outside ASM
- create *hard links* to existing ASM files or directories

In addition:

- You must have DBA privileges to view folder `/sys/asm`.
- To access `/sys/asm` using Oracle XML DB protocols, you must log in as a user other than `SYS`.

Again, ASM virtual-folder operations are intended only for *DBAs*, not developers.

See Also:

- "Using FTP with ASM Files" on page 28-11 for an example of using protocol FTP with `/sys/asm`
- *Oracle Database Administrator's Guide* for information about the syntax of a fully qualified ASM filename and details on the virtual folder structure

Query-Based Access

There are two views that enable SQL access to Oracle XML DB Repository data:

- `PATH_VIEW`
- `RESOURCE_VIEW`

Table 21–2 summarizes the differences between PATH_VIEW and RESOURCE_VIEW.

Table 21–2 Differences Between PATH_VIEW and RESOURCE_VIEW

PATH_VIEW	RESOURCE_VIEW
Contains link properties	No link properties
Has one row for each unique *path* in repository	Has one row for each *resource* in repository

Rows in these two repository views are of XMLType. In the RESOURCE_VIEW, the single path associated with a resource is arbitrarily chosen from among the possible paths that refer to the resource. Oracle XML DB provides SQL functions like under_path that enable applications to search for the resources contained (recursively) within a particular folder, obtain the resource depth, and so on.

DML can be used on the repository views to insert, rename, delete, and update resource properties and contents. Programmatic APIs must be used for other operations, such as creating links to existing resources.

See Also:

- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW" for details on SQL access to Oracle XML DB Repository
- Chapter 27, "Repository Resource Security"

Accessing Repository Data Using Servlets

Oracle XML DB implements Java Servlet API, version 2.2, with the following exceptions:

- All servlets must be distributable. They must expect to run in different virtual machines.
- WAR and web.xml files are not supported. Oracle XML DB supports a subset of the XML configurations in this file. An XSL style sheet can be applied to the web.xml to generate servlet definitions. An external tool must be used to create database roles for those defined in the web.xml file.
- JSP (Java Server Pages) support can be installed as a servlet and configured manually.
- HTTPSession and related classes are not supported.
- Only one servlet context (that is, one Web application) is supported.

See Also: Chapter 32, "Writing Oracle XML DB Applications in Java"

Accessing Data Stored in Repository Resources

The main ways you can access data stored in Oracle XML DB Repository resources are through:

- Oracle XML DB resource APIs for Java
- A combination of Oracle XML DB resource views API and Oracle XML DB resource API for PL/SQL
- Internet protocols (HTTP(S)/WebDAV and FTP) and Oracle XML DB protocol server

- Oracle XML DB Content Connector and, through it, the standard Content Repository API for Java (JCR).

Various access methods can be used equivalently; it does not matter how you add content to the repository or retrieve it from there. For example, you can add content to the repository using SQL or PL/SQL and then retrieve it using an Internet protocol,or the other way around.

Table 21–3 lists common Oracle XML DB Repository operations, and describes how these operations can be accomplished using each of several access methods. The table shows functionality common to the different methods, but not all of the methods are equally suited to any particular task. Unless mentioned otherwise, "resource" in this table can be either a file resource or a folder resource.

Table 21–3 also shows the resource privileges that are required for each operation. In addition to the privileges listed in the table, privilege `xdb:read-properties` is required on each resource affected by an operation. Operations that affect the parent folder of a resource, in addition to the resource targeted by the operation, also require privilege `xdb:read-properties` on that parent folder. For example, deleting a resource affects both the resource to delete and its parent folder, so you need privilege `xdb:read-properties` on both the resource and its parent folder.

Table 21–3 Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support

Create resource	`DBMS_XDB.createResource()`
	`INSERT INTO PATH_VIEW`
	`  VALUES (path, res, linkprop);`
		HTTP: `PUT;`
		FTP: `PUT`
			`dav:bind` on parent folder	Yes

Update resource contents	`UPDATE RESOURCE_VIEW`
	`  SET RES =`
	`  updateXML(`
	`  res,`
	`  '/Resource/Contents', lob)`
	`  WHERE equals_path(res, path) > 0`
		HTTP: `PUT;`
		FTP: `PUT`
			`xdb:write-content` on resource	Yes

Update resource properties	`UPDATE RESOURCE_VIEW`
	`  SET RES =`
	`  updateXML(`
	`  res, '/Resource/propname1',`
	`  newval,`
	`  '/Resource/propname2' ...)`
	`  WHERE equals_path(res, path) > 0`
		WebDAV: `PROPPATCH;`	`dav:write-properties` on resource	Yes

Update resource ACL	`UPDATE RESOURCE_VIEW`
	`  SET RES =`
	`  updateXML(`
	`  res,`
	`  '/ Resource/ACL', XMLType)`
	`  WHERE equals_path(res, path) > 0`
		not applicable	`dav:write-acl` on resource	No

Unlink resource (delete if last link)	`DBMS_XDB.deleteResource()`
	`DELETE FROM RESOURCE_VIEW`
	`  WHERE equals_path(res, path) > 0`
		HTTP: `DELETE;`
		FTP: `delete`
			`dav:unbind` on parent folder
			`xdb:unlink-from` on resource
				Yes

Forcibly remove all links to resource	`DBMS_XDB.deleteResource()`
	`DELETE FROM PATH_VIEW`
	`  WHERE`
	`  extractValue(res,`
	`  'display_name')`
	`  = 'My resource'`
		FTP: `quote rm_rf` *`resource`*	`dav:unbind` on all parent folders
			`xdb:unlink-from` on resource
				Yes

Table 21–3 (Cont.) Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support
Move resource	`UPDATE PATH_VIEW SET path = newpath WHERE equals_path(res, path) > 0`	WebDAV: `MOVE`; FTP: `rename`	`dav:unbind` on source parent folder `dav:bind` on target parent folder `xdb:unlink-from` and `xdb:link-to` on resource	Yes
Copy resource	`INSERT INTO PATH_VIEW SELECT newpath, res, link FROM PATH_VIEW WHERE equals_path(res, oldpath) > 0`	WebDAV: `COPY`;	▪ Copy to new: `dav:bind` on target parent folder `dav:read` on resource ▪ Copy to existing (replacement): `dav:read` on resource `dav:write-properties` and `dav:write-content` on existing target resource	Yes
Create hard link to existing resource	`DBMS_XDB.link( srcpath IN VARCHAR2, linkfolder IN VARCHAR2, linkname IN VARCHAR2);`	N/A	`dav:bind` on parent folder `xdb:link-to` on resource	No
Create weak link to existing resource	`DBMS_XDB.link( srcpath IN VARCHAR2, linkfolder IN VARCHAR2, linkname IN VARCHAR2, DBMS_XDB.LINK_TYPE_WEAK);`	N/A	`dav:bind` on parent folder `xdb:link-to` on resource	No
Change owner of resource	`UPDATE RESOURCE_VIEW SET RES = updateXML( RES, '/Resource/Owner/text()', 'new_owner') WHERE equals_path(res,path) > 0`	N/A	`dav:take-ownership` on resource	Yes
Get binary or text representation of resource contents	`SELECT XDBURIType(path).getBLOB() FROM DUAL;` `SELECT p.res.extract( '/Resource/Contents') FROM RESOURCE_VIEW p WHERE equals_path(res, path) > 0`	HTTP: `GET`; FTP: `get`	`xdb:read-contents` on resource	Yes
Get `XMLType` representation of resource contents	`SELECT XDBURIType(path).getBLOB().getXML FROM DUAL;` `SELECT extract( res, '/Resource/Contents/*') FROM RESOURCE_VIEW p WHERE equals_path(Res, path) > 0`	not applicable	`xdb:read-contents` on resource	No
Get resource properties	`SELECT extractValue( res, '/Resource/XXX') FROM RESOURCE_VIEW WHERE equals_path(res, path) > 0`	WebDAV: `PROPFIND (depth = 0);`	`xdb:read-properties` on resource	Yes
List resources in folder	`SELECT PATH FROM PATH_VIEW WHERE under_path(res, path, 1) > 0`	WebDAV: `PROPFIND (depth = 0);`	`xdb:read-contents` on folder	Yes

Table 21–3 (Cont.) Accessing Oracle XML DB Repository: API Options

Data Access	SQL and PL/SQL	Protocols	Resource Privileges Required	JCR Support
Create folder	`Call DBMS_ XDB.createFolder(VARCHAR2)`	WebDAV: `MKCOL;` FTP: `mkdir`	`dav:bind` on parent folder	Yes
Unlink folder	`DBMS_XDB.deleteResource()` `DELETE FROM PATH_VIEW WHERE equals_path(res, path) > 0;`	HTTP: `DELETE;` FTP: `rmdir`	`dav:unbind` on parent folder `xdb:unlink-from` on resource	Yes
Forcibly delete folder and all links to it	`DBMS_XDB.deleteResource(VARCHAR2);`	not applicable	`dav:unbind` on all parent folders `xdb:unlink-from` on folder resource	Yes
Get resource with a row lock	`SELECT ... FROM RESOURCE_VIEW FOR UPDATE ...;`	not applicable	`xdb:read-properties` and `xdb:read-contents` on resource	No
Add WebDAV lock on resource	`DBMS_XDB.LockResource( path, true, true);`	WebDAV: `LOCK;` FTP: `quote lock`	`dav:write-properties` on resource	No
Remove WebDAV lock	`BEGIN DBMS_XDB.GetLockToken( path, deltoken); DBMS_XDB.UnlockToken( path, deltoken); END;`	WebDAV: `UNLOCK;` FTP: `quote unlock`	`dav:write-properties` and `dav:unlock` on resource	No
Check out file resource	`DBMS_XDB_VERSION.checkOut`	not applicable	`dav:write-properties` on resource	No
Check in file resource	`DBMS_XDB_VERSION.checkIn`	not applicable	`dav:write-properties` on resource	No
Uncheck out file resource	`DBMS_XDB_VERSION.unCheckOut`	not applicable	`dav:write-properties` on resource	No
Make file resource versioned	`DBMS_XDB_VERSION.makeVersioned`	not applicable	`dav:write-properties` on resource	No
Remove an event handler	`DBMS_XEVENT.remove`	not applicable	`xdb:write-config` on resource or parent folder (depending on the context)	No
Commit changes	`COMMIT;`	Automatic commit after each request	not applicable	Yes
Rollback changes	`ROLLBACK;`	not applicable	not applicable	Yes

See Also:

- Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW"
- Chapter 26, "Using PL/SQL to Access the Repository"
- Chapter 28, "Using Protocols to Access the Repository"
- Chapter 31, "Using Oracle XML DB Content Connector"
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDB`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDB_VERSION`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XEVENT`

Managing and Controlling Access to Resources

You can set access control privileges on Oracle XML DB folders and resources.

See Also:

- Chapter 27, "Repository Resource Security" for more detail on using access control on Oracle XML DB folders
- *Oracle Database PL/SQL Packages and Types Reference*

22

Configuring Oracle XML DB Repository

This chapter describes how to configure Oracle XML DB Repository. It contains these topics:

- Resource Configuration Files Configure a Resource
- Configuring a Resource
- Common Configuration Parameters

This chapter describes general configuration that applies to all repository resources. It does not describe configuration parameters for specific uses of resources. In particular, it does not describe configuration parameters for handling events or managing XLink and XInclude processing.

See Also:

- "Configuring Repository Events" on page 30-8
- Configuring Resources for XLink and XInclude on page 23-9
- XDBResource.xsd: XML Schema for Oracle XML DB Resources on page A-1
- XDBResConfig.xsd: XML Schema for Resource Configuration on page A-9

Resource Configuration Files Configure a Resource

Resource configuration is a general mechanism that you can use for events, mime-type mappings, servlet parameters, XLink and XInclude processing, default ACL specifications, and more.

You configure a Oracle XML DB Repository resource for any purpose by associating it with a resource configuration file, which defines configurable parameters for the resource. A **resource configuration file** is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. This XML schema is defined by Oracle XML DB, and you cannot alter it.

A resource configuration file is itself a resource in Oracle XML DB Repository. You use PL/SQL procedure `DBMS_RESCONFIG.addResConfig` to map a resource to the file that configures it. A single resource configuration file can alternatively apply to all resources in the repository. In that case, you use PL/SQL procedure `DBMS_RESCONFIG.addRepositoryResConfig` to map it to the repository as a whole.

The same resource configuration file can be used to configure more than one resource, if appropriate. Oracle recommends that you have resources share a configuration file

this way whenever the same configuration makes sense. This can improve runtime performance. It also simplifies repository management by letting you update a configuration in a single place and have the change affect multiple resources.

Avoid creating multiple, equivalent resource configuration files, because that can impact performance negatively. If Oracle XML DB detects duplicate resource configuration files, it raises an error.

Typically, you configure a resource for use with a particular application. In order for a resource to be shared by multiple applications, it must be possible for different applications to configure it differently. You do this by creating multiple resource configuration files and mapping them to the same resource. Each resource is thus associated with a list of configurations, a **resource configuration list**. Configurations in a configuration list are processed in the list order.

The repository itself has a list of resource configuration files, for repository-wide configuration, which really means configuration of all resources in the repository. The same configuration file must not be used for both the repository itself and a specific resource; otherwise, an error is raised. An error is also raised if the same resource configuration file appears more than once in any given resource configuration list.

The resource configuration list of a new resource is based on the information in the `configuration` elements of all resource configuration files for the parent folder of the new resource. If there is no such information (no configuration file or no `defaultChildConfig` elements in the files), then the `configuration` elements of the repository resource configuration list are used. If that information is also missing, then the new resource has an empty resource configuration list.

You can view the configuration list for a particular resource by extracting element `/Resource/RCList` from column `RES` of view `RESOURCE_VIEW`, or by using PL/SQL procedure `DBMS_RESCONFIG.getResConfigPath`. You can view the configuration list for the repository as a whole by using PL/SQL procedure `DBMS_RESCONFIG.getRepositoryResConfigPath`. To modify the repository-wide configuration list, you must be granted role `XDBADMIN`.

See Also: "Configuration Element defaultChildConfig" on page 22-3

Configuring a Resource

Follow these steps to configure an Oracle XML DB Repository resource or the repository as a whole (all resources):

1. Create a resource configuration file that defines the configuration. This XML file must conform to XML schema `XDBResConfig.xsd`.
2. Add the resource configuration file to the repository as a resource in its own right: a configuration resource. You can use PL/SQL procedure `DBMS_XDB.createResource` to do this.
3. Map this configuration resource to the resources that it configures, or to the repository if it applies to all resources. Use PL/SQL procedure `DBMS_RESCONFIG.addResConfig` or `DBMS_RESCONFIG.appendResConfig` to map an individual resource. Use `DBMS_RESCONFIG.addRepositoryResConfig` to map the repository as a whole.
4. Commit.

Note: Before performing any operation that uses a resource configuration file, you must perform a `COMMIT` operation. Until you do that, an ORA-22881 "dangling REF" error will be raised whenever you use the configuration file.

PL/SQL package `DBMS_RESCONFIG` provides additional procedures to delete a configuration from a configuration list, obtain a list of paths to configurations in a configuration list, and more.

Note: If you delete a resource configuration file that is referenced by another resource, a dangling `REF` error will be raised whenever an attempt is made to access the configured resource.

See Also:

- Example 22–1 for an example of a simple resource configuration file
- "Configuring Repository Events" on page 30-8 for complete examples of configuring resources
- "XDBResConfig.xsd: XML Schema for Resource Configuration" on page A-9
- *Oracle Database PL/SQL Packages and Types Reference* for information about package `DBMS_RESCONFIG`

Common Configuration Parameters

This section describes commonly used configuration parameters, that is, elements in a configuration file. Parameters specific to particular types of configuration are described elsewhere.

Configuration Element ResConfig

The top-level element of a resource configuration file is `ResConfig`. Besides `namespace` and `schemaLocation` attributes, it can contain an optional `enable` attribute. Set the value of attribute `enable` to `false` to disable the resource configuration file, so that it has no effect on the resources mapped to it. This can be useful for debugging or disabling an application. The default value of `enable`, used if the attribute is not present, is `true`.

Configuration Element defaultChildConfig

This configuration element applies to folders only. It holds configuration information that you want to be applied to all child resources in the folder. Element `defaultChildConfig` has one or more `configuration` child elements, each of which defines a possible configuration for resources in the folder.

A `configuration` element has the following child elements:

- `pre-condition` (optional) – This element specifies a condition that must be met before the resource configuration identified by the `path` element (see next) can be used as the default configuration. If element `pre-condition` is absent, then the

resource configuration file targeted by `path` applies to all resources in the folder. That is, the precondition is treated as true.

A `pre-condition` element has an optional `existsNode` child element. An `existsNode` element has a required `XPath` child element and an optional `namespace` child element, both strings. These define an XPath 1.0 expression and a namespace, respectively, that are used to check the existence of a resource. If that resource exists, then the precondition is satisfied, so the resource configuration file identified by `path` is used as a default resource configuration file for all child resources in the folder. The first component of the `XPath` element must be `Resource`.

> **Note:** A complex XPath expression for element `XPath` can impact performance negatively.

If multiple `configuration` elements have true preconditions, then each of the resource configuration files identified by their associated `path` elements applies to all of the resources in the folder.

- `path` (required) – This element specifies an absolute repository path to a resource configuration file that is to be used as the default configuration for a new resource whenever the precondition specified by element `pre-condition` is satisfied.

Typically, the value of the `path` element is a path to the current resource configuration file, that is, the file that contains the `path` element. Example 22–1 illustrates this, assuming that the resource configuration file is located at path `/cm/app_rc.xml` in the repository. In this example, the precondition is that there be a `Resource` node whose content is of type `xml`. When that precondition is met, the resource configuration file in Example 22–1 applies to all resources in same folder as the configuration file (`/cm/app_rc.xml`).

Example 22–1 Resource Configuration File

```
<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                               http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
  <defaultChildConfig>
    <configuration>
      <pre-condition>
        <existsNode>
          <XPath>/Resource[ContentType="xml"]</XPath>
        </existsNode>
      </pre-condition>
      <path>/cm/app_rc.xml<path>
    </configuration>
  </defaultChildConfig>
</ResConfig>
```

Configuration Element applicationData

You use element `applicationData` to store application-specific data. An application typically passes this data to an event handler when the handler is run. You can use any XML content that you want inside element `applicationData`. An event handler uses PL/SQL function `DBMS_XEVENT.getApplicationData` or Java function `oracle.xdb.XMLType.getApplicationData` to access the data in the `applicationData` of the resource configuration file for the event listener.

Example 22–2 shows an `applicationData` element for use with an Oracle Spatial application.

Example 22–2 applicationData Element

```
<applicationData>
  <spatial:data xmlns:spatial="http://oracle/cartridge/spatial.xsd">
    <spatial:xpos>5</spatial:xpos>
    <spatial:ypos>10</spatial:ypos>
  </spatial:data>
</applicationData>
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL function `DBMS_XEVENT.getApplicationData`
- *Oracle Database XML Java API Reference*, class `XDBRepositoryEvent` for information about Java function `oracle.xdb.XMLType.getApplicationData`
- Example 30–1, "Resource Configuration File for Java Event Listeners With Preconditions" on page 30-10 for an example of a resource configuration file for event listeners

23

Using XLink and XInclude With Oracle XML DB

This chapter describes how to use XLink and XInclude with resources in Oracle XML DB Repository. It contains these topics:

Overview of XLink and XInclude

A document-oriented, or **content-management**, application often tracks relationships, between documents, and those relationships are often represented and manipulated as links of various kinds. Such links can affect application behavior in various ways, including affecting the document content and the response to user operations such as mouse clicks.

W3C has two recommendations that are pertinent in this context, for documents that are managed in XML repositories:

- **XLink –** Defines various types of links between resources. These links can model arbitrary relationships between documents. Those documents can reside inside or outside the repository.
- **XInclude –** Defines ways to include the content of multiple XML documents or fragments in a single infoset. This provides for compound documents, which model inclusion relationships. **Compound documents** are documents that contain other documents; more precisely, they are file resources that include documents or document fragments. The included objects can be file resources in the same repository or documents or fragments outside the repository.

Each of these standards is very general, and it is not limited to modeling relationships between XML documents. There is no requirement that the documents linked using XLink or included in an XML document using XInclude be XML documents.

Using XLink and XInclude to represent document relationships provides flexibility for applications, facilitates reuse of component documents, and enables their fine-grained manipulation (access control, versioning, metadata, and so on). Whereas using XML data structure (an ancestor–descendents hierarchy) to model relationships requires those relationships to be relatively fixed, using XLink and XInclude to model relationships can easily allow for change in those relationships.

Note: For XML schema-based documents to be able to use XLink and XInclude attributes, the XML schema must either explicitly declare those attributes or allow any attributes.

See Also:

- `http://www.w3.org/TR/xlink` for information about the XLink standard
- `http://www.w3.org/TR/xinclude` for information about the XInclude standard

XLink and Include Link Types

This section describes XLink and XInclude link types and the relation between these and Oracle XML DB Repository links. XLink links are more general than repository links. XLink links can be simple or extended. Oracle XML DB supports only simple XLink links, not extended links.

XLink and XInclude Links Model Document Relationships

XLink and XInclude links model arbitrary relationships among documents; the semantics of a relationship is determined by the applications that use the link; it is not inherent in the link itself. XLink and XInclude links can be mapped to Oracle XML DB **document links**. When document links target Oracle XML DB Repository resources, they can (according to a configuration option) be hard or weak links; in this, they are similar to repository links in that context. Repository links can be navigated using file system-related protocols such as FTP and HTTP; document links cannot, but they can be navigated using the XPath 2.0 function `fn:doc`.

See Also: "Hard Links and Weak Links" on page 21-7

XLink and XInclude Link Types

XLink and XInclude can provide links to other documents. In the case of XInclude, attributes `href` and `xpointer` are used to specify the target document.

Xlink links can be simple or extended. **Simple** links are unidirectional, from a source to a target. **Extended** links (sometimes called **complex**) can model relationships between multiple documents, with different directionalities. Both simple and extended links can include link metadata. XLink links are represented in XML data using various attributes of the namespace `http://www.w3.org/1999/xlink`, which has the predefined prefix `xlink`. Simple links are represented in XML data using attribute `type` with value `simple`, that is, `xlink:type="simple"`. Extended Xlink links are represented using `xlink:type="extended"`.

Third-party extended Xlink links are not contained in any of the documents whose relationships they model. Third-party links can thus be used to relate documents, such as binary files, that, themselves, have no way of representing a link.

The source end of a simple Xlink link (that is, the document containing the link) must be an XML document; the target end can be any document; there are no such restrictions for extended links. Example 23–3 shows examples of simple links; the link targets are represented using attribute `xlink:href`.

XInclude: Compound Documents

XInclude is the W3C recommendation for the syntax and processing model for merging the infosets of multiple XML documents into a single infoset. Element `xi:include` is used to include another document, specifying its URI as the value of an `href` attribute. Element `xi:include` can be nested; that is, an included document can itself include other documents.

(However, an inclusion cycle raises an error in Oracle XML DB. The resources will be created, but an error is raised when the inclusions are expanded.)

XInclude thus provides for *compound* documents: repository file resources that include other XML documents or fragments. The included objects can be file resources in the same repository or documents or fragments outside the repository.

A book might be an example of a typical compound document, as managed by a content-management system. Each book includes chapter documents, which can each be managed as separate objects, with their own URLs. A chapter document can have its own metadata and access control, and it can be versioned. A book can include (reference) a specific version of a chapter document. The same chapter document can be included in multiple book documents, for reuse. Because inclusion is modeled using XInclude, content management is simplified. It is easy, for example, to replace one chapter in a book by another.

Example 23–1 illustrates an XML `Book` element that includes four documents. One of those documents, part1.xml, is also shown; it includes other documents, representing chapters.

Example 23–1 XInclude Used in a Book Document to Include Parts and Chapters

The top-level document representing a book contains element `Book`.

```
<Book xmlns:xi="http://www.w3.org/2001/XInclude">
  <xi:include href=toc.xml"/>
  <xi:include href=part1.xml"/>
  <xi:include href=part2.xml"/>
  <xi:include href=index.xml"/>
</Book>
```

A major book part, file (resource) `part2.xml`, contains a `Part` element, which includes multiple chapter documents.

```
<?xml version="1.0"?>
<Part xmlns:xi="http://www.w3.org/2001/XInclude">
  <xi:include href="chapter5.xml"/>
  <xi:include href="chapter6.xml"/>
  <xi:include href="chapter8.xml"/>
  <xi:include href="chapter9.xml"/>
</Part>
```

These are some additional features of XInclude:

- Inclusion of plain text – You can include unparsed, non-XML text using attribute `parse` with a value of `text`: `parse="text"`.

- Inclusion of XML fragments – You can use an `xpointer` attribute in an `xi:include` element to specify an XML fragment to include, instead of an entire document.
- Fallback processing – In case of error, such as inability to access the URI of an included document, an `xi:include` syntax error, or an `xpointer` reference that returns null, XInclude performs the treatment specified by element `xi:fallback`. This generally specifies an alternative element to be included. The alternative element can itself use `xi:include` to include other documents.

Using XLink With Oracle XML DB

Oracle XML DB supports only simple XLink links, not extended XLink links.

When an XML document containing XLink attributes is added to Oracle XML DB Repository, either as resource content or as user-defined resource metadata, special processing can occur, depending on how the repository or individual repository resources are configured. Element `XLinkConfig` of the resource configuration document, `XDBResConfig.xsd`, determines this behavior. In particular, you can configure resources so that XLink links are ignored, or so that they are mapped to Oracle XML DB document links. In the latter case, configuration can specify that the document links are to be hard or weak. Hard and weak document links have the same properties as hard and weak repository links.

The privileges needed to create or update document links are the same as those needed to create or update repository links. Even partially updating a document requires the same privileges needed to delete the entire document and reinsert it. In particular, this means that even if you update just one document link, you must have delete and insert privileges for *each* of the documents linked by the document containing the link.

If configuration maps XLink links to document links, then, whenever a document containing XLink links is added to the repository, the XLink information is extracted and stored in a system link table. Link target (destination) locations are replaced by direct paths that are based on the resource OIDs. Configuration can also specify whether OID paths are to be replaced by named paths (URLs) upon document retrieval. Using OID paths instead of named paths generally offers a performance advantage when links are processed, including when resource contents are retrieved.

You can use XLink within resource content, but not within resource metadata.

See Also:

- "Using DOCUMENT_LINKS View to Examine XLink and XInclude Links" on page 23-7
- Chapter 29, "User-Defined Repository Metadata"
- "Hard Links and Weak Links" on page 21-7
- "Configuring Resources for XLink and XInclude" on page 23-9
- "XDBResConfig.xsd: XML Schema for Resource Configuration" on page A-9

Using XInclude With Oracle XML DB

Oracle XML DB supports XInclude 1.0 as the standard mechanism for managing compound documents. It does not support attribute `xpointer` and the inclusion of

document fragments, however; only complete documents can be included (using attribute `href`).

You can use XInclude to create XML documents that include existing content. You can also configure the implicit decomposition of non-schema-based XML documents, creating a set of repository resources that contain XInclude inclusion references.

The content of included documents must be XML data or plain text (with attribute `parse="text"`). You cannot include binary content directly using XInclude, but you can use XLink to link to binary content.

You can use XInclude within resource content, but not within resource metadata.

> **See Also:** "Using DOCUMENT_LINKS View to Examine XLink and XInclude Links" on page 23-7

Expanding Compound-Document Inclusions

When you retrieve a compound document from Oracle XML DB Repository, you have a choice:

- Retrieve it as is, with the `xi:include` elements remaining as such. This is the default behavior.
- Retrieve it after replacing the `xi:include` elements with their targets, recursively, that is, after expansion of all inclusions. An error is raised if any `xi:include` element cannot be resolved.

To retrieve the document in expanded form, use PL/SQL constructor `XDBURIType`, passing a value of `'1'` or `'3'` as the second argument (flags). Example 23–2 illustrates this. These are the possible values for the `XDBURIType` constructor second argument:

- `1` – Expand all XInclude inclusions before returning the result. If any such inclusion cannot be resolved according to the XInclude standard fallback semantics, then raise an error.
- `2` – Suppress all errors that might occur during document retrieval. This includes dangling `href` pointers.
- `3` – Same as `1` and `2` together.

Example 23–2 Using XDBURIType to Expand Document Inclusions

This example retrieves all documents that are under repository folder `public/bookdir`, expanding each inclusion:

```
SELECT XDBURIType(ANY_PATH, '1').getXML() FROM RESOURCE_VIEW
  WHERE under_path(RES, '/public/bookdir') = 1;

XDBURITYPE(ANY_PATH,'1').GETXML()
--------------------------------
<Book>
  <Title>A book</Title>
  <Chapter id="1">
    <Title>Introduction</Title>
    <Body>
      <Para>blah blah</Para>
      <Para>foo bar</Para>
    </Body>
  </Chapter>
  <Chapter id="2">
    <Title>Conclusion</Title>
```

```
    <Body>
      <Para>xyz xyz</Para>
      <Para>abc abc</Para>
    </Body>
  </Chapter>
</Book>

<Chapter id="1">
  <Title>Introduction</Title>
  <Body>
    <Para>blah blah</Para>
    <Para>foo bar</Para>
  </Body>
</Chapter>

<Chapter id="2">
  <Title>Conclusion</Title>
  <Body>
    <Para>xyz xyz</Para>
    <Para>abc abc</Para>
  </Body>
</Chapter>

3 rows selected.
```

(The result shown here corresponds to the resource `bookfile.xml` shown in Example 23–8, together with its included resources, `chap1.xml` and `chap2.xml`.)

See Also:

- "Versioning, Locking, and Controlling Access to Compound Documents" on page 23-7 for information about access control during expansion
- *Oracle Database PL/SQL Packages and Types Reference* for more information about `XDBURIType`

Validating Compound Documents

You validate a compound document the way you would any XML document. However, you can choose to validate it in either form: with `xi:include` elements as is or after replacing them with their targets.

You can also choose to use one XML schema to validate the unexpanded form, and another to validate the expanded form. For example, you might use one XML schema to validate without first expanding, in order to set up storage structures, and then use another XML schema to validate the expanded document after it is stored.

Updating Compound Documents

You can update a compound document just as you would update any resource. This replaces the resource with a new value; that is, it corresponds to a resource deletion followed by a resource insertion. This means, in particular, that any `xi:include` elements in the original resource are deleted. Any `xi:include` elements in the replacement (inserted) document are processed as usual, according to the configuration defined at the time of insertion.

Versioning, Locking, and Controlling Access to Compound Documents

The components of a compound document are separate resources. This means that they are versioned and locked independently, and their access is controlled independently.

- Document links to version-controlled resources (VCRs) always resolve to the latest version of the target resource, or the selected version within the current workspace. You can, however, explicitly refer to any specific version, by identifying the target resource by its OID-based path.
- Locking a document that contains `xi:include` elements does not also lock the included documents. Locking an included document does not also lock documents that include it.
- The access control list (ACL) on each referenced document is checked whenever you retrieve a compound document with expansion. This is done using the privileges of the current user (invoker rights). If privileges are insufficient for any of the included documents, the expansion is cancelled and an error is raised.

See Also:

- "Expanding Compound-Document Inclusions" on page 23-5
- Chapter 24, "Managing Resource Versions" for information about VCRs
- Chapter 27, "Repository Resource Security" for information about resource ACLs

Using DOCUMENT_LINKS View to Examine XLink and XInclude Links

You can query the read-only public view `DOCUMENT_LINKS` to obtain system information about document links derived from both XLink and XInclude links. The information in this view includes the following columns, for each link:

- `SOURCE_ID` – The source resource OID. `RAW(16)`.
- `TARGET_ID` – The target resource OID. `RAW(16)`.
- `TARGET_PATH` – Always `NULL`. Reserved for future use. `VARCHAR2(4000)`.
- `LINK_TYPE` – The document link type: `Hard` or `Weak`. `VARCHAR2(8)`.
- `LINK_FORM` – Whether the original link was of form `XLink` or `XInclude`. `VARCHAR2(8)`.
- `SOURCE_TYPE` – Always `Resource Content`. `VARCHAR2(17)`.

You can obtain information about a resource from this view only if one of the following conditions holds:

- The resource is a link source, and you have the privilege `read-contents` or `read-properties` on it.
- The resource is a link target, and you have the privilege `read-properties` on it.

See Also: *Oracle Database Reference* for more information on public view `DOCUMENT_LINKS`

Querying DOCUMENT_LINKS for XLink Information

Example 23–3 shows how XLink links are treated when resources are created, and how to obtain system information about document links from view `DOCUMENT_LINKS`. It

assumes that the folder containing the resource has been configured to map XLink links to document hard links.

Example 23–3 Querying Document Links Mapped From XLink Links

```
DECLARE
  b BOOLEAN;
BEGIN
  b := DBMS_XDB.createResource(
         '/public/hardlinkdir/po101.xml',
         '<PurchaseOrder id="101" xmlns:xlink="http://www.w3.org/1999/xlink">
            <Company xlink:type="simple"
                     xlink:href="/public/hardlinkdir/oracle.xml">Oracle Corporation</Company>
            <Approver xlink:type="simple"
                      xlink:href="/public/hardlinkdir/quine.xml">Willard Quine</Approver>
          </PurchaseOrder>');

  b := DBMS_XDB.createResource(
         '/public/hardlinkdir/po102.xml',
         '<PurchaseOrder id="102" xmlns:xlink="http://www.w3.org/1999/xlink">
            <Company xlink:type="simple"
                     xlink:href="/public/hardlinkdir/oracle.xml">Oracle Corporation</Company>
            <Approver xlink:type="simple"
                      xlink:href="/public/hardlinkdir/curry.xml">Haskell Curry</Approver>
            <ReferencePO xlink:type="simple"
                         xlink:href="/public/hardlinkdir/po101.xml"/>
          </PurchaseOrder>');
END;
/

SELECT r1.ANY_PATH source, r2.ANY_PATH target, dl.LINK_TYPE, dl.LINK_FORM
  FROM DOCUMENT_LINKS dl, RESOURCE_VIEW r1, RESOURCE_VIEW r2
  WHERE dl.SOURCE_ID = r1.RESID and dl.TARGET_ID = r2.RESID;

SOURCE                         TARGET                         LINK_TYPE LINK_FORM
------------------------------ ------------------------------ --------- ---------
/public/hardlinkdir/po101.xml /public/hardlinkdir/oracle.xml Hard      XLink
/public/hardlinkdir/po101.xml /public/hardlinkdir/quine.xml  Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/oracle.xml Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/curry.xml  Hard      XLink
/public/hardlinkdir/po102.xml /public/hardlinkdir/po101.xml  Hard      XLink
```

> **See Also:** "Mapping XInclude Links to Hard Document Links, With OID Retrieval" on page 23-12 for an example of configuring a folder to map XLink links to hard links

Querying DOCUMENT_LINKS for XInclude Information

Example 23–4 queries view `DOCUMENT_LINKS` to show all document links.

Example 23–4 Querying Document Links Mapped From XInclude Links

```
DECLARE
  ret BOOLEAN;
BEGIN
  ret := DBMS_XDB.createResource(
           '/public/hardlinkdir/book.xml',
           '<Book xmlns:xi="http://www.w3.org/2001/XInclude">
              <xi:include href="/public/hardlinkdir/toc.xml"/>
              <xi:include href="/public/hardlinkdir/part1.xml"/>
              <xi:include href="/public/hardlinkdir/part2.xml"/>
              <xi:include href="/public/hardlinkdir/index.xml"/>
```

```
            </Book>');
END;

SELECT r1.ANY_PATH source, r2.ANY_PATH target, dl.LINK_TYPE, dl.LINK_FORM
  FROM DOCUMENT_LINKS dl, RESOURCE_VIEW r1, RESOURCE_VIEW r2
  WHERE dl.SOURCE_ID = r1.RESID and dl.TARGET_ID = r2.RESID;

SOURCE                       TARGET                         LINK_TYPE LINK_FORM
------                       ------                         --------- ---------
/public/hardlinkdir/book.xml /public/hardlinkdir/toc.xml    Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/part1.xml  Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/part2.xml  Hard      XInclude
/public/hardlinkdir/book.xml /public/hardlinkdir/index.xml  Hard      XInclude
```

Configuring Resources for XLink and XInclude

You configure XLink and XInclude treatment for Oracle XML DB Repository resources as you would configure any other treatment of repository resources—see "Configuring a Resource" on page 22-2. The rest of this section describes the resource configuration file that you use as a resource to configure XLink and XInclude processing for other resources.

A resource configuration file is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. You use elements `XLinkConfig` and `XIncludeConfig`, children of element `ResConfig`, to configure XLink and XInclude treatment, respectively. If one of these elements is absent, then there is no treatment of the corresponding type of links.

Both `XLinkConfig` and `XIncludeConfig` can have attribute `UnresolvedLink` and child elements `LinkType` and `PathFormat`. Element `XIncludeConfig` can also have child element `ConflictRule`. If the `LinkType` element content is `None`, however, then there must be no `PathFormat` or `ConflictRule` element.

You cannot define any preconditions for `XLinkConfig` or `XIncludeConfig`. During repository resource creation, the `ResConfig` element of the parent folder determines the treatment of XLink and XInclude links for the new resource. If the parent folder has no `ResConfig` element, then the repository-wide configuration applies.

Any change to the resource configuration file applies only to documents that are created or updated after the configuration-file change. To process links in existing documents, use PL/SQL procedure `DBMS_XDB.processLinks`, after specifying the appropriate resource configuration parameters.

See Also:

- "Using DBMS_XDB.processLinks to Manage XLink and XInclude Links" on page 23-13
- Chapter 22, "Configuring Oracle XML DB Repository"

Configuring Treatment of Unresolved Links: UnresolvedLink Attribute

A `LinkConfig` element can have an `UnresolvedLink` attribute with a value of `Error` (default value) or `Skip`. This determines what happens if an XLink or XInclude link cannot be resolved at the time of document insertion into the repository (resource creation): `Error` means raise an error and roll back the current operation; `Skip` means skip any treatment of the XLink or XInclude link. Skipping treatment creates the resource with no corresponding document links, and sets the resource's

HasUnresolvedLinks attribute to true, to indicate that the resource has unresolved links.

Using Skip as the value of attribute UnresolvedLink can be especially useful when you create a resource that contains a cycle of weak links, which would otherwise lead to unresolved-link errors during resource creation. After the resource and all of its linked resources have been created, you can use PL/SQL procedure DBMS_XDB.processLinks to process the skipped links. If all XLink and XInclude links have been resolved by this procedure, then attribute HasUnresolvedLinks is set to false.

Resource attribute HasUnresolvedLinks is also set to true for a resource that has a weak link to a resource that has been deleted. Deleting a resource thus effectively also deletes any weak links pointing to that resource. In particular, whenever the last hard link to a resource is deleted, the resource is itself deleted, and all resources that point to the deleted resource with a weak link have attribute HasUnresolvedLinks set to true.

See Also:

- "Hard Links and Weak Links" on page 21-7
- "Using DBMS_XDB.processLinks to Manage XLink and XInclude Links" on page 23-13

Configuring the Document Links to Create: LinkType Element

You use the LinkType element of a resource configuration file to specify the type of document link to be created whenever an XLink or XInclude link is encountered when a document is stored in Oracle XML DB Repository. The LinkType element has these possible values (element content):

- None (default) – Ignore XLink or XInclude links: create no corresponding document links.
- Hard – Map XLink or XInclude links to hard document links in repository documents.
- Weak – Map XLink or XInclude links to weak document links in repository documents.

See Also:

- Example 23–5
- Example 23–6

Configuring the Path Format for Retrieval: PathFormat Element

You use the PathFormat element of a resource configuration file to specify the path format to be used when retrieving documents with xlink:href or xi:include:href attributes. The PathFormat element has these possible values (element content) for hard and weak document links:

- OID (default) – Map XLink or XInclude href paths to OID-based paths in repository documents—that is, use OIDs directly.
- Named – Map XLink or XInclude href paths to named paths (URLs) in repository documents. The path is computed from the internal OID when the document is retrieved, so retrieval can be slower than in the case of using OID paths directly.

See Also:

- Example 23–5
- Example 23–6

Configuring Conflict-Resolution for XInclude: ConflictRule Element

You use the `ConflictRule` element of a resource configuration file to specify the conflict-resolution rules to use if the path computed for a component document is already present in Oracle XML DB Repository. The `ConflictRule` element has these possible values (element content):

- `Error` (default) – Raise an error.
- `Overwrite` – Update the document targeted by the existing repository path, replacing it with the document to be included. If the existing document is a VCR, then it must already be checked out, unless it is autoversioned; otherwise, an error is raised.
- `Syspath` – Change the path to the included document to a new, system-defined path.

Configuring Decomposition of Documents Using XInclude: SectionConfig Element

You use the `SectionConfig` element of a resource configuration file to specify how non-schema-based XML documents are to be decomposed when added to Oracle XML DB Repository, to create a set of resources that contain XInclude inclusion references. You use simple XPath expressions in the resource configuration file to identify which parts of a document to map to separate resources, and which resources to map them to.

Element `SectionConfig` contains one or more `Section` elements, each of which contains the following child elements:

- `sectionPath` – Simple XPath 1.0 expression that identifies a section root. This must use only child and descendant axes, and it must not use wildcards.
- `documentPath` (optional) – Simple XPath 1.0 expression that is evaluated to identify the resources to be created from decomposing the document according to `sectionPath`. The XPath expression must use only child, descendant, and attribute axes.
- `namespace` (optional) – Namespace in effect for `sectionPath` and `documentPath`.

Element `Section` also has a `type` attribute that specifies the type of section to be created. Value `Document` means create a document. The default value, `None`, means do not create anything; it is equivalent to removing the `SectionConfig` element. You can thus set the `type` attribute to `None` to disable a `SectionConfig` element temporarily, without removing it, and then set it back to `Document` to enable it again.

If an element in the document being added to the repository matches more than one `sectionPath` value, only the first such expression (in document order) is used.

If no `documentPath` element is present, then the resource created has a system-defined name, and is put into the folder specified for the original document.

See Also:

- Example 23–7, "Configuring XInclude Document Decomposition" on page 23-12
- Example 23–8, "Repository Document, Showing Generated xi:include Elements" on page 23-13

XLink and XInclude Configuration Examples

Example 23–5 shows a configuration-file section that configures XInclude treatment, mapping XInclude attributes to Oracle XML DB Repository hard document links. Repository paths in retrieved resources are configured to be based on resource OIDs.

Example 23–5 Mapping XInclude Links to Hard Document Links, With OID Retrieval

```
<ResConfig>
  . . .
  <XIncludeConfig UnresolvedLink="Skip">
    <LinkType>Hard</LinkType>
    <PathFormat>OID</PathFormat>
  </XIncludeConfig>
  . . .
</ResConfig>
```

Example 23–6 shows an `XLinkConfig` section that maps XLink links to weak document links in the repository. In this case, retrieval of a document uses named paths (URLs).

Example 23–6 Mapping XLInk Links to Weak Links, With Named-Path Retrieval

```
<ResConfig>
  . . .
  <XLinkConfig UnresolvedLink="Skip">
    <LinkType>Weak</LinkType>
    <PathFormat>Named</PathFormat>
  </XLinkConfig>
  . . .
</ResConfig>
```

Example 23–7 shows a `SectionConfig` section that specifies that each `Chapter` element in an input document is to become a separate repository file, when the input document is added to Oracle XML DB Repository. The repository path for the resulting file is specified using configuration element `documentPath`, and this path is relative to the location of the resource configuration file of Example 23–6.

Example 23–7 Configuring XInclude Document Decomposition

```
<ResConfig>
  . . .
  <SectionConfig>
    <Section type = "Document">
      <sectionPath>//Chapter</sectionPath>
      <documentPath>concat("chap", @id, ".xml")</documentPath>
    </Section>
  </SectionConfig>
  . . .
</ResConfig>
```

The XPath expression here uses XPath function `concat` to concatenate the following strings to produce the resulting repository path to use:

- `chap` – (prefix) `chap`.
- The value of attribute `id` of element `Chapter` in the input document.
- `.xml` as a file extension.

For example, a repository path of `chap27.xml` would result from an input document with a `Chapter` element that has an `id` attribute with value `27`:

```
<Chapter id="27"> ... </Chapter>
```

If the configuration document of Example 23–6 and the book document that contains the `XInclude` elements are in repository folder `/public/bookdir`, then the individual chapter files generated from `XInclude` decomposition will be in files `/public/bookdir/chap`*N*`.xml`, where the values of *N* are the values of the `id` attributes of `Chapter` elements.

The book document that is added to the repository is derived from the input book document. The embedded `Chapter` elements in the input book document are replaced by `xi:include` elements that reference the generated chapter documents—Example 23–8 illustrates this.

Example 23–8 Repository Document, Showing Generated xi:include Elements

```
SELECT XDBURIType('/public/bookdir/bookfile.xml').getclob() FROM DUAL;

XDBURITYPE('/PUBLIC/BOOKDIR/BOOKFILE.XML').GETCLOB()
--------------------------------------------------------------------------------
<Book>
  <Title>A book</Title>
  <xi:include xmlns:xi="http://www.w3.org/2001/XInclude" href="/public/bookdir/chap1.xml"/>
  <xi:include xmlns:xi="http://www.w3.org/2001/XInclude" href="/public/bookdir/chap2.xml"/>
</Book>
```

See Also:

- Chapter 22, "Configuring Oracle XML DB Repository"
- XDBResConfig.xsd: XML Schema for Resource Configuration
- "Configuring Decomposition of Documents Using XInclude: SectionConfig Element" on page 23-11

Using DBMS_XDB.processLinks to Manage XLink and XInclude Links

You can use PL/SQL procedure `DBMS_XDB.processLinks` to manually process all XLink and XInclude links in a single document or in all documents of a folder. Pass `RECURSIVE` as the mode argument to this procedure, if you want to process all hard-linked subfolders recursively. All XLink and XInclude links are processed according to the corresponding configuration parameters. If any of the links within a resource cannot be resolved, the resource's `HasUnresolvedLinks` attribute is set to `true`, to indicate that the resource has unresolved links. The default value of attribute `HasUnresolvedLinks` is `false`.

See Also: "Configuring Treatment of Unresolved Links: UnresolvedLink Attribute" on page 23-9

24

Managing Resource Versions

This chapter describes how to create and manage versions of Oracle XML DB resources.

This chapter contains these topics:

Overview of Oracle XML DB Versioning

Oracle XML DB versioning provides a way to create and manage different versions of a resource in Oracle XML DB. When you update a resource such as a table or column, Oracle XML DB stores the pre-update contents as a separate resource version.

Oracle XML DB provides PL/SQL package `DBMS_XDB_VERSION` to put a resource under version-control and retrieve different versions of the resource.

Oracle XML DB Versioning Features

Versioning helps you keep track of changes to resources in Oracle XML DB Repository. The following sections discuss these features in detail. Oracle XML DB versioning features include the following:

- *Version control on a resource*. You can turn version control on or off for an Oracle XML DB Repository resource. See "Creating a Version-Controlled Resource (VCR)".
- *Updating process of a version-controlled resource.* When Oracle XML DB updates a version-controlled resource (VCR), it creates a new version of the resource. This new version will not be deleted from the database when you delete the version-controlled resource. See "Updating a Version-Controlled Resource (VCR)".
- *Loading a VCR is similar to loading a resource* in Oracle XML DB using the path name. See "Creating a Version-Controlled Resource (VCR)".
- *Loading a version of the resource.* To load a version of a resource, you must first find the resource object id of the version and then load the version using that id. The resource object id can be found from the resource version history or from the version-controlled resource itself. See "Oracle XML DB Resource ID and Path Name".

Note: Oracle XML DB supports version control for Oracle XML DB resources. It does *not* support version control for user-defined tables or data in Oracle Database.

Oracle does *not* guarantee that the resource object ID of a version is preserved across check-in and check-out. Everything but the resource object ID of the last version is preserved.

Oracle XML DB supports versioning of XML *schema*-based resources only if the schema tables have *no* associated triggers or constraints.

Oracle XML DB Versioning Terms Used in This Chapter

Table 24–1 lists the Oracle XML DB versioning terms used in this chapter.

Table 24–1 Oracle XML DB Versioning Terms

Oracle XML DB Versioning Term	Description
Version control	When a record or history of all changes to an Oracle XML DB resource is stored and managed, the resource is said to be put under version control.
Versionable resource	Versionable resource is an Oracle XML DB resource that can be put under version control.
Version-controlled resource	A **version-controlled resource** (**VCR**) is an Oracle XML DB resource that is under version control.
Version resource	A version resource is a version of the Oracle XML DB resource that is put under version control. A version resource is a read-only Oracle XML DB resource. It cannot be updated or deleted.
Checked-out resource	An Oracle XML DB resource created when a version-controlled resource is checked out.
`checkOut`, `checkIn`, `unCheckOut`	Operations for updating Oracle XML DB resources. Version-controlled resources must be checked out before they are changed. Use `checkIn` to make the change permanent. Use `unCheckOut` to cancel the change.

Oracle XML DB Resource ID and Path Name

A resource ID is a unique system-generated ID for an Oracle XML DB resource. It helps identify resources that do not have path names. For example, a version resource is a system-generated resource and does not have a path name. You can use PL/SQL function `GetResourceByResId` to retrieve resources given the resource object ID. The first version ID is returned if a resource is versioned.

Example 24–1 Using DBMS_XDB_VERSION.GetResourceByResId To Retrieve a Resource

```
DECLARE
  resid DBMS_XDB_VERSION.resid_type;
  res XMLType;
BEGIN
  resid := DBMS_XDB_VERSION.makeVersioned('/home/QUINE/versample.html');
  -- Obtain the resource
  res := DBMS_XDB_VERSION.getResoureceByResId(resid);
END;
/
```

Creating a Version-Controlled Resource (VCR)

Oracle XML DB does not automatically keep a history of updates because not all Oracle XML DB resources need this. You must send a request to Oracle XML DB to put an Oracle XML DB resource under version control. In this release, all Oracle XML DB resources are versionable resources except for the following:

- Folders (directories or collections)
- Access control list (ACL), the list of access control entries (ACEs) that determines which principals have access to a given resource or resources.

When a version-controlled resource is created, the first version resource of the VCR is created, and the VCR is a reference to this newly-created version.

See "Version Resource ID or VCR Version" on page 24-3.

Example 24–2 Using DBMS_XDB_VERSION.makeVersioned To Create a VCR

Resource '`/home/QUINE/versample.html`' is turned into a version-controlled resource.

```
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.makeVersioned('/home/QUINE/versample.html');
END;
/
```

PL/SQL function `makeVersioned` returns the resource ID of the first version of the version-controlled resource. This version is represented by a resource ID – see "Resource ID of a New Version" on page 24-3.

Function `makeVersioned` does *not* auto-commit; you must perform a `COMMIT`.

Version Resource ID or VCR Version

Oracle XML DB does not provide path names for version resources. However, it does provide a version resource ID. Version resources are read-only resources.

The version resource ID is returned by a few methods in package `DBMS_XDB_VERSION`, as described in the following sections.

Resource ID of a New Version

When a VCR is checked out and updated for the first time, a copy of the existing resource is created. The resource ID of the latest version of the resource is never changed—*you can always access the latest version using the original resource ID*. You can obtain the resource ID of the old version by getting the predecessor of the current resource.

Example 24–3 Retrieving the Resource ID of the New Version After Check-In

The following example shows how to get the resource ID of the new version after checking in `/home/index.html`:

```
-- Declare a variable for resource id
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
  res XMLType;
BEGIN
```

```
  -- Get the id as user checks in.
  resid := DBMS_XDB_VERSION.checkIn('/home/QUINE/versample.html');
  -- Obtain the resource
  res := DBMS_XDB_VERSION.GetResourceByResId(resid);
END;
/
```

Example 24–4 Oracle XML DB: Creating and Updating a Version-Controlled Resource (VCR)

```
DECLARE
  resid1 DBMS_XDB_VERSION.RESID_TYPE;
  resid2 DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  -- Put a resource under version control.
  resid1 := DBMS_XDB_VERSION.makeVersioned('/home/QUINE/versample.html');

  -- Check out VCR to update its contents
  DBMS_XDB_VERSION.checkOut('/home/QUINE/versample.html');

  -- Use RESOURCE_VIEW to update versample.html
  UPDATE RESOURCE_VIEW
    SET RES =
          SYS.XMLTYPE.createXML(
            '<Resource
                 xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResource.xsd
                                     http://xmlns.oracle.com/xdb/XDBResource.xsd">
               <Author>Jane Doe</Author>
               <DisplayName>versample</DisplayName>
               <Comment>Has this got updated or not ?? </Comment>
               <Language>en</Language>
               <CharacterSet>ASCII</CharacterSet>
               <ContentType>text/plain</ContentType>
             </Resource>')
      WHERE equals_path(RES, '/home/QUINE/versample.html') = 1';

  -- Check in the change
  resid2 := DBMS_XDB_VERSION.checkIn('/home/QUINE/versample.html');

  -- The latest version can be obtained by resid2 and its predecessor
  -- can be obtained by using getPredecessor() or getPredsbyResId() functions.
  -- resid1 is no longer valid.
END;
/
-- Delete the VCR
DELETE FROM RESOURCE_VIEW
  WHERE equals_path(RES, '/home/QUINE/versample.html') = 1';

-- Once the preceding delete is done, any reference to the resource
-- (that is, check-in, check-out, and so on, results in
-- ORA-31001: Invalid resource handle or path name "/home/QUINE/versample.html"
```

Accessing a Version-Controlled Resource (VCR)

VCR also has a path name as any regular resource. Accessing a VCR is the same as accessing any other resources in Oracle XML DB.

Updating a Version-Controlled Resource (VCR)

Updating a VCR requires more steps than updating a resource that is not version-controlled. Before updating the contents and metadata properties of a VCR, check out the resource. The resource must then be checked in to make the update permanent. You must explicitly commit the SQL transaction.

To update a VCR follow these steps:

1. *Check out the VCR,* passing the VCR path name to Oracle XML DB.
2. *Update the VCR.* You can update either the contents or the metadata properties of the VCR. A new VCR version is not created until check-in, In particular, an update or a deletion operation does not permanently take effect until after check-in. (You can perform an update using SQL through `RESOURCE_VIEW` or `PATH_VIEW`, or through any protocol such as WebDAV.)
3. *Check in the VCR or cancel its check-out*. If the resource is not checked out, then the previous version is copied onto the current version. The previous version is then deleted.

Procedure DBMS_XDB_VERSION.checkOut

In Oracle9*i* release 2 (9.2) and later, the VCR check-out operation is executed by calling `DBMS_XDB_VERSION.checkOut`. If you want to commit an update of a resource, then it is a good idea to commit after check-out. If you do not commit right after checking out, then you may have to rollback your transaction at a later point, and the update is lost.

Example 24–5 VCR Check-Out

For example:

```
BEGIN
  -- Resource '/home/QUINE/versample.html' is checked out.
  DBMS_XDB_VERSION.checkout('/home/QUINE/versample.html');
END;
/
```

Procedure DBMS_XDB_VERSION.checkIn

In Oracle9*i* release 2 (9.2) and higher, the VCR check-in operation is executed by calling `DBMS_XDB_VERSION.checkIn`. Procedure `checkIn` takes the path name of a resource. This path name does not have to be the same as the path name that was passed to check-out, but the check-in and check-out path names must be of the same resource.

Example 24–6 VCR Check-In

For example:

```
-- Resource '/home/QUINE/versample.html' is checked in.
DECLARE
  resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.checkIn('/home/QUINE/versample.html');
END;
/
```

Procedure DBMS_XDB_VERSION.unCheckOut

In Oracle9*i* release 2 (9.2) and later, a check-out is cancelled by calling `DBMS_XDB_VERSION.unCheckOut`. This path name does not have to be the same as the path name that was passed to check-out, but the check-in and check-out path names must be of the same resource.

Example 24–7 VCR unCheckOut

For example:

```
-- Resource '/home/QUINE/versample.html' is unchecked out.
DECLARE
 resid DBMS_XDB_VERSION.RESID_TYPE;
BEGIN
  resid := DBMS_XDB_VERSION.unCheckOut('/home/QUINE/versample.html');
END;
/
```

Update Contents and Properties

After checking out a VCR, all Oracle XML DB user interfaces for updating contents and properties of a regular resource can be applied to a VCR. For example, you can use `RESOURCE_VIEW`, `PATH_VIEW`, or WebDAV.

> **See Also:** Chapter 25, "SQL Access Using RESOURCE_VIEW and PATH_VIEW" for details on updating an Oracle XML DB resource.

Access Control and Security of a VCR

Access control of a VCR or version resource is the same as for a resource that is not version-controlled. When you request access to these resources, the access control list (ACL) is checked.

> **See Also:** Chapter 27, "Repository Resource Security"

Version Resource

When a regular resource is converted to a VCR using `makeversion`, the first version resource is created, and the ACL of this first version resource is the same as the ACL of the original resource. When a checked-out resource is checked in, a new version is created, and the ACL of this new version is the same as the ACL of the checked-out resource. After a version resource is created, its ACL cannot be changed.

ACLs of Version-Controlled Resources Are the Same as the First Versions

When a VCR is created by `makeversioned`, the ACL of the VCR is the same as the ACL of the first version of the resource. When a resource is checked in, a new version is created, and the VCR will have the same contents and properties including ACL property with this new version.

Table 24–2 describes the subprograms in `DBMS_XDB_VERSION`.

Table 24–2 DBMS_XDB_VERSION Functions and Procedures

Function/Procedure	Description
`FUNCTION makeVersioned` `makeVersioned(pathname VARCHAR2) RETURN DBMS_XDB_VERSION.RESID_TYPE;`	Turns a regular resource whose path name is given into a version controlled resource. If two or more path names are bound with the same resource, then a copy of the resource will be created, and the given `path name` will be bound with the newly-created copy. This new resource is then put under version control. All other path names continue to refer to the original resource. `pathname` - the path name of the resource to be put under version control. `return` - This function returns the resource ID of the first version (root) of the VCR. This is not an auto-commit SQL operation. It is legal to call `makeVersioned` for a VCR, and neither an exception nor a warning is raised. It is not permitted to call `makeVersioned` for a folder, version resource, or ACL. An exception is raised if the resource does not exist.
`PROCEDURE checkOut` `checkOut(pathname VARCHAR2);`	Checks out a VCR before updating or deleting it. `pathname` - the path name of the VCR to be checked out. This is not an auto-commit SQL operation. Two users cannot check out the same VCR at the same time. If this happens, then one user must rollback. As a result, it is a good idea for you to commit the check-out operation before updating a resource. That way, you do not loose the update when rolling back the transaction. An exception is raised when: ■ the given resource is not a VCR, ■ the VCR is already checked out ■ the resource does not exist
`FUNCTION checkIn` `checkIn (pathname VARCHAR2) RETURN DBMS_XDB_VERSION.RESID_TYPE;`	Checks in a checked-out VCR. `pathname` - the path name of the checked-out resource. `return` - the resource id of the newly-created version. This is not an auto-commit SQL operation. Procedure `checkIn` does not have to take the same path name that was passed to check-out operation. However, the check-in path name and the check-out path name must be of the same resource for the operations to function correctly. If the resource has been renamed, then the new name must be used to check in because the old name is either invalid or bound with a different resource at the time being. Exception is raised if the path name does not exist. If the path name has been changed, then the new path name must be used to check in the resource.
`FUNCTION unCheckOut` `unCheckOut(pathname VARCHAR2) RETURN DBMS_XDB.RESID_TYPE;`	Checks in a checked-out resource. `pathname` - the path name of the checked-out resource. `return` - the resource id of the version before the resource is checked out. This is not an auto-commit SQL operation. Procedure `unCheckOut` does not have to take the same `path name` that was passed to check-out operation. However, the `unCheckOut` path name and the check-out path name must be of the same resource for the operations to function correctly. If the resource has been renamed, then the new name must be used for `unCheckOut` because the old name is either invalid or bound with a different resource at the time being. An exception is raised if the path name does not exist. If the path name has been changed, then the new path name must be used to check in the resource.

Table 24–2 (Cont.) DBMS_XDB_VERSION Functions and Procedures

Function/Procedure	Description
FUNCTION GetPredecessors GetPredecessors(pathname VARCHAR2) RETURN RESID_LIST_TYPE; GetPredsByResId(resid DBMS_XDB.RESID_TYPE) RETURN RESID_LIST_TYPE;	Given a version resource or a VCR, gets the predecessors of the resource by pathname, the path name of the resource. return - list of predecessors. Getting predecessors by resid is more efficient than by pathname. An exception is raised if the resid or pathname is not permitted. Given a version resource or a VCR, gets the predecessors of the resource by resid (resource id) Note: The list of predecessors only contains one element (immediate parent), because Oracle does not support branching in this release. The following function GetSuccessors also returns only one element.
FUNCTION GetSuccessors GetSuccessors(pathname VARCHAR2) RETURN RESID_LIST_TYPE; GetSuccsByResId(resid DBMS_XDB.RESID_TYPE) RETURN RESID_LIST_TYPE;	Given a version resource or a VCR, gets the successors of the resource by pathname, the path name of the resource. return - list of predecessors. Getting successors by resid is more efficient than by path name. An exception is raised if the resid or pathname is not permitted. Given a version resource or a VCR, get the successors of the resource by resid (resource id).
FUNCTION GetResourceByResId GetResourceByResId(resid DBMS_XDB.RESID_TYPE) RETURN XMLType;	Given a resource object ID, gets the resource as an XMLType. resid - the resource object ID return - the resource as an XMLType

Guidelines for Using Oracle XML DB Versioning

This section describes guidelines for using Oracle XML DB versioning.

- You cannot change a VCR to no longer be version-controlled.
- You can access an old copy of a VCR after updating it. The old copy is the version resource of the last one checked-in, hence:
  - If you have the version ID or path name, then you can load it using that ID.
  - If you do not have its ID, then you can call getPredecessors() to get the ID.
- Only data in Oracle XML DB resources can be put under version control.
- When a resource is turned into a VCR, a copy of the resource is created and placed into the version history. A flag marks the resource as a VCR. Earlier in this chapter it states that a version-controlled resource is an Oracle XML DB resource that is put under version control where a VCR is a reference to a version Oracle XML DB resource. It is not physically stored in the database. In other words no extra copy of the resource is stored when the resource is versioned, that is, turned into a VCR.
- Versions are stored in the same object-relational tables as resources. Versioning works for non-schema-based resources. It works also for XML schema-based resources, if the schema tables have no associated triggers or constraints.
- The documentation states that a version resource is a system-generated resource and does not have a path name. However you can still access the resource using the navigational path.
- When the VCR resource is checked out, no copy of the resource is created. When it is updated the first time, a copy of the resource is created. You can make several

changes to the resource without checking it in. You will get the latest copy of the resource. Even if you are a different user, you will get the latest copy.

- Updates cannot be made to a checked out version by more than one use. Once the check-out happens and the transaction is committed, any user can edit the resource.
- When a checked-out resource is checked in, the original previously checked-out version is added to the version history.
- Resource metadata is maintained for each version. Versions are stored in the same tables. Versioning works only for non-schema-based resources or XML schema-based resources if the schema tables have no associated triggers or constraints.

25

SQL Access Using RESOURCE_VIEW and PATH_VIEW

This chapter describes the predefined public views, RESOURCE_VIEW and PATH_VIEW, that provide access to Oracle XML DB repository data. It discusses SQL functions under_path and equals_path that query resources based on their path names and path and depth that return resource path names and depths, respectively.

This chapter contains these topics:

- Overview of Oracle XML DB RESOURCE_VIEW and PATH_VIEW
- RESOURCE_VIEW and PATH_VIEW SQL Functions
- Using RESOURCE_VIEW and PATH_VIEW SQL Functions
- Working with Multiple Oracle XML DB Resources
- Performance Tuning of Oracle XML DB Resource Queries
- Searching for Resources Using Oracle Text

See Also:

- *Oracle Database Reference* for more information about view PATH_VIEW
- *Oracle Database Reference* for more information about view RESOURCE_VIEW

Overview of Oracle XML DB RESOURCE_VIEW and PATH_VIEW

Figure 25–1 shows how Oracle XML DB RESOURCE_VIEW and PATH_VIEW provide a mechanism for using SQL to access data stored in Oracle XML DB Repository. Data stored in the repository using protocols such as FTP and WebDAV, or using application program interfaces (APIs), can be accessed in SQL using RESOURCE_VIEW values and PATH_VIEW values.

RESOURCE_VIEW consists of a resource, itself an XMLType, that contains the name of the resource that can be queried, its ACLs, and its properties, static or extensible.

- If the content comprising the resource is XML, stored somewhere in an XMLType table or view, then the RESOURCE_VIEW points to the XMLType row that stores the content.
- If the content is not XML, then the RESOURCE_VIEW stores it as a LOB.

Parent-child relationships between folders (necessary to construct the hierarchy) are maintained and traversed efficiently using the hierarchical repository index. Text

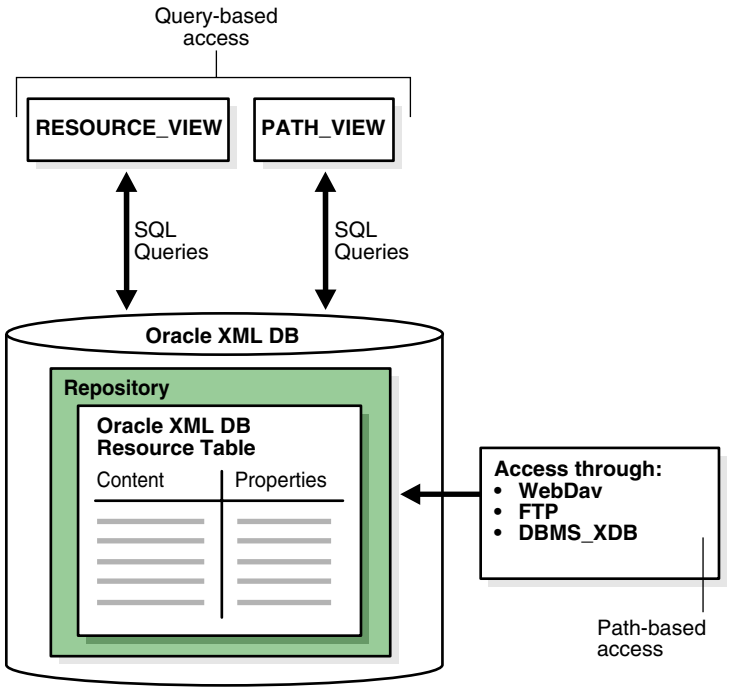
indexes are available to search the properties of a resource, and internal B-tree indexes over Names and ACLs speed up access to these attributes of the Resource XMLType.

RESOURCE_VIEW and PATH_VIEW, along with PL/SQL package DBMS_XDB, provide all query-based access to Oracle XML DB and DML functionality that is available through the API.

The base table for RESOURCE_VIEW is XDB.XDB$RESOURCE. This table should only be accessed through RESOURCE_VIEW or the DBMS_XDB API.

See Also: Chapter 3, "Using Oracle XML DB"

Figure 25–1 Accessing Repository Resources Using RESOURCE_VIEW and PATH_VIEW



RESOURCE_VIEW Definition and Structure

The RESOURCE_VIEW contains one row for each resource in Oracle XML DB Repository. Table 25–1 describes its structure.

Table 25–1 Structure of RESOURCE_VIEW

Column	Data Type	Description
RES	XMLType	A resource in the repository
ANY_PATH	VARCHAR2	An (absolute) path to the resource
RESID	RAW	Resource OID, which is a unique handle to the resource

PATH_VIEW Definition and Structure

The PATH_VIEW contains one row for each unique path to access a resource in Oracle XML DB Repository. Each resource may have multiple paths, also called **links**. Table 25–2 describes its structure.

Table 25–2 Structure of PATH_VIEW

Column	Data Type	Description
PATH	VARCHAR2	An (absolute) path to repository resource RES
RES	XMLType	The resource referred to by column PATH
LINK	XMLType	Link property
RESID	RAW	Resource OID

Figure 25–2 illustrates the structure of RESOURCE_VIEW and PATH_VIEW.

The path in the RESOURCE_VIEW is an arbitrary one and one of the accessible paths that can be used to access that resource. Oracle XML DB provides SQL function under_path, which enables applications to search for resources contained (recursively) within a particular folder, get the resource depth, and so on. Each row in the PATH_VIEW and RESOURCE_VIEW columns is of XMLType. DML on repository views can be used to insert, rename, delete, and update resource properties and contents. Programmatic APIs must be used for some operations, such as creating links to existing resources.

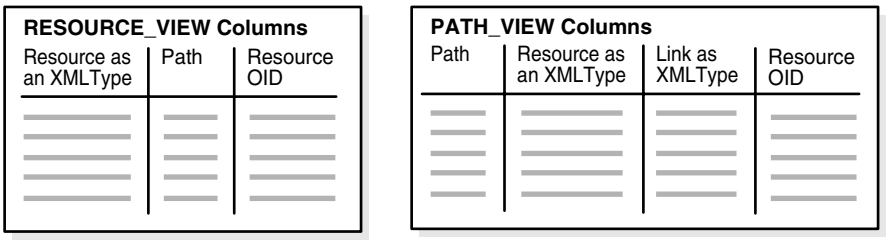
Paths in the ANY_PATH column of the RESOURCE_VIEW and the PATH column in the PATH_VIEW are *absolute* paths: they start at the root.

> **Note:** You should test resource paths for equality using SQL function equals_path: equals_path('/my/path') = 1. Do *not* test ANY_PATH for equality against an absolute path: ANY_PATH = '/my/path'.

Paths returned by the path function are *relative* paths under the path name specified by function under_path. For example, if there are two resources referenced by path names /a/b/c and /a/d, respectively, then a path expression that retrieves paths under folder /a will return relative paths b/c and d.

When there are multiple links to the same resource, only paths under the path name specified by function under_path are returned. If /a/b/c, /a/b/d, and /a/e are all links to the same resource, then a query on PATH_VIEW that retrieves all of the paths under /a/b returns only /a/b/c and /a/b/d, not /a/e.

Figure 25–2 RESOURCE_VIEW and PATH_VIEW Structure



Understanding the Difference Between RESOURCE_VIEW and PATH_VIEW

Views RESOURCE_VIEW and PATH_VIEW differ as follows:

- PATH_VIEW displays *all* the path names to a particular resource. RESOURCE_VIEW displays *one* of the possible path names to the resource

- PATH_VIEW also displays the properties of the link

Figure 25–3 illustrates this difference between RESOURCE_VIEW and PATH_VIEW.

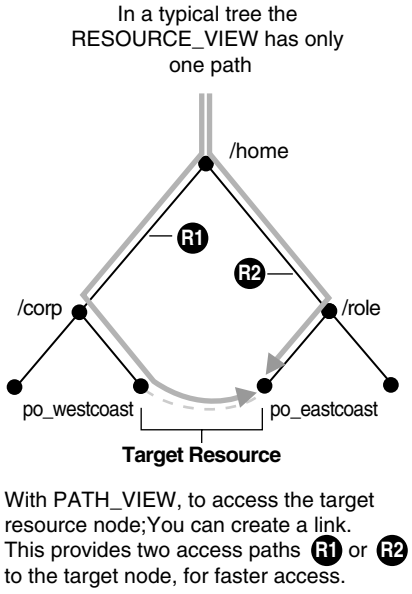
Because many Internet applications only need one URL to access a resource, RESOURCE_VIEW is widely applicable.

PATH_VIEW contains the *link* properties as well as resource properties, whereas the RESOURCE_VIEW only contains resource properties.

The RESOURCE_VIEW benefit is generally optimization. If the database knows that only one path is needed, then the index does not have to do as much work to determine all the possible paths.

Note: When using the RESOURCE_VIEW, if you are specifying a path with functions under_path or equals_path, then they will find the resource regardless of whether or not that path is the arbitrary one chosen to normally appear with that resource using RESOURCE_VIEW.

Figure 25–3 RESOURCE_VIEW and PATH_VIEW Explained



RESOURCE_VIEW Example:
select path(1) from RESOURCE_VIEW where under_path(res, '/sys',1);
displays one path to the resource:
/home/corp/po_westcoast

PATH_VIEW Example:
select path from PATH_VIEW;
displays all pathnames to the resource:
/home/corp/po_westcoast
/home/role/po_eastcoast

Operations You Can Perform Using UNDER_PATH and EQUALS_PATH

You can perform the following operations using under_path and equals_path:

- Given a path name:
  - Get a resource or its OID
  - List the directory given by the path name
  - Create a resource
  - Delete a resource
  - Update a resource
- Given a condition, containing SQL function under_path or other SQL functions:

- Update resources
- Delete resources
- Get resources or their OID

See the "Using RESOURCE_VIEW and PATH_VIEW SQL Functions" and `equals_path`.

RESOURCE_VIEW and PATH_VIEW SQL Functions

This section describes the SQL functions applicable to `RESOURCE_VIEW` and `PATH_VIEW`.

UNDER_PATH SQL Function

SQL function `under_path` uses the hierarchical index of Oracle XML DB Repository to return the paths under a particular path. This index is designed to speed access when traversing a path (the most common usage).

If the other parts of the query predicate are very selective, however, then a functional implementation of `under_path` can be chosen that walks back up the repository. This can be more efficient, because a much smaller number of links are required to be traversed. Figure 25–4 shows the `under_path` syntax.

Figure 25–4 UNDER_PATH Syntax

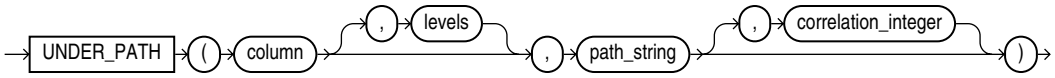


Table 25–3 details the signature of SQL function `under_path`.

Table 25–3 UNDER_PATH SQL Function Signature

Syntax	Description
`under_path(resource_column, pathname);`	Determines if a resource is under a specified path. Parameters: ▪ `resource_column` - The column name or column alias of the `RESOURCE` column in the `PATH_VIEW` or `RESOURCE_VIEW`. ▪ `pathname` - The path name to resolve.
`under_path(resource_column, depth, pathname);`	Determines if a resource is under a specified path, with a depth argument to restrict the number of levels to search. Parameters: ▪ `resource_column` - The column name or column alias of the `RESOURCE` column in the `PATH_VIEW` or `RESOURCE_VIEW`. ▪ `depth` - The maximum depth to search. A nonnegative integer. ▪ `pathname` - The path name to resolve.

Table 25–3 (Cont.) UNDER_PATH SQL Function Signature

Syntax	Description
`under_path(resource_column, pathname, correlation);`	Determines if a resource is under a specified path, with a correlation argument for related SQL functions. Parameters: ▪ `resource_column` - The column name or column alias of the `RESOURCE` column in the `PATH_VIEW` or `RESOURCE_VIEW`. ▪ `pathname` - The path name to resolve. ▪ `correlation` - An integer that can be used to correlate `under_path` with related SQL functions (`path` and `depth`).
`under_path(resource_column, depth, pathname, correlation);`	Determines if a resource is under a specified path with a depth argument to restrict the number of levels to search, and with a correlation argument for related SQL functions. Parameters: ▪ `resource_column` - The column name or column alias of the `RESOURCE` column in the `PATH_VIEW` or `RESOURCE_VIEW`. ▪ `depth` - The maximum depth to search. A nonnegative integer. ▪ `pathname` - The path name to resolve. ▪ `correlation` - An integer that can be used to correlate `under_path` with related SQL functions (`path` and `depth`). Note that only one of the accessible paths to the resource must be under the path argument for a resource to be returned.

EQUALS_PATH SQL Function

SQL function `equals_path` is used to find the resource with the specified path name. It is functionally equivalent to `under_path` with a depth restriction of zero.

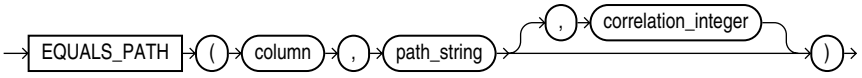
```
equals_path(resource_column, pathname);
```

where:

- `resource_column` is the column name or column alias of the `RESOURCE` column in `PATH_VIEW` or `RESOURCE_VIEW`.
- `pathname` is the (absolute) path name to resolve. This can contain components that are hard or weak resource links.

Figure 25–5 illustrates the complete `equals_path` syntax.

Figure 25–5 EQUALS_PATH Syntax



Note: You should test resource paths for equality using SQL function `equals_path`: `equals_path('/my/path') = 1`. Do *not* test `ANY_PATH` for equality against an absolute path: `ANY_PATH = '/my/path'`.

PATH SQL Function

SQL function path returns the relative path name of the resource under the specified pathname argument. Note that the path column in the RESOURCE_VIEW always contains the absolute path of the resource. The path syntax is:

```
path(correlation);
```

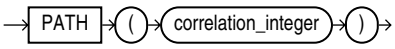
where:

- correlation is an integer that can be used to correlate under_path with related SQL functions (path and depth).

> **Note:** If a path is not under the specified pathname argument, a NULL value is returned as the output of the current path.

Figure 25–6 illustrates the path syntax.

Figure 25–6 PATH Syntax



DEPTH SQL Function

SQL function depth returns the folder depth of the resource under the specified starting path.

```
depth(correlation);
```

where:

correlation is an integer that can be used to correlate under_path with related SQL functions (path and depth).

Using RESOURCE_VIEW and PATH_VIEW SQL Functions

The following RESOURCE_VIEW and PATH_VIEW examples use SQL functions under_path, equals_path, path, and depth.

Accessing Repository Data Paths, Resources and Links: Examples

The following examples illustrate how you can access paths, resources, and link properties in Oracle XML DB Repository. The first few examples use resources specified by the following paths:

```
/a/b/c
/a/b/c/d
/a/e/c
/a/e/c/d
```

Example 25–1 Determining Paths Under a Path: Relative

This example uses SQL function path to retrieve the *relative* paths under path /a/b.

```
SELECT path(1) FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b', 1) = 1;
```

Returns the following:

```
PATH(1)
-------
c
c/d

2 rows selected.
```

Example 25–2 Determining Paths Under a Path: Absolute

This example uses `ANY_PATH` to retrieve the *absolute* paths under path `/a/b`.

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b') = 1;
```

This returns the following:

```
ANY_PATH
--------
/a/b/c
/a/b/c/d

2 rows selected.
```

Example 25–3 Determining Paths Not Under a Path

This is the same example as Example 25–2, except that the test is *not*-equals (`!=`) instead of equals (=). This query finds *all paths in the repository* that are *not* under path `/a/b`.

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/a/b') != 1
```

This produces a result like the following:

```
ANY_PATH
--------
/a
/a/b
/a/e
/a/e/c
/a/e/c/d
/home
/home/OE
/home/OE/PurchaseOrders
/home/OE/PurchaseOrders/2002
/home/OE/PurchaseOrders/2002/Apr
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336271PDT.xml
/home/OE/PurchaseOrders/2002/Apr/EABEL-20021009123336251PDT.xml
. . .
/public
/sys
/sys/acls
/sys/acls/all_all_acl.xml
/sys/acls/all_owner_acl.xml
/sys/acls/bootstrap_acl.xml
/sys/acls/ro_all_acl.xml
/sys/apps
/sys/databaseSummary.xml
/sys/log
/sys/schemas
/sys/schemas/OE
/sys/schemas/OE/localhost:8080
. . .
```

```
202 rows selected.
```

Example 25–4 Determining Paths Using Multiple Correlations

```
SELECT ANY_PATH, path(1), path(2)
  FROM RESOURCE_VIEW
  WHERE under_path(RES, '/a/b', 1) = 1 OR under_path(RES, '/a/e', 2) = 1;
```

This returns the following:

```
ANY_PATH   PATH(1)  PATH(2)
---------- -------- --------
/a/b/c     c
/a/b/c/d   c/d
/a/e/c              c
/a/e/c/d            c/d

4 rows selected.
```

To obtain all of the resources under a directory, you can use `LIKE`, as shown in Example 25–5. To obtain all of the resources up to a certain number of levels or to obtain the relative path, use SQL function `under_path`, as shown in Example 25–7. Example 25–5 is more efficient than Example 25–7.

Example 25–5 Using ANY_PATH with LIKE

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE ANY_PATH LIKE '/sys%';
```

This produces a result like the following:

```
ANY_PATH
--------
/sys
/sys/acls
/sys/acls/all_all_acl.xml
/sys/acls/all_owner_acl.xml
/sys/acls/bootstrap_acl.xml
/sys/acls/ro_all_acl.xml
/sys/apps
/sys/databaseSummary.xml
/sys/log
/sys/schemas
/sys/schemas/OE
/sys/schemas/OE/localhost:8080
/sys/schemas/OE/localhost:8080/source
/sys/schemas/OE/localhost:8080/source/schemas
/sys/schemas/OE/localhost:8080/source/schemas/poSource
/sys/schemas/OE/localhost:8080/source/schemas/poSource/xsd
/sys/schemas/OE/localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd
/sys/schemas/PUBLIC
/sys/schemas/PUBLIC/www.w3.org
/sys/schemas/PUBLIC/www.w3.org/2001
/sys/schemas/PUBLIC/www.w3.org/2001/xml.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com
. . .

42 rows selected.
```

Example 25–6 Relative Path Names for Three Levels of Resources

```
SELECT path(1) FROM RESOURCE_VIEW WHERE under_path(RES, 3, '/sys', 1) = 1;
```

This produces a result like the following:

```
PATH(1)
-------
acls
acls/all_all_acl.xml
acls/all_owner_acl.xml
acls/bootstrap_acl.xml
acls/ro_all_acl.xml
apps
databaseSummary.xml
log
schemas
schemas/OE
schemas/OE/localhost:8080
schemas/PUBLIC
schemas/PUBLIC/www.w3.org
schemas/PUBLIC/xmlns.oracle.com

14 rows selected.
```

Example 25–7 Extracting Resource Metadata using UNDER_PATH

```
SELECT ANY_PATH, extract(RES, '/Resource') FROM RESOURCE_VIEW
   WHERE under_path(RES, '/sys') = 1;
```

This produces a result like the following:

```
ANY_PATH
--------
EXTRACT(RES,'/RESOURCE')
------------------------
/sys/acls
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd">
  <CreationDate>2005-02-07T18:31:53.093179</CreationDate>
  <ModificationDate>2005-02-07T18:31:55.852963</ModificationDate>
  <DisplayName>acls</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>ISO-8859-1</CharacterSet>
  <ContentType>application/octet-stream</ContentType>
  <RefCount>1</RefCount>
</Resource>

/sys/acls/all_all_acl.xml
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd">
  <CreationDate>2005-02-07T18:31:55.745970</CreationDate>
  <ModificationDate>2005-02-07T18:31:55.745970</ModificationDate>
  <DisplayName>all_all_acl.xml</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>ISO-8859-1</CharacterSet>
  <ContentType>text/xml</ContentType>
  <RefCount>1</RefCount>
</Resource>
. . .
41 rows selected.
```

Example 25–8 Using Functions PATH and DEPTH with PATH_VIEW

```
SELECT path(1) path, depth(1) depth FROM PATH_VIEW
  WHERE under_path(RES, 3, '/sys', 1) = 1;
```

This produces a result like the following:

```
PATH                                     DEPTH
----                                     -----
acls                                     1
acls/all_all_acl.xml                     2
acls/all_owner_acl.xml                   2
acls/bootstrap_acl.xml                   2
acls/ro_all_acl.xml                      2
apps                                     1
databaseSummary.xml                      1
log                                      1
schemas                                  1
schemas/OE                               2
schemas/OE/localhost:8080                3
schemas/PUBLIC                           2
schemas/PUBLIC/www.w3.org                3
schemas/PUBLIC/xmlns.oracle.com          3

14 rows selected.
```

Example 25–9 Extracting Link and Resource Information from PATH_VIEW

```
SELECT PATH,
       extract(LINK, '/LINK/Name/text()').getstringval(),
       extract(LINK, '/LINK/ParentName/text()').getstringval(),
       extract(LINK, '/LINK/ChildName/text()').getstringval(),
       extract(RES,  '/Resource/DisplayName/text()').getstringval()
  FROM PATH_VIEW
  WHERE PATH LIKE '/sys%';
```

This produces a result like the following:

```
/sys
sys
/
sys
sys

/sys/acls
acls
sys
acls
acls

/sys/acls/all_all_acl.xml
all_all_acl.xml
acls
all_all_acl.xml
all_all_acl.xml

/sys/acls/all_owner_acl.xml
all_owner_acl.xml
acls
all_owner_acl.xml
all_owner_acl.xml
```

```
/sys/acls/bootstrap_acl.xml
bootstrap_acl.xml
acls
bootstrap_acl.xml
bootstrap_acl.xml
. . .

42 rows selected.
```

Example 25–10 All Paths to a Certain Depth Under a Path

```
SELECT path(1) FROM PATH_VIEW WHERE under_path(RES, 3, '/sys', 1) > 0 ;
```

This produces a result like the following:

```
PATH(1)
-------
schemas
acls
log
schemas/PUBLIC
schemas/PUBLIC/xmlns.oracle.com
acls/bootstrap_acl.xml
acls/all_all_acl.xml
acls/all_owner_acl.xml
acls/ro_all_acl.xml
schemas/PUBLIC/www.w3.org
apps
databaseSummary.xml

12 rows selected.
```

Example 25–11 Using EQUALS_PATH to Locate a Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE equals_path(RES, '/sys') > 0;
```

This produces the following result:

```
ANY_PATH
--------
/sys

1 row selected.
```

Example 25–12 Retrieve RESID of a Given Resource

```
SELECT RESID FROM RESOURCE_VIEW
  WHERE extract(RES, '/Resource/Dispname') = 'example';
```

This produces a result like the following:

```
RESID
--------------------------------
F301A10152470252E030578CB00B432B

1 row selected.
```

Example 25–13 Obtaining the Path Name of a Resource from its RESID

```
DECLARE
  resid_example RAW(16);
  path          VARCHAR2(4000);
```

```
BEGIN
  SELECT RESID INTO resid_example FROM RESOURCE_VIEW
    WHERE extractValue(RES, '/Resource/DisplayName') = 'example';
  SELECT ANY_PATH INTO path FROM RESOURCE_VIEW WHERE RESID = resid_example;
  DBMS_OUTPUT.put_line('The path is: ' || path);
END;
/
The path is: /public/example

PL/SQL procedure successfully completed.
```

Example 25–14 Folders Under a Given Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE under_path(RES, 1, '/sys') = 1
    AND existsNode(RES, '/Resource[@Container="true"]') = 1;
```

This produces a result like the following:

```
ANY_PATH
--------
/sys/acls
/sys/apps
/sys/log
/sys/schemas

4 rows selected.
```

Example 25–15 Joining RESOURCE_VIEW with an XMLType Table

```
SELECT ANY_PATH, extract(value(e), '/PurchaseOrder/LineItems').getclobval()
  FROM purchaseorder e, RESOURCE_VIEW r
  WHERE extractValue(r.RES, '/Resource/XMLRef') = ref(e) AND ROWNUM < 2;
```

This produces the following result:

```
ANY_PATH
--------------------------------------------------------------------------------
EXTRACT(VALUE(E),'/PURCHASEORDER/LINEITEMS').GETCLOBVAL()
--------------------------------------------------------------------------------
/home/OE/PurchaseOrders/2002/Apr/AMCEWEN-20021009123336171PDT.xml
<LineItems>
  <LineItem ItemNumber="1">
    <Description>Salesman</Description>
    <Part Id="37429158920" UnitPrice="39.95" Quantity="2"/>
  </LineItem>
  <LineItem ItemNumber="2">
    <Description>Big Deal on Madonna Street</Description>
    <Part Id="37429155424" UnitPrice="29.95" Quantity="1"/>
  </LineItem>
  <LineItem ItemNumber="3">
    <Description>Hearts and Minds</Description>
    <Part Id="37429166321" UnitPrice="39.95" Quantity="1"/>
  </LineItem>

. . .

  <LineItem ItemNumber="23">
    <Description>Great Expectations</Description>
    <Part Id="37429128022" UnitPrice="39.95" Quantity="4"/>
```

```
  </LineItem>
</LineItems>

1 row selected.
```

Deleting Repository Resources: Examples

The following examples illustrate how you can delete resources and paths.

Example 25–16 Deleting Resources

If you delete only *leaf* resources, then you can use `DELETE FROM RESOURCE_VIEW`:

```
DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, '/public/myfile') = 1';
```

For multiple links to the same resource, deleting from `RESOURCE_VIEW` deletes the resource together with *all* of its links; deleting from `PATH_VIEW` deletes only the link with the specified path.

Example 25–17 Deleting Links to Resources

For example, suppose `'/home/myfile1'` is a link to `'/public/myfile'`:

```
CALL DBMS_XDB.link('/public/myfile', '/home', 'myfile1');
```

This SQL DML statement deletes everything in Oracle XML DB Repository that is found at path `/home/myfile1` – both the link and the resource:

```
DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, '/home/myfile1') = 1;
```

This DML statement deletes *only the link* with path `/home/file1`:

```
DELETE FROM PATH_VIEW WHERE equals_path(RES, '/home/file1') = 1;
```

Deleting Nonempty Folder Resources

The `DELETE` DML operator is not allowed on a nonempty folder. If you try to delete a nonempty folder, you must first delete its contents and then delete the resulting empty folder. This rule must be applied recursively to any folders contained in the target folder.

However, the order of the paths returned from a `WHERE` clause is not guaranteed, and the `DELETE` operator does not allow an `ORDER BY` clause in its table-expression subclause. This means that you *cannot* do the following:

```
DELETE FROM (SELECT 1 FROM RESOURCE_VIEW
               WHERE under_path(RES, '/public', 1) = 1
               ORDER BY depth(1) DESCENDING);
```

Example 25–18 illustrates how to delete a nonempty folder.

Example 25–18 Deleting a Nonempty Folder

In this example, folder `example` is deleted, along with its subfolder `example1`.

```
SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/home/US1') = 1;

PATH
--------------------------
/home/US1/example
/home/US1/example/example1
```

```
2 rows selected.

DECLARE
  CURSOR c1 IS
    SELECT ANY_PATH p FROM RESOURCE_VIEW
      WHERE under_path(RES, '/home/US1', 1) = 1
        AND existsNode(RES, '/Resource[Owner="US1"]') = 1
      ORDER BY depth(1) DESC;
  del_stmt VARCHAR2(500)
    := 'DELETE FROM RESOURCE_VIEW WHERE equals_path(RES, :1)=1';
BEGIN
  FOR r1 IN c1 LOOP
    EXECUTE IMMEDIATE del_stmt USING r1.p;
  END LOOP;
END;
/

PL/SQL procedure successfully completed.

SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/home/US1') = 1;

no rows selected
```

Note: As always, care should be taken to avoid deadlocks with concurrent transactions when operating on multiple rows.

Updating Repository Resources: Examples

This section illustrates how to update resources and paths.

Example 25–19 Updating a Resource

This example changes the resource at path `/test/HR/example/paper`. This is the complete resource before the update:

```
SELECT r.RES.getCLOBVal()
  FROM RESOURCE_VIEW r WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;

R.RES.GETCLOBVAL()
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
  <CreationDate>2005-04-29T16:30:01.588835</CreationDate>
  <ModificationDate>2005-04-29T16:30:01.588835</ModificationDate>
  <DisplayName>paper</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>ISO-8859-1</CharacterSet>
  <ContentType>application/octet-stream</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracl
e.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:sch
emaLocation="http://xmlns.oracle.com/xdb/acl.xsd                          http:
//xmlns.oracle.com/xdb/acl.xsd">
      <ace>
        <principal>PUBLIC</principal>
        <grant>true</grant>
        <privilege>
```

```
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>TESTUSER1</Owner>
  <Creator>TESTUSER1</Creator>
  <LastModifier>TESTUSER1</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#binary</SchemaElement
>
  <Contents>
    <binary>4F7261636C65206F7220554E4958</binary>
  </Contents>
</Resource>

1 row selected.
```

All of the XML elements shown here are resource *metadata* elements, with the exception of `Contents`, which contains the resource *content*.

This `UPDATE` statement updates (only) the `DisplayName` metadata element.

```
UPDATE RESOURCE_VIEW r
  SET r.RES = updateXML(r.RES, '/Resource/DisplayName/text()', 'My New Paper')
    WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;

1 row updated.

SELECT r.RES.getCLOBVal()
  FROM RESOURCE_VIEW r WHERE equals_path(r.RES, '/test/HR/example/paper') = 1;

R.RES.GETCLOBVAL()
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
  <CreationDate>2005-04-29T16:30:01.588835</CreationDate>
  <ModificationDate>2005-04-29T16:30:01.883838</ModificationDate>
  <DisplayName>My New Paper</DisplayName>
  <Language>en-US</Language>

  . . .

  <Contents>
    <binary>4F7261636C65206F7220554E4958</binary>
  </Contents>
</Resource>

1 row selected.
```

> **See Also:** Chapter 29, "User-Defined Repository Metadata" for additional examples of updating resource metadata

Note that, by default, the `DisplayName` element content, `paper`, was the same text as the last location step of the resource path, `/test/HR/example/paper`. This is only the default value, however. The `DisplayName` is independent of the resource path, so updating it does not change the path.

Element `DisplayName` is defined by the WebDAV standard, and it is recognized by WebDAV applications. Applications, such as an FTP client, that are not WebDAV-based

will not recognize the DisplayName of a resource. An FTP client lists the resource as paper (using FTP command ls, for example) even after the UPDATE operation.

Example 25–20 Updating a Path in the PATH_VIEW

This example changes the path for the resource from /test/HR/example/paper to /test/myexample. It is analogous to using the Unix or Linux command mv /test/HR/example/paper /test/myexample.

```
SELECT ANY_PATH FROM RESOURCE_VIEW WHERE under_path(RES, '/test') = 1;

ANY_PATH
--------
/test/HR
/test/HR/example
/test/HR/example/paper

3 rows selected.

UPDATE PATH_VIEW
  SET PATH = '/test/myexample' WHERE PATH = '/test/HR/example/paper';

ANY_PATH
--------
/test/HR
/test/HR/example
/test/myexample

3 rows selected.
```

> **See Also:** Table 21–3, " Accessing Oracle XML DB Repository: API Options" on page 21-15 for additional examples that use the SQL functions that apply to RESOURCE_VIEW and PATH_VIEW

Working with Multiple Oracle XML DB Resources

The repository operations listed in Table 21–3 on page 21-15 typically apply to a single resource at a time. To perform the same operation on multiple Oracle XML DB resources, or to find one or more Oracle XML DB resources that meet a certain set of criteria, use SQL with RESOURCE_VIEW and PATH_VIEW.

For example, you can perform the following operations:

- Updating based on attributes – see Example 25–21
- Finding resources inside a folder – see Example 25–22
- Copying a set of Oracle XML DB resources – see Example 25–23

Example 25–21 Updating Resources Based on Attributes

```
UPDATE RESOURCE_VIEW
  SET RES = updateXML(RES, '/Resource/DisplayName/text()', 'My New Paper')
    WHERE extractValue(resource, '/Resource/DisplayName') = 'My Paper';

SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE extractValue(RES, '/Resource/DisplayName') = 'My New Paper';

ANY_PATH
---------------
/test/myexample
```

```
1 row selected.
```

Example 25–22 Finding Resources Inside a Folder

```
SELECT ANY_PATH FROM RESOURCE_VIEW
  WHERE under_path(resource, '/sys/schemas/PUBLIC/xmlns.oracle.com/xdb') = 1;

ANY_PATH
------------------------------------------------------------
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBFolderListing.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResource.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBSchema.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBStandard.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/dav.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/ftplog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/httplog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/log/xdblog.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/stats.xsd
/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/xdbconfig.xsd

12 rows selected.
```

Example 25–23 Copying Resources

This SQL DML statement copies all of the resources in folder `public` to folder `newlocation`. It is analogous to the Unix or Linux command `cp /public/* /newlocation`. Target folder `newlocation` must exist before the copy.

```
SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/test') = 1;

PATH
-----------------
/test/HR
/test/HR/example
/test/myexample

3 rows selected.

INSERT INTO PATH_VIEW
  SELECT '/newlocation/' || path(1), RES, LINK, NULL FROM PATH_VIEW
    WHERE under_path(RES, '/test', 1) = 1
    ORDER BY depth(1);

3 rows created.

SELECT PATH FROM PATH_VIEW WHERE under_path(RES, '/newlocation') = 1;

PATH
------------------------
/newlocation/HR
/newlocation/HR/example
/newlocation/myexample

3 rows selected.
```

Performance Tuning of Oracle XML DB Resource Queries

Oracle XML DB uses the `xdbconfig.xml` file for configuring the system and protocol environment. It includes an element parameter `resource-view-cache-size` that defines the in-memory size of the `RESOURCE_VIEW` cache. The default value is `1048576`.

The performance of some queries on `RESOURCE_VIEW` and `PATH_VIEW` can be improved by tuning `resource-view-cache-size`. In general, the bigger the cache size, the faster the query. The default `resource-view-cache-size` is appropriate for most cases, but you may want to enlarge your `resource-view-cache-size` element when querying a sizable `RESOURCE_VIEW`.

The extensible optimizer decides whether SQL functions `under_path` and `equals_path` are evaluated by a domain index scan or by functional implementation. To achieve the optimal query plan, the optimizer needs statistics for Oracle XML DB. Statistics can be collected by analyzing the Oracle XML DB tables and the hierarchical repository index under database schema (user account) `XDB` using PL/SQL package `DBMS_STATS`.

The default limits for the following elements are soft limits. The system automatically adapts when these limits are exceeded.

- `xdbcore-loadableunit-size` - This element indicates the maximum size to which a loadable unit (partition) can grow in Kilobytes. When a partition is read into memory or a partition is built while consuming a new document, the partition is built until it reaches the maximum size. The default value is 16 KB.
- `xdbcore-xobmem-bound` - This element indicates the maximum memory in kilobytes that a document is allowed to occupy. The default value is 1024 KB. Once the document exceeds this number, some loadable units (partitions) are swapped out.

See Also:

- Chapter 34, "Administering Oracle XML DB"
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Searching for Resources Using Oracle Text

Table `XDB$RESOURCE` in database schema `XDB` stores the metadata and content of repository resources. You can search for resources that contain a specific keyword by using SQL function `contains` with `RESOURCE_VIEW` or `PATH_VIEW`.

Example 25–24 Find All Resources Containing "Paper"

```
SELECT PATH FROM PATH_VIEW WHERE contains(RES, 'Paper') > 0;

PATH
-----------------------
/newlocation/myexample
/test/myexample

2 rows selected.
```

Example 25–25 Find All Resources Containing "Paper" that are Under a Specified Path

```
SELECT ANY_PATH FROM RESOURCE_VIEW
   WHERE contains(RES, 'Paper') > 0 AND under_path(RES, '/test') > 0;
```

```
ANY_PATH
---------------
/test/myexample

1 row selected.
```

To evaluate such queries, you must first create a context index on the XDB$RESOURCE table. Depending on the type of documents stored in Oracle XML DB, choose one of the following options for creating your context index:

- *If Oracle XML DB contains only XML documents*, that is, no binary data, then a regular Context Index can be created on the XDB$RESOURCE table. This is the case for Example 25–25.

  ```
  CREATE INDEX xdb$resource_ctx_i ON XDB.XDB$RESOURCE(OBJECT_VALUE)
    INDEXTYPE IS CTXSYS.CONTEXT;
  ```

  See Also: Chapter 4, "XMLType Operations" and Chapter 11, "Full-Text Search Over XML Data"

- *If Oracle XML DB contains binary data* such as Microsoft Word documents, then a user filter is required to filter such documents prior to indexing. Use package DBMS_XDBT (dbmsxdbt.sql) to create and configure the Context Index.

  ```
  -- Install the package - connected as SYS
  @dbmsxdbt
  -- Create the preferences
  EXEC DBMS_XDBT.createPreferences;
  -- Create the index
  EXEC DBMS_XDBT.createIndex;
  ```

  See Also:

  - *Oracle Database PL/SQL Packages and Types Reference*, for information about installing and using DBMS_XDBT.
  - "APIs for XML" on page 1-5

Package DBMS_XDBT also includes procedures to synchronize and optimize the index. You can use procedure configureAutoSync() to configure automatically sync the index by using job queues.

26

Using PL/SQL to Access the Repository

This chapter describes the Oracle XML DB resource application program interface (API) for PL/SQL (PL/SQL package `DBMS_XDB`). It contains these topics:

Overview of PL/SQL Package DBMS_XDB

PL/SQL package `DBMS_XDB` is the Oracle XML DB resource application program interface (API) for PL/SQL. It is also known as the PL/SQL *foldering* API. This API provides functions and procedures to access and manage Oracle XML DB Repository resources using PL/SQL. It includes methods for managing resource security and Oracle XML DB configuration.

Oracle XML DB Repository is modeled on XML, and provides a database file system for any data. The repository maps path names (or URLs) onto database objects of `XMLType` and provides management facilities for these objects.

PL/SQL package `DBMS_XDB` is an API that you can use to manage all of the following:

- Oracle XML DB resources
- Oracle XML DB security based on access control lists (ACLs). An ACL is a list of access control entries (ACEs) that determines which principals (users and roles) have access to which resources
- Oracle XML DB configuration

See Also:

- *Oracle Database PL/SQL Packages and Types Reference*
- "APIs for XML" on page 1-5

DBMS_XDB: Resource Management

Table 26–1 describes the `DBMS_XDB` Oracle XML DB resource management functions and procedures.

Table 26–1 DBMS_XDB Resource Management Functions and Procedures

Function/Procedure	Description
appendResourceMetadata	Add user-defined metadata to a resource.
createFolder	Create a new folder resource.
createOIDPath	Create a virtual path to a resource, based on its object identifier (OID).
createResource	Create a new file resource.
deleteResource	Delete a resource from the repository.
deleteResourceMetadata	Delete specific user-defined metadata from a resource.
existsResource	Indicate whether or not a resource exists, given its absolute path.
getLockToken	Return a resource lock token for the current user, given a path to the resource.
getResOID	Return the object identifier (OID) of a resource, given its absolute path.
getXDB_tablespace	Return the current tablespace of database schema (user account) XDB.
link	Create a link to an existing resource.
lockResource	Obtain a WebDAV-style lock on a resource, given a path to the resource.
moveXDB_tablespace	Move user XDB to the specified tablespace.
purgeResourceMetadata	Delete all user-defined metadata from a resource.
rebuildHierarchicalIndex	Rebuild the hierarchical repository index, after import or export operations.
renameResource	Rename a resource.
unlockResource	Unlock a resource, given its lock token and path.
updateResourceMetadata	Modify user-defined resource metadata.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

The examples in this section illustrate the use of these functions and procedures.

Example 26–1 Using DBMS_XDB to Manage Resources

This example uses package DBMS_XDB to manage repository resources. It creates the following:

- a folder, mydocs, under folder /public
- two file resources, emp_selby.xml and emp_david.xml
- two links to the file resources, person_selby.xml and person_david.xml

It then deletes each of the newly created resources and links. The folder contents are deleted before the folder itself.

```
DECLARE
  retb BOOLEAN;
BEGIN
  retb := DBMS_XDB.createfolder('/public/mydocs');
  retb := DBMS_XDB.createresource('/public/mydocs/emp_selby.xml',
                                  '<emp_name>selby</emp_name>');
  retb := DBMS_XDB.createresource('/public/mydocs/emp_david.xml',
                                  '<emp_name>david</emp_name>');
END;
/
PL/SQL procedure successfully completed.
```

```
CALL DBMS_XDB.link('/public/mydocs/emp_selby.xml',
                   '/public/mydocs',
                   'person_selby.xml');
Call completed.

CALL DBMS_XDB.link('/public/mydocs/emp_david.xml',
                   '/public/mydocs',
                   'person_david.xml');
Call completed.

CALL DBMS_XDB.deleteresource('/public/mydocs/emp_selby.xml');
Call completed.

CALL DBMS_XDB.deleteresource('/public/mydocs/person_selby.xml');
Call completed.

CALL DBMS_XDB.deleteresource('/public/mydocs/emp_david.xml');
Call completed.

CALL DBMS_XDB.deleteresource('/public/mydocs/person_david.xml');
Call completed.

CALL DBMS_XDB.deleteresource('/public/mydocs');
Call completed.
```

> **See Also:** Chapter 29, "User-Defined Repository Metadata" for examples using `appendResourceMetadata` and `deleteResourceMetadata`

DBMS_XDB: ACL-Based Security Management

Table 26–2 lists the `DBMS_XDB` Oracle XML DB ACL- based security management functions and procedures.

Table 26–2 DBMS_XDB: Security Management Procedures and Functions

Function/Procedure	Description
`ACLCheckPrivileges`	Checks the access privileges granted to the current user by an ACL.
`changePrivileges`	Adds an ACE to a resource ACL.
`checkPrivileges`	Checks the access privileges granted to the current user for a resource.
`getACLDocument`	Retrieves the ACL document that protects a resource, given the path name of the resource.
`getPrivileges`	Returns all privileges granted to the current user for a resource.
`setACL`	Sets the ACL on a resource.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle XML Developer's Kit Programmer's Guide*

The examples in this section illustrate the use of these functions and procedures.

Example 26–2 Using Procedure DBMS_XDB.getACLDocument

In this example, database sample-schema user `hr` creates two resources: a folder, `/public/mydocs`, with a file in it, `emp_selby.xml`. Procedure `getACLDocument` is called on the file resource, showing that the `<principal>` user for the document is `PUBLIC`.

```
CONNECT hr/hr
Connected.

DECLARE
  retb BOOLEAN;
BEGIN
  retb := DBMS_XDB.createFolder('/public/mydocs');
  retb := DBMS_XDB.createResource('/public/mydocs/emp_selby.xml',
                                  '<emp_name>selby</emp_name>');
END;
/
PL/SQL procedure successfully completed.

SELECT DBMS_XDB.getACLDocument('/public/mydocs/emp_selby.xml').getCLOBVal()
  FROM DUAL;

DBMS_XDB.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML').GETCLOBVAL()
--------------------------------------------------------------------------------
<acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracle.co
m/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaL
ocation="http://xmlns.oracle.com/xdb/acl.xsd                          http://xm
lns.oracle.com/xdb/acl.xsd">
  <ace>
    <principal>PUBLIC</principal>
    <grant>true</grant>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

Example 26–3 Using Procedure DBMS_XDB.setACL

In this example, the system manager connects and uses procedure `setACL` to give the owner (`hr`) all privileges on the file resource created in Example 26–2. Procedure `getACLDocument` then shows that the `<principal>` user is `dav:owner`, the owner (`hr`).

```
CONNECT SYSTEM/MANAGER
Connected.

-- Give all privileges to owner, HR.
CALL DBMS_XDB.setACL('/public/mydocs/emp_selby.xml',
                     '/sys/acls/all_owner_acl.xml');
Call completed.
COMMIT;
Commit complete.

SELECT DBMS_XDB.getACLDocument('/public/mydocs/emp_selby.xml').getCLOBVal()
  FROM DUAL;

DBMS_XDB.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML').GETCLOBVAL()
```

```
--------------------------------------------------------------------------------
<acl description="Private:All privileges to OWNER only and not accessible to oth
ers" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:" xmlns:xsi="htt
p://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.
com/xdb/acl.xsd                          http://xmlns.oracle.com/xdb/acl.xsd">
  <ace>
    <principal>dav:owner</principal>
    <grant>true</grant>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

Example 26–4 Using Function DBMS_XDB.changePrivileges

In this example, user `hr` connects and uses function `changePrivileges` to add a new access control entry (ACE) to the ACL, which gives all privileges on resource `emp_selby.xml` to user `oe`. Procedure `getACLDocument` shows that the new ACE was added to the ACL.

```
CONNECT hr
Password: *************

Connected.

SET SERVEROUTPUT ON

-- Add an ACE giving privileges to user OE
DECLARE
  r        PLS_INTEGER;
  ace      XMLType;
  ace_data VARCHAR2(2000);
BEGIN
  ace_data := '<ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                    xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                        http://xmlns.oracle.com/xdb/acl.xsd
                                        DAV:http://xmlns.oracle.com/xdb/dav.xsd">
                <principal>OE</principal>
                <grant>true</grant>
                <privilege><all/></privilege>
              </ace>';
  ace := XMLType.createXML(ace_data);
  r := DBMS_XDB.changePrivileges('/public/mydocs/emp_selby.xml', ace);
END;
/

PL/SQL procedure successfully completed.

SELECT DBMS_XDB.getACLDocument('/public/mydocs/emp_selby.xml').getCLOBVal()
  FROM DUAL;

DBMS_XDB.GETACLDOCUMENT('/PUBLIC/MYDOCS/EMP_SELBY.XML').GETCLOBVAL()
--------------------------------------------------------------------------------
<acl description="Private:All privileges to OWNER only and not accessible to oth
ers" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:" xmlns:xsi="htt
p://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.
com/xdb/acl.xsd                          http://xmlns.oracle.com/xdb/acl.xsd" s
```

```
hared="false">
  <ace>
    <principal>dav:owner</principal>
    <grant>true</grant>
    <privilege>
      <all/>
    </privilege>
  </ace>
  <ace>
    <principal>OE</principal>
    <grant>true</grant>
    <privilege>
      <all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

Example 26–5 Using Function DBMS_XDB.getPrivileges

In this example, user `oe` connects and calls `DBMS_XDB.getPrivileges`, which shows all of the privileges granted to user `oe` on resource `emp_selby.xml`.

```
CONNECT oe/oe
Connected.

SELECT DBMS_XDB.getPrivileges('/public/mydocs/emp_selby.xml') FROM DUAL;

DBMS_XDB.GETPRIVILEGES('/PUBLIC/MYDOCS/EMP_SELBY.XML').GETCLOBVAL()
--------------------------------------------------------------------------------
<privilege xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.
org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl
.xsd http://xmlns.oracle.com/xdb/acl.xsd DAV: http://xmlns.oracle.com/xdb/dav.xs
d" xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:">
  <read-properties/>
  <read-contents/>
  <update/>
  <link/>
  <unlink/>
  <read-acl/>
  <write-acl-ref/>
  <update-acl/>
  <resolve/>
  <link-to/>
  <unlink-from/>
  <dav:lock/>
  <dav:unlock/>
</privilege>

1 row selected.
```

DBMS_XDB: Configuration Management

Table 26–3 lists the `DBMS_XDB` Oracle XML DB configuration management functions and procedures.

Table 26–3 DBMS_XDB: Configuration Management Functions and Procedures

Function/Procedure	Description
`cfg_get`	Returns the configuration information for the current session.
`cfg_refresh`	Refreshes the session configuration information using the current Oracle XML DB configuration file, `xdbconfig.xml`.
`cfg_update`	Updates the Oracle XML DB configuration information. This writes the configuration file, `xdbconfig.xml`.
`getFTPPort`	Returns the current FTP port number.
`getHTTPPort`	Returns the current HTTP port number.
`setFTPPort`	Sets the Oracle XML DB FTP port to the specified port number.
`setHTTPPort`	Sets the Oracle XML DB HTTP port to the specified port number.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

The examples in this section illustrate the use of these functions and procedures.

Example 26–6 Using Function DBMS_XDB.cfg_get

In this example, function `cfg_get` is used to retrieve the Oracle XML DB configuration file, `xdbconfig.xml`.

```
CONNECT SYSTEM/MANAGER
Connected.

SELECT DBMS_XDB.cfg_get() FROM DUAL;

DBMS_XDB.CFG_GET()
--------------------------------------------------------------------------------
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd" xmlns:xsi="http://w
ww.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/x
db/xdbconfig.xsd                                    http://xmlns.oracle.com/xdb
/xdbconfig.xsd">
  <sysconfig>
    <acl-max-age>900</acl-max-age>
    <acl-cache-size>32</acl-cache-size>
    <invalid-pathname-chars>,</invalid-pathname-chars>
    <case-sensitive>true</case-sensitive>
    <call-timeout>300</call-timeout>
    <max-link-queue>65536</max-link-queue>
    <max-session-use>100</max-session-use>
    <persistent-sessions>false</persistent-sessions>
    <default-lock-timeout>3600</default-lock-timeout>
    <xdbcore-logfile-path/>
    <xdbcore-log-level>0</xdbcore-log-level>
    <resource-view-cache-size>1048576</resource-view-cache-size>
    <protocolconfig>
      <common>
        . . .
      </common>
      <ftpconfig>
        . . .
      </ftpconfig>
      <httpconfig>
        <http-port>8000</http-port>
        <http-listener>local_listener</http-listener>
```

```
        <http-protocol>tcp</http-protocol>
        <max-http-headers>64</max-http-headers>
        <max-header-size>16384</max-header-size>
        <max-request-body>2000000000</max-request-body>
        <session-timeout>6000</session-timeout>
        <server-name>XDB HTTP Server</server-name>
        <logfile-path/>
        <log-level>0</log-level>
        <servlet-realm>Basic realm=&amp;quot;XDB&amp;quot;</servlet-realm>
        <webappconfig>
        . . .
        </webappconfig>
      </httpconfig>
    </protocolconfig>
    <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
    <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
  </sysconfig>
</xdbconfig>

1 row selected.
```

Example 26–7 Using Procedure DBMS_XDB.cfg_update

This example illustrates the use of procedure `cfg_update`. The current configuration is retrieved as an `XMLType` instance and modified. It is then rewritten using `cfg_update`.

```
DECLARE
  configxml    SYS.XMLType;
  configxml2   SYS.XMLType;
BEGIN
  -- Get the current configuration
  configxml := DBMS_XDB.cfg_get();

  -- Modify the configuration
  SELECT updateXML(
           configxml,
           '/xdbconfig/sysconfig/protocolconfig/httpconfig/http-port/text()',
           '8000',
           'xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd"')
    INTO configxml2 FROM DUAL;

  -- Update the configuration to use the modified version
  DBMS_XDB.cfg_update(configxml2);
END;
/

PL/SQL procedure successfully completed.

SELECT DBMS_XDB.cfg_get() FROM DUAL;

DBMS_XDB.CFG_GET()
--------------------------------------------------------------------------------
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd" xmlns:xsi="http://w
ww.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/x
db/xdbconfig.xsd                                    http://xmlns.oracle.com/xdb
/xdbconfig.xsd">
  <sysconfig>
    <acl-max-age>900</acl-max-age>
    <acl-cache-size>32</acl-cache-size>
    <invalid-pathname-chars>,</invalid-pathname-chars>
```

```
    <case-sensitive>true</case-sensitive>
    <call-timeout>300</call-timeout>
    <max-link-queue>65536</max-link-queue>
    <max-session-use>100</max-session-use>
    <persistent-sessions>false</persistent-sessions>
    <default-lock-timeout>3600</default-lock-timeout>
    <xdbcore-logfile-path/>
    <xdbcore-log-level>0</xdbcore-log-level>
    <resource-view-cache-size>1048576</resource-view-cache-size>
    <protocolconfig>
      <common>
      . . .
      </common>
      <ftpconfig>
      . . .
      </ftpconfig>
      <httpconfig>
        <http-port>8000</http-port>
        . . .
      </httpconfig>
    </protocolconfig>
    <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
    <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
  </sysconfig>
</xdbconfig>

1 row selected.
```

27

Repository Resource Security

This chapter describes the security mechanism for Oracle XML DB resources, which is based on access control lists (ACLs). It includes how to create, set, and change resource ACLs and how ACL security interacts with other Oracle Database security mechanisms.

This chapter contains these topics:

Overview of Oracle XML DB Resource Security and ACLs

Oracle XML DB maintains object-level security for all resources in Oracle XML DB Repository.

> **Note:** XML objects that are not stored in the repository do *not* have object-level access control.

Oracle XML DB uses a security mechanism that is based on *access control lists* (ACLs) to restrict access to any Oracle XML DB resource. An ACL is a list of *access control entries* (ACEs) that determine which users, roles, and groups have access to a given resource.

ACLs are a standard security mechanism that is used in some languages, such as Java, and some operating systems, such as Microsoft Windows. ACLs are also a part of the WebDAV standard, and Oracle XML DB resource ACLs act as WebDAV ACLs. Resource ACLs are enforced no matter how resources are accessed, whether by WebDAV, SQL, or any other way.

See Also:

- Chapter 28, "Using Protocols to Access the Repository" for more information about WebDAV
- Chapter 34, "Administering Oracle XML DB" for information about configuring and administering resource security
- "APIs for XML" on page 1-5 for information about the PL/SQL APIs you can use to manage resource security

How the ACL-Based Security Mechanism Works

ACLs in Oracle XML DB are XML schema-based resources, stored and managed in Oracle XML DB. Each resource in Oracle XML DB Repository is protected by an ACL. Before a user performs an operation on a resource, the user privileges on the resource are checked. The set of privileges checked depends on the operation to be performed.

Some ACLs are supplied with Oracle XML DB. There is only one ACL, the **bootstrap ACL,** located at `/sys/acls/bootstrap_acl.xml` in Oracle XML DB Repository, that is self-protected; that is, it is protected by its own contents. This ACL, supplied with Oracle XML DB, grants `READ` privilege to all users. The bootstrap ACL also grants `FULL ACCESS` to roles `XDBADMIN` (the Oracle XML DB `ADMIN`) and `DBA`. Role `XDBADMIN` is particularly useful for users who must register global XML schemas.

Other ACLs supplied with Oracle XML DB include the following. Each is protected by the bootstrap ACL.

- `all_all_acl.xml` Grants all privileges to all users
- `all_owner_acl.xml` Grants all privileges to the owner of the resource
- `ro_all_acl.xml` Grants read privileges to all users

All ACLs must conform to the Oracle XML DB ACL XML schema, which is located in the repository at `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/acl.xsd`.

All ACLs are stored in table **`XDB$ACL`**, which is owned by database user `XDB`. This is an XML schema-based `XMLType` table. Each row in this table (and therefore each ACL) has a system-generated object identifier (**OID**) that can be accessed as a column named **`OBJECT_ID`**.

Each resource has a property named **`ACLOID`**. The `ACLOID` stores the OID of the ACL that protects the resource. As mentioned, an ACL is itself a resource. Hence, the `XMLRef` property of an ACL resource, for example, `/sys/acls/all_all_acl.xml`, is a `REF` to the row in table `XDB$ACL` that contains the content of the ACL. These two properties form the link between table `XDB$RESOURCE`, which stores Oracle XML DB resources, and table `XDB$ACL`.

See Also:

- Appendix A, "Oracle-Supplied XML Schemas and Examples" for the ACL XML schema
- *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Access Control List Concepts

This section describes several access control list (ACL) terms and concepts.

Principal

A **principal** is an entity that may be granted access control privileges to an Oracle XML DB resource. Oracle XML DB supports the following as principals:

- Database users
- Database roles. A database role can be understood as a group; for example, the DBA role represents the group of all database administrators.
- LDAP users and groups. For details on using LDAP principals see "Integrating Oracle XML DB with LDAP" on page 27-16.

The special principal, `dav:owner`, corresponds to the owner of the resource being secured. The owner of the resource is one of the properties of the resource. Use of the `dav:owner` principal facilitates greater ACL sharing between users, because the owner of the document often has special rights. See Also "Access Privileges" on page 27-5.

Privilege

A **privilege** is a particular right that can be granted or denied to a principal. Oracle XML DB has a set of system-defined rights (such as `READ` or `UPDATE`) that can be referenced in any ACL. Privileges can be granted or denied to the principal `dav:owner`, that represents the owner of the document, regardless of who the owner is. Privileges can be one of the following:

- Aggregate (containing other privileges)
- Atomic (which cannot be subdivided)

Aggregate privileges are a naming convenience to simplify usability when the number of privileges becomes large, as well as to promote inter operability between ACL clients. Please see "Access Privileges" on page 27-5 for the list of atomic and aggregate privileges that can be used in ACLs.

The set of privileges granted to a principal controls the ability of that principal to perform a given operation or method on an Oracle XML DB resource. For example, if the principal `HR` wants to perform the `read` operation on a given resource, then the `read` privileges must be granted to `HR` prior to the read operation. Therefore, privileges control how users can operate on resources.

Access Control Entry (ACE)

An **access control entry** (**ACE**) is an element (`ace`) that serves as an entry in an ACL that grants or denies access to a particular principal (database user). An ACL consists of a sequence of ACEs, where ordering is relevant. See "ACL Evaluation Rules" on page 27-4.

An Oracle XML DB ACE either grants or denies privileges for a principal. An `ace` element has the following:

- Operation: Either `grant` or `deny`.
- Principal: A valid principal (element `principal`).
- Privileges: A set of privileges to be granted or denied for a particular principal (element `privilege`).
- Principal Format (optional): The format of the principal. An LDAP distinguished name (DN), a short name (database user/role or LDAP nickname), or an LDAP GUID. The default value is `short name`. If the principal name matches both a

database user and an LDAP nickname, it is assumed to refer to the LDAP nickname.

- Collection (optional): A `BOOLEAN` attribute that specifies whether the principal is a collection of users (LDAP group or database role) or a single user (LDAP or database user).

Access Control List (ACL)

An **access control list** (**ACL**) is a list of access control entries (ACEs). It defines access control for a resource.

The following example shows entries in an ACL:

```
<acl description="myacl"
     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
     xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>
```

In this ACL there is only one ACE. The ACE grants all privileges to the owner of the resource.

Default ACL

When a resource is inserted into Oracle XML DB Repository, by default the ACL on its parent folder is used to protect the resource. After the resource is created, a new ACL can be set on it.

ACL File-Naming Conventions

Supplied ACLs use the file-naming convention *<privilege>*_*<users>*_acl.xml, where *<privilege>* represents the privilege granted, and *<users>* represents the users that are granted access to the resource.

ACL Evaluation Rules

Privileges are checked before a user is allowed to access a resource. This is done by evaluating the resource ACL for the current user. To evaluate an ACL, the database collects the ACEs in the ACL that apply to the user logged into the current database session. The list of currently active roles for the user is maintained as part of the session, and it is used to match ACEs, which specify roles as principals, with the current users.

If one ACE grants a certain privilege to the current user and another ACE denies that privilege to the user, then a conflict arises. There are two possible ways to manage conflicts among ACEs for the same principal.

- The default behavior, termed `ace-order`, is to use only the first ACE that occurs for a given principal; additional ACEs for that principal have no effect. In this case, ACE order is relevant.

- You can, however, configure the database to use an alternate behavior, `deny-trumps-grant`. In this case, an ACE with child `deny` for a given principal denies permission to that principal, whether or not there are other ACEs for that principal that have a `grant` child. In this case, `deny` always takes precedence over `grant`, and ACE order is irrelevant.

You configure ACL evaluation behavior by setting configuration parameter `acl-evaluation-method`, in configuration file `xdbconfig.xml`, to either `ace-order` or `deny-trumps-grant`. The default configuration file specifies `ace-method`, but the default value for element `acl-evaluation-method`, used when no method is given, is `deny-trumps-grant`.

Note: In releases prior to Oracle Database 11*g* Release 1, only one ACL evaluation behavior was available: `deny-trumps-grant` (though it was not specified in the configuration file).

The change to use `ace-order` as the default behavior has important consequences for upgrading and downgrading between database versions. See "Upgrading an Existing Oracle XML DB Installation" on page 34-4.

Access Privileges

Oracle XML DB provides a set of privileges to control access to Oracle XML DB resources. Access privileges in an ACE are stored in the privilege element. Privileges can be either aggregate (composed of other privileges) or atomic.

When an ACL is stored in Oracle XML DB, the aggregate privileges retain their identity: they are not decomposed into the corresponding leaf privileges. In WebDAV terms, these are aggregate privileges that are *not abstract*.

Atomic Privileges

Table 27–1 lists the atomic privileges supported by Oracle XML DB. Note that Oracle XML DB supports all WebDAV privileges. Privilege names are used as XML element names. Privileges with a `dav:` prefix are part of the WebDAV namespace. Other privileges are part of the Oracle XML DB ACL namespace: `http://xmlns.oracle.com/xdb/acl.xsd`.

Because you can directly access the `XMLType` storage for ACLs, the XML structure is part of the client interface. Hence, ACLs can be manipulated using the `XMLType` APIs.

See Also:

- "Upgrading an Existing Oracle XML DB Installation" on page 34-4 for information about treatment of access privileges when upgrading
- RFC 3744: "Web Distributed Authoring and Versioning (WebDAV) Access Control Protocol", IETF Network Working Group Request For Comments #3744, May 2004

Table 27–1 Oracle XML DB Supported Atomic Privileges

Privilege Name	Description	Database Counterpart
dav:lock	Lock a resource using WebDAV locks.	UPDATE
dav:read-current-user-privilege-set	Access the dav:current-user-privilege-set property of a resource.	N/A
dav:take-ownership	Take ownership of a resource.	N/A
dav:unlock	Unlock a resource locked using a WebDAV lock.	UPDATE
dav:write-content	Modify the content of a resource.	UPDATE
dav:write-properties	Modify the properties of a resource; lock or unlock a resource. Modifiable properties include Author, DisplayName, Language, CharacterSet, ContentType, SBResExtra, Owner, OwnerID, CreationDate, Modification Date, ACL, ACLOID, Lock, and Locktoken.	UPDATE
link	For containers only. Lets resources be bound to the container.	INSERT
link-to	Allow resources to be linked.	N/A
read-acl	Read the resource ACL.	SELECT
read-contents	Read the contents of a resource.	SELECT
read-properties	Read the properties of a resource.	SELECT
resolve	Lets a container be traversed (for folders only).	SELECT
unlink	Lets resources be unbound from a container (for folders only).	DELETE
unlink-from	Lets resources be unlinked.	N/A
update-acl	Change the contents of the resource ACL.	UPDATE
write-acl-ref	Change the ACLOID of a resource.	UPDATE

Aggregate Privileges

Table 27–2 lists the aggregate privileges defined by Oracle XML DB, along with the atomic privileges of which they are composed.

Table 27–2 Aggregate Privileges

Aggregate Privilege Names	Atomic Privileges
all	All atomic privileges
dav:all	All atomic privileges except linkto
dav:bind	link
dav:read	read-properties, read-contents, resolve
dav:read-acl	read-acl
dav:unbind	unlink
dav:write	update, link, unlink, unlink-from
dav:write-acl	write-acl-ref, update-acl
update	dav:write-contents, dav:write-properties

Table 27–3 shows the privileges required for some common operations on resources in Oracle XML DB Repository. Column Privileges Required assumes that you already

have the `resolve` privilege on container C and all its parent containers, up to the root of the hierarchy.

Table 27–3 Database Privileges Needed for Operations on Oracle XML DB Resources

Operation	Description	Privileges Required
`CREATE`	Create a new resource in container C	`update` and `link` on C
`DELETE`	Delete resource R from container C	`update` and `unlink-from` on R, `update` and `unlink` on C
`UPDATE`	Update the contents or properties of resources R	`update` on R
`GET`	An FTP or HTTP(S) retrieval of resource R	`read-properties`, `read-contents` on R
`SET_ACL`	Set the ACL of a resource R	`dav:write-acl` on R
`LIST`	List the resources in container C	`read-properties` on C, `read-properties` on resources in C. Only those resources on which the user has `read-properties` privilege are listed.

Interaction with Database Table Security

Resources in Oracle XML DB Repository are of two types:

- LOB-based (content is stored in a LOB which is part of the resource). Access is determined only by the ACL that protects the resource.
- `REF`-based (content is XML and is stored in a database table). Users must have the appropriate privilege in the underlying table or view where the XML content is stored, as well as permissions through the ACL for the resource.

Since the content of a `REF`-based resource may be stored in a table, it is possible to access this data directly using SQL queries on the table. A uniform access control mechanism is one where the privileges needed for access are independent of the method of access (for example, FTP, HTTP, or SQL). To provide a uniform security mechanism using ACLs, the underlying table must first be **hierarchy-enabled**, before resources that reference the rows in the table are inserted into Oracle XML DB.

The default tables produced by XML schema registration are hierarchy-enabled; that is, enabling hierarchy is the default behavior when you register an XML schema. You can also enable hierarchy after registration, using procedure `DBMS_XDBZ.enable_hierarchy`.

Enabling hierarchy on a resource table does the following:

- Adds two hidden columns to store the `ACLOID` and the `OWNER` of the resources that reference the rows in the table.
- Adds a row-level security (RLS) policy to the table, which checks the ACL whenever a `SELECT`, `UPDATE`, or `DELETE` operation is executed on the table.
- Creates a database trigger, called the **path-index trigger**, that ensures that the last-modified information for a resource is updated whenever the corresponding row is updated in the `XMLType` table where the content is stored.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `DBMS_XMLSCHEMA.registerSchema`
- *Oracle Database PL/SQL Packages and Types Reference* for information about procedure `DBMS_XDBZ.enable_hierarchy`

In any given table, it is possible that only some of the objects are mapped to Oracle XML DB resources. Only those objects that are mapped undergo ACL checking, but all of the objects have table-level security.

Note: You cannot hide data in `XMLType` tables from other users when using *out-of-line* storage. Out-of-line data is *not* protected by ACL security.

Working with Oracle XML DB ACLs

Oracle XML DB ACLs are (file) resources, so all of the methods that operate on resources also apply to ACLs. In addition, there are several APIs specific to ACLs in package `DBMS_XDB`. Those procedures and functions let you use PL/SQL to access Oracle XML DB security mechanisms, check user privileges based on a particular ACL, and list the set of privileges the current user has for a particular ACL and resource.

See Also: Chapter 34, "Administering Oracle XML DB"

Creating an ACL Using DBMS_XDB.createResource

Example 27–1 creates an ACL as file resource `/TESTUSER/acl1.xml`. If applied to a resource, this ACL grants all privileges to the owner of a resource.

Example 27–1 Creating an ACL Using DBMS_XDB.createResource

```
DECLARE
  b BOOLEAN;
BEGIN
  b := DBMS_XDB.createFolder('/TESTUSER');
  b := DBMS_XDB.createResource(
         '/TESTUSER/acl1.xml',
         '<acl description="myacl"
               xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
               xmlns:dav="DAV:"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
               xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                   http://xmlns.oracle.com/xdb/acl.xsd">
            <ace>
              <grant>true</grant>
              <principal>dav:owner</principal>
              <privilege>
                <dav:all/>
              </privilege>
            </ace>
          </acl>');
END;
```

Note: Before performing any operation that uses an ACL file resource created during the current transaction, you must perform a `COMMIT` operation. Until you do that, an ORA-22881 "dangling REF" error will be raised whenever you use the ACL file.

Retrieving an ACL Document, Given its Repository Path

Example 27–2 shows how to retrieve an ACL document, given its location in Oracle XML DB Repository.

Example 27–2 Retrieving an ACL Document, Given its Repository Path

```
SELECT a.OBJECT_VALUE FROM RESOURCE_VIEW r, XDB.XDB$ACL a
  WHERE ref(a) = extractValue(r.RES, '/Resource/XMLRef')
    AND equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;

OBJECT_VALUE
--------------------------------------------------------------------------------
<acl description="myacl" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="
DAV:" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="
http://xmlns.oracle.com/xdb/acl.xsd                                    http://xm
lns.oracle.com/xdb/acl.xsd" shared="true">
  <ace>
    <grant>true</grant>
    <principal>dav:owner</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

Setting the ACL of a Resource

Example 27–3 Setting the ACL of a Resource

This example creates resource `/TESTUSER/po1.xml` and sets its ACL to `/TESTUSER/acl1.xml` using procedure `DBMS_XDB.setACL`.

```
DECLARE
  b BOOLEAN;
BEGIN
  b := DBMS_XDB.createResource('/TESTUSER/po1.xml', 'Hello');
END;
/

CALL DBMS_XDB.setACL('/TESTUSER/po1.xml', '/TESTUSER/acl1.xml');
```

Deleting an ACL

Example 27–4 illustrates how to delete an ACL using procedure `DBMS_XDB.deleteResource`.

Example 27–4 Deleting an ACL

This example deletes the ACL created in Example 27–1.

```
CALL DBMS_XDB.deleteResource('/TESTUSER/acl1.xml');
```

If a resource is being protected by an ACL that you will delete, first change the ACL of that resource before deleting the ACL.

Updating an ACL

This can be done using standard methods for updating resources. In particular, since an ACL is an XML document, SQL function `updateXML` and related XML-updating functions can be used to manipulate ACLs.

Oracle XML DB ACLs are *cached*, for fast evaluation. When a transaction that updates an ACL is committed, the modified ACL is picked up by existing database sessions, after the timeout specified in the Oracle XML DB configuration file, `/xdbconfig.xml`. The XPath location for this timeout parameter is `/xdbconfig/sysconfig/acl-max-age`; the value is expressed in seconds. Sessions initiated after the ACL is modified use the new ACL without any delay.

If an ACL resource is updated with non-ACL content, the same rules apply as for deletion. Thus, if any resource is being protected by an ACL that is being updated, you must first change the ACL.

> **See Also:** "Updating XML Instances and XML Data in Tables" on page 4-19 for information about the SQL functions used here to update XML data

You can use FTP or WebDAV to update an ACL. For more details on how to use these protocols, see Chapter 28, "Using Protocols to Access the Repository". You can update an ACL or an access control entry (ACE) using `RESOURCE_VIEW`.

Example 27–5 Updating (Replacing) an Access Control List

This example uses SQL function `updateXML` to update the ACL `/TESTUSER/acl1.xml` by replacing it entirely. The effect is to replace the principal value `dav:owner` by `TESTUSER`, because the rest of the replacement ACL is the same as it was before.

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
        updateXML(
          r.RES,
          '/r:Resource/r:Contents/a:acl',
          '<acl description="myacl"
                xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                xmlns:dav="DAV:"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                    http://xmlns.oracle.com/xdb/acl.xsd">
             <ace>
               <grant>true</grant>
               <principal>TESTUSER</principal>
               <privilege>
                 <dav:all/>
               </privilege>
             </ace>
           </acl>',
          'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
           xmlns:a="http://xmlns.oracle.com/xdb/acl.xsd"')
  WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Example 27–6 Appending ACEs to an Access Control List

This example uses SQL function `appendChildXML` to append an ACE to an existing ACL. The ACE gives privileges `read-properties` and `read-contents` to user `hr`.

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
        appendChildXML(
          r.RES,
          '/r:Resource/r:Contents/a:acl',
          XMLType('<ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd">
                     <grant>true</grant>
                     <principal>HR</principal>
                     <privilege>
                       <read-properties/>
                       <read-contents/>
                     </privilege>
                   </ace>'),
                  'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                   xmlns:a="http://xmlns.oracle.com/xdb/acl.xsd"')
  WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Example 27–7 Deleting an ACE from an Access Control List

This examples uses SQL function `deleteXML` to delete an ACE from an ACL. The first ACE is deleted here.

```
UPDATE RESOURCE_VIEW r
  SET r.RES =
        deleteXML(r.RES,
                  '/r:Resource/r:Contents/a:acl/a:ace[1]',
                  'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                   xmlns:a="http://xmlns.oracle.com/xdb/acl.xsd"')
  WHERE equals_path(r.RES, '/TESTUSER/acl1.xml') = 1;
```

Retrieving the ACL Document that Protects a Given Resource

Example 26–2 illustrates how to use function `DBMS_XDB.getACLDocument` to retrieve the ACL document that protects a given resource.

Example 27–8 Retrieving the ACL Document for a Resource

```
SELECT DBMS_XDB.getACLDocument('/TESTUSER/po1.xml').getCLOBVal() FROM DUAL;

DBMS_XDB.GETACLDOCUMENT('/TESTUSER/PO1.XML').GETCLOBVAL()
--------------------------------------------------------------------------------
<acl description="myacl" xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="
DAV:" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="
http://xmlns.oracle.com/xdb/acl.xsd                                    http://x
mlns.oracle.com/xdb/acl.xsd">
  <ace>
    <grant>true</grant>
    <principal>TESTUSER</principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
  <ace xmlns="http://xmlns.oracle.com/xdb/acl.xsd">
    <grant>true</grant>
    <principal>HR</principal>
    <privilege>
```

```
      <read-properties/>
      <read-contents/>
    </privilege>
  </ace>
</acl>

1 row selected.
```

See Also: Example 26–2, "Using Procedure DBMS_XDB.getACLDocument" on page 26-4

Retrieving Privileges Granted to the Current User for a Particular Resource

Example 27–9 illustrates how to retrieve privileges granted to the current user using function `DBMS_XDB.getPrivileges`.

Example 27–9 Retrieving Privileges Granted to the Current User for a Particular Resource

```
SELECT DBMS_XDB.getPrivileges('/TESTUSER/po1.xml').getCLOBVal() FROM DUAL;

DBMS_XDB.GETPRIVILEGES('/TESTUSER/PO1.XML').GETCLOBVAL()
--------------------------------------------------------------------------------
<privilege xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.
org/2001/XMLSchema-instance" xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl
.xsd http://xmlns.oracle.com/xdb/acl.xsd DAV: http://xmlns.oracle.com/xdb/dav.xs
d" xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:">
  <dav:take-ownership/>
  <dav:execute/>
  <dav:unlock/>
  <read-properties/>
  <dav:lock/>
  <read-contents/>
  <dav:read-current-user-privilege-set/>
  <write-config/>
  <dav:write-content/>
  <resolve/>
  <dav:write-properties/>
  <unlink-from/>
  <unlink/>
  <read-acl/>
  <write-acl-ref/>
  <update-acl/>
  <link/>
</privilege>

1 row selected.
```

Checking if the Current User Has Privileges on a Resource

Example 27–10 illustrates how to use function `DBMS_XDB.checkPrivileges` to check if the current user has a given set of privileges on a resource. This function returns a nonzero value if the user has the privileges.

Example 27–10 Checking If a User Has a Certain Privileges on a Resource

This example checks to see if the access privileges `read-contents` and `read-properties` have been granted to the current user on resource `/TESTUSER/po1.xml`. The positive-integer return value shows that they have.

```
SELECT DBMS_XDB.checkPrivileges(
         '/TESTUSER/po1.xml',
         XMLType('<privilege
                     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                     xmlns:dav="DAV:"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                         http://xmlns.oracle.com/xdb/acl.xsd">
                   <read-contents/>
                   <read-properties/>
                 </privilege>'))
  FROM DUAL;

DBMS_XDB.CHECKPRIVILEGES('/TESTUSER/PO1.XML',
-------------------------------------------
                                          1

1 row selected.
```

Checking if the Current User Has Privileges With the ACL and Resource Owner

Function `DBMS_XDB.ACLCheckPrivileges` is typically used by applications that must perform ACL evaluation on their own, before allowing a user to perform an operation.

Example 27–11 Checking User Privileges using ACLCheckPrivileges

This example checks whether the ACL `/TESTUSER/acl1.xml` grants the privileges `read-contents` and `read-properties` to the current user, `sh`. The second argument, `TESTUSER`, is the user that is substituted for `dav:owner` in the ACL when checking. Since user `sh` does *not* match any of the users granted the specified privileges, the return value is zero.

```
CONNECT sh/sh

SELECT DBMS_XDB.ACLCheckPrivileges(
         '/TESTUSER/acl1.xml',
         'TESTUSER',
         XMLType('<privilege
                     xmlns="http://xmlns.oracle.com/xdb/acl.xsd"
                     xmlns:dav="DAV:"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                                         http://xmlns.oracle.com/xdb/acl.xsd">
                   <read-contents/>
                   <read-properties/>
                 </privilege>'))
  FROM DUAL;

DBMS_XDB.ACLCHECKPRIVILEGES('/TESTUSER/ACL1.XML','TESTUSER',
------------------------------------------------------------
                                                           0

1 row selected.
```

Retrieving the Path of the ACL that Protects a Given Resource

Example 27–12 retrieves the path of the ACL that protects a given resource, by using a RESOURCE_VIEW query. The query uses the fact that the XMLRef and ACLOID elements of the resource form the link between an ACL and a resource.

Example 27–12 Retrieving the Path of the ACL that Protects a Given Resource

This example retrieves the path to an ACL, given a resource protected by the ACL. The ACLOID of a protected resource (r) stores the OID of the ACL resource (a) that protects it. The REF of the ACL resource is the same as that of the object identified by the protected-resource ACLOID.

The REF of the resource ACLOID can be obtained using SQL function make_ref, which returns a REF to an object-table row with a given OID.

In this example, make_ref returns a REF to the row of table XDB$ACL whose OID is the /Resource/ACLOID for the resource /TESTUSER/po1.xml (r). The inner query returns the ACLOID of the resource. The outer query returns the path to the corresponding ACL.

```
SELECT a.ANY_PATH
  FROM RESOURCE_VIEW a
  WHERE extractValue(a.RES, '/Resource/XMLRef')
        = make_ref(XDB.XDB$ACL,
                   (SELECT extractValue(r.RES, '/Resource/ACLOID')
                      FROM RESOURCE_VIEW r
                      WHERE equals_path(r.RES, '/TESTUSER/po1.xml') = 1));

ANY_PATH
------------------
/TESTUSER/acl1.xml

1 row selected.
```

Retrieving the Paths of All Resources Protected by a Given ACL

Example 27–13 retrieves the paths of all resources protected by a given ACL.

Example 27–13 Retrieving the Paths of All Resources Protected by a Given ACL

This example retrieves the paths to the resources whose ACLOID REF matches the REF of the ACL resource whose path is /TESTUSER/acl1.xml. Function make_ref returns the resource ACLOID REF.

The inner query retrieves the REF of the specified ACL. The outer query selects the paths of the resources whose ACLOID REF matches the REF of the specified ACL.

```
SELECT r.ANY_PATH
  FROM RESOURCE_VIEW r
  WHERE make_ref(XDB.XDB$ACL, extractValue(r.RES, '/Resource/ACLOID'))
        = (SELECT extractValue(a.RES, '/Resource/XMLRef')
             FROM RESOURCE_VIEW a
             WHERE equals_path(a.RES, '/TESTUSER/acl1.xml') = 1);

ANY_PATH
-----------------
/TESTUSER/po1.xml

1 row selected.
```

Managing Fine-Grained Access Control to External Network Services from the Database

You can configure fine-grained access control to external network resources from within your database. With this kind of access control, a group of users can connect to one or more hosts, according to the privileges that you grant them. You generally use control access to applications that run on specific host addresses.

To implement fine-grained access control on database network services, you must create an access control list (ACL), which is then stored in Oracle XML DB. You use package `DBMS_XDB` to create an ACL. You can also use PL/SQL packages `DBMS_NETWORK_ACL_ADMIN` and `DBMS_NETWORK_ACL_UTILITY` to work with ACLs.

By implementing access control, you can specify which external hosts a database user can access using the PL/SQL network utility packages such as `UTL_TCP`, `UTL_SMTP`, `UTL_MAIL`, `UTL_HTTP`, `UTL_INADDR`, and `HTTPURIType`. In a default database creation, privilege `EXECUTE` is granted on PL/SQL utility packages to `PUBLIC` users. By denying access to non-privileged users, the default access control behavior thus ensures the security of your database system.

Implementing fine-grained access control to external network resources involves privileges `CONNECT` and `RESOLVE`. A database user requires `CONNECT` privilege to an external network host in order to connect to it using PL/SQL utility packages `UTL_TCP`, `UTL_HTTP`, `UTL_SMTP`, and `UTL_MAIL`. To retrieve the host name or the IP address of the current host using package `UTL_INADDR`, a database user requires privilege `RESOLVE`.

See Also:

- *Oracle Database Security Guide* for information about creating ACLs using the `DBMS_NETWORK_ACL_ADMIN` package
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_NETWORK_ACL_ADMIN`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_NETWORK_ACL_UTILITY`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_TCP`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_HTTP`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_SMTP`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_MAIL`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `UTL_INADDR`

Finding Information about Access Control Lists

You can use data dictionary views to find information about existing access control lists. Table 27–4 shows the data dictionary views for ACLs.

Table 27–4 Data Dictionary Views for Access Control Lists

View	Description
DBA_NETWORK_ACLS	Shows the ACL assignments to the network hosts. Privilege SELECT on this view is granted only to role SELECT_CATALOG_ROLE.
DBA_NETWORK_ACL_PRIVILEGES	Shows the network privileges defined in all ACLS that are currently assigned to network hosts. Privilege SELECT on this view is granted only to role SELECT_CATALOG_ROLE.
USER_NETWORK_ACL_PRIVILEGES	Shows the status of the network privileges for the current user to access network hosts. Privilege SELECT on the view is granted to PUBLIC.

See Also: *Oracle Database Reference* for information about data dictionary views

Checking Privilege Assignments

When a database user tries to access a service, the access control list (ACL) for the service is checked to determine the access privileges for the user. Access control entries (ACEs) contained in the ACL are used to grant or deny access permissions to a user or role.

Use PL/SQL package DBMS_NETWORK_ACL_ADMIN to check privilege assignments that might affect permissions of the user to access a network host. Function check_privilege checks ACLs to determine the access of a given user to a particular network resource. It checks whether a specified privilege is granted or denied to the user.

If you are a database administrator, you can use view DBA_NETWORK_ACLS to determine the ACL assignments for the network hosts or domains. You can then use view DBA_NETWORK_ACL_PRIVILEGES to determine if each ACL grants (GRANTED), denies (DENIED), or does not apply to (NULL) the access privilege of the user.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package DBMS_NETWORK_ACL_ADMIN
- *Oracle Database Reference* for information about views DBA_NETWORK_ACLS and DBA_NETWORK_ACL_PRIVILEGES

Integrating Oracle XML DB with LDAP

This section deals with allowing LDAP users to use the features of Oracle XML DB. The typical scenario is a single, shared database schema, to which multiple LDAP users are mapped. This mapping is maintained in the Oracle Internet Directory. Users can log in to the database using their LDAP username and password; they are then automatically mapped to the corresponding shared schema. (Users can log in using SQL or any of the supported Oracle XML DB protocols.) The implicit ACL resolution is based on the current LDAP user and the corresponding LDAP group membership information.

Before you can use LDAP users and groups as principals in Oracle XML DB ACLs, the following prerequisites must be satisfied:

- An Oracle Internet Directory must be set up, and the database must be registered with it.

- SSL authentication must be set up between the database and the Oracle Internet Directory.
- A database user must be created that corresponds to the shared database schema.
- The LDAP users must be created and mapped in the Oracle Internet Directory to the shared database schema.
- The LDAP groups must be created and their members must be specified.
- ACLs must be defined for the LDAP groups and users, and they must be used to protect the repository resources to be accessed by the LDAP users.

See Also:

- *Oracle Internet Directory Administrator's Guide* for information about setting up the Oracle Internet Directory and registering the database
- *Oracle Database Advanced Security Administrator's Guide* for information about setting up SSL authentication
- *Oracle Database Enterprise User Security Administrator's Guide* for information about using shared database schemas for enterprise (LDAP) users

Example 27–14 ACL Referencing an LDAP User

This is an example of an ACL for an LDAP user. Element `<principal>` contains the full *distinguished name* of the LDAP user – in this case, `cn=user1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US`.

```
<acl description="/public/txmlacl1/acl1.xml"
     xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace principalFormat="DistinguishedName">
    <grant>true</grant>
    <principal>cn=user1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US
    </principal>
    <privilege>
      <dav:all/>
    </privilege>
  </ace>
</acl>
```

See Also: *Oracle Internet Directory Administrator's Guide* for the format of an LDAP user distinguished name

Example 27–15 ACL Referencing an LDAP Group

This is an example of an ACL for an LDAP group. Element `<principal>` contains the full distinguished name of the LDAP group.

```
<acl xmlns="http://xmlns.oracle.com/xdb/acl.xsd" xmlns:dav="DAV:"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://xmlns.oracle.com/xdb/acl.xsd
                         http://xmlns.oracle.com/xdb/acl.xsd">
  <ace principalFormat="DistinguishedName">
    <grant>true</grant>
    <principal>cn=grp1,ou=Americas,o=oracle,l=redwoodshores,st=CA,c=US</principal>
```

```
    <privilege>
      <dav:read/>
    </privilege>
  </ace>
</acl>
```

See Also: *Oracle Internet Directory Administrator's Guide* for the format of an LDAP group distinguished name

Performance Issues for Using ACLs

Since ACLs are checked for each access to Oracle XML DB Repository, the performance of the ACL check operation is critical to the performance of the repository. In Oracle XML DB, the required performance for this operation is achieved by employing several caches. ACLs are cached in a shared (shared by all sessions in the instance) cache. The performance of this cache is better when there are fewer ACLs in your system. Hence it is recommended that you share ACLs (between resources) as much as possible. Also, the cache works best when the number of ACEs in an ACL is at most 16.

There is also a session-specific cache of privileges granted to a given user by a given ACL. The entries in this cache have a time out (in seconds) specified by the element `<acl-max-age>` in the Oracle XML DB configuration file (`/xdbconfig.xml`). For maximum performance, set this timeout as large as possible. But note that there is a trade-off here: the greater the timeout, the longer it will take for current sessions to pick up an updated ACL.

Oracle XML DB also maintains caches to improve performance when using ACLs that have LDAP principals (LDAP groups or users). The goal of these caches is to minimize network communication with the LDAP server. One is a shared cache that maps LDAP GUIDs to the corresponding LDAP nicknames and Distinguished Names (DNs). This is used when an ACL document is being displayed (or converted to `CLOB` or `VARCHAR2` values from an `XMLType` instance). To purge this cache, use procedure `DBMS_XDBZ.purgeLDAPCache`. The other cache is session-specific and maps LDAP groups to their members (nested membership). Note that whenever Oracle XML DB encounters an LDAP group for the first time (in a session) it will get the nested membership of that group from the LDAP server. Hence it is best to use groups with as few members and levels of nesting as possible.

28

Using Protocols to Access the Repository

This chapter describes how to access Oracle XML DB Repository data using FTP, HTTP(S)/WebDAV protocols.

This chapter contains these topics:

- Overview of Oracle XML DB Protocol Server
- Oracle XML DB Protocol Server Configuration Management
- Using FTP and Oracle XML DB Protocol Server
- Using HTTP(S) and Oracle XML DB Protocol Server
- Using WebDAV and Oracle XML DB

Overview of Oracle XML DB Protocol Server

As described in Chapter 2, "Getting Started with Oracle XML DB" and Chapter 21, "Accessing Oracle XML DB Repository Data", Oracle XML DB Repository provides a hierarchical data repository in the database, designed for XML. Oracle XML DB Repository maps path names (or URLs) onto database objects of `XMLType` and provides management facilities for these objects.

Oracle XML DB also provides the Oracle XML DB *protocol server*. This supports standard Internet protocols, FTP, WebDAV, and HTTP(S), for accessing its hierarchical repository or file system. Note that HTTPS provides *secure* access to Oracle XML DB Repository.

These protocols can provide direct access to Oracle XML DB for many users without having to install additional software. The user names and passwords to be used with the protocols are the same as those for SQL*Plus. Enterprise users are also supported. DBAs can use these protocols and resource APIs such as `DBMS_XDB` to access Automatic Storage Management (ASM) files and folders in the repository virtual folder `/sys/asm`.

> **See Also:** Chapter 21, "Accessing Oracle XML DB Repository Data" for more information about accessing repository information, and restrictions on that access

Note:

- When accessing virtual folder `/sys/asm` using Oracle XML DB protocols, you must log in as a DBA user other than `SYS`.
- Oracle XML DB protocols are *not* supported on EBCDIC platforms.

Session Pooling

Oracle XML DB protocol server maintains a shared pool of sessions. Each protocol connection is associated with one session from this pool. After a connection is closed the session is put back into the shared pool and can be used to serve later connections.

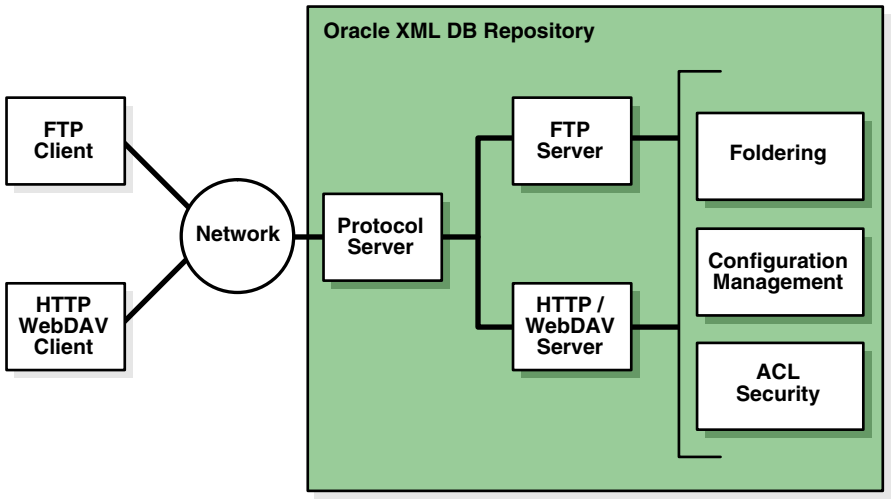
Session pooling improves performance of HTTP(S) by avoiding the cost of re-creating session states, especially when using HTTP 1.0, which creates new connections for each request. For example, a couple of small files can be retrieved by an existing HTTP/1.1 connection in the time necessary to create a database session. You can tune the number of sessions in the pool by setting session-pool-size in Oracle XML DB `xdbconfig.xml` file, or disable it by setting pool size to zero.

Session pooling can affect users writing *Java servlets*, because other users can see session state initialized by another request for a different user. Hence, servlet writers should only use session memory, such as Java static variables, to hold data for the entire application rather than for a particular user. State for each user must be stored in the database or in a lookup table, rather than assuming that a session will only exist for a single user.

See Also: Chapter 32, "Writing Oracle XML DB Applications in Java"

Figure 28–1 illustrates the Oracle XML DB protocol server components and how they are used to access files in Oracle XML DB Repository and other data. Only the relevant components of the repository are shown

Figure 28–1 Oracle XML DB Architecture: Protocol Server



Oracle XML DB Protocol Server Configuration Management

Oracle XML DB protocol server uses configuration parameters stored in `/xdbconfig.xml` to initialize its startup state and manage session level configuration. The following section describes the protocol-specific configuration parameters that you can configure in the Oracle XML DB configuration file. The session pool size and timeout parameters cannot be changed dynamically, that is, you will need to restart the database in order for these changes to take effect.

> **See Also:** "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5

Configuring Protocol Server Parameters

Figure 28–1 shows the parameters common to all protocols. All parameter names in this table, except those starting with `/xdbconfig`, are relative to the following XPath in the Oracle XML DB configuration schema:

```
/xdbconfig/sysconfig/protocolconfig/common
```

- *FTP-specific parameters* – Table 28–2 shows the FTP-specific parameters. These are relative to the following XPath in the Oracle XML DB configuration schema:

  ```
  /xdbconfig/sysconfig/protocolconfig/ftpconfig
  ```

- *HTTP(S)/WebDAV specific parameters, except servlet-related parameters* – Table 28–3 shows the HTTP(S)/WebDAV-specific parameters. These parameters are relative to the following XPath in the Oracle XML DB configuration schema:

  ```
  /xdbconfig/sysconfig/protocolconfig/httpconfig
  ```

Note: You must either configure the port separately for each node of a Real Application Cluster (RAC) or configure it for one node and then restart the database instances on the other nodes. See "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5.

See Also:

- Chapter 34, "Administering Oracle XML DB" for more information about the configuration file `xdbconfig.xml`
- "xdbconfig.xsd: XML Schema for Configuring Oracle XML DB" on page A-16
- "Configuring Default Namespace to Schema Location Mappings" on page 34-11 for more information about the `schemaLocation-mappings` parameter
- "Configuring XML File Extensions" on page 34-13 for more information about the `xml-extensions` parameter

For examples of the usage of these parameters, see the configuration file, `xdbconfig.xml`.

Table 28–1 Common Protocol Configuration Parameters

Parameter	Description
`extension-mappings/mime-mappings`	Specifies the mapping of file extensions to mime types. When a resource is stored in Oracle XML DB Repository, and its mime type is not specified, this list of mappings is used to set its mime type.
`extension-mappings/lang-mappings`	Specifies the mapping of file extensions to languages. When a resource is stored in Oracle XML DB Repository, and its language is not specified, this list of mappings is used to set its language.
`extension-mappings/encoding-mappings`	Specifies the mapping of file extensions to encodings. When a resource is stored in Oracle XML DB Repository, and its encoding is not specified, this list of mappings is used to set its encoding.
`xml-extensions`	Specifies the list of filename extensions that are treated as XML content by Oracle XML DB.
`session-pool-size`	Maximum number of sessions that are kept in the protocol server session pool
`/xdbconfig/sysconfig/call-timeout`	If a connection is idle for this time (in hundredths of a second), then the shared server serving the connection is freed up to serve other connections.
`session-timeout`	Time (in hundredths of a second) after which a session (and consequently the corresponding connection) will be terminated by the protocol server if the connection has been idle for that time. This parameter is used only if the specific protocol session timeout is not present in the configuration
`schemaLocation-mappings`	Specifies the default schema location for a given namespace. This is used if the instance XML document does not contain an explicit `xsi:schemaLocation` attribute.
`/xdbconfig/sysconfig/default-lock-timeout`	Time period after which a WebDAV lock on a resource becomes invalid. This could be overridden by a Timeout specified by the client that locks the resource.

Table 28–2 Configuration Parameters Specific to FTP

Parameter	Description
`buffer-size`	Size of the buffer, in bytes, used to read data from the network during an FTP `put` operation. Set `buffer-size` to larger values for higher `put` performance. There is a trade-off between `put` performance and memory usage. Value can be from 1024 to 1048496, inclusive; the default value is 8192.
`ftp-port`	Port on which FTP server listens. By default, this is `0`, which means that FTP is *disabled*. FTP is disabled by default because the FTP specification requires that passwords be transmitted in clear text, which can present a security hazard. To enable FTP, set this parameter to the FTP port to use, such as `2100`.
`ftp-protocol`	Protocol over which the FTP server runs. By default, this is `tcp`.
`ftp-welcome-message`	A user-defined welcome message that is displayed whenever an FTP client connects to the server. If this parameter is empty or missing, then the following default welcome message is displayed: "Unauthorized use of this FTP server is prohibited and may be subject to civil and criminal prosecution."
`session-timeout`	Time (in hundredths of a second) after which an FTP connection will be terminated by the protocol server if the connection has been idle for that time.

Table 28–3 Configuration Parameters Specific to HTTP(S)/WebDAV (Except Servlet Parameters)

Parameter	Description
`http-port`	Port on which the HTTP(S)/WebDAV server listens, using protocol `http-protocol`. By default, this is `0`, which means that HTTP is *disabled*. If this parameter is empty (`<http-port/>`), then the default value of `0` applies. An empty parameter is *not* recommended. This parameter must be present, whether or not it is empty; otherwise, validation of `xdbconfig.xml` against XML schema `xdbconfig.xsd` fails. The value must be different from the value of `http2-port`; otherwise, an error is raised.
`http2-port`	Port on which the HTTP(S)/WebDAV server listens, using protocol `http2-protocol`. This parameter is *optional*, but, if present, then `http2-protocol` must also be present; otherwise, an error is raised. The value must be different from the value of `http-port`; otherwise, an error is raised. An empty parameter (`<http2-port/>`) also raises an error.

Table 28–3 (Cont.) Configuration Parameters Specific to HTTP(S)/WebDAV (Except Servlet Parameters)

Parameter	Description
`http-protocol`	Protocol over which the HTTP(S)/WebDAV server runs on port `http-port`. Must be either `TCP` or `TCPS`. This parameter must be present; otherwise, validation of `xdbconfig.xml` against XML schema `xdbconfig.xsd` fails. An empty parameter (`<http-protocol/>`) also raises an error.
`http2-protocol`	Protocol over which the HTTP(S)/WebDAV server runs on port `http2-port`. Must be either `TCP` or `TCPS`. If this parameter is empty (`<http2-protocol/>`), then the default value of `TCP` applies. (An empty parameter is *not* recommended.) This parameter is *optional*, but, if present, then `http2-port` must also be present; otherwise, an error is raised.
`session-timeout`	Time (in hundredths of a second) after which an HTTP(S) session (and consequently the corresponding connection) will be terminated by the protocol server if the connection has been idle for that time.
`max-header-size`	Maximum size (in bytes) of an HTTP(S) header
`max-request-body`	Maximum size (in bytes) of an HTTP(S) request body
`webappconfig/welcome-file-list`	List of filenames that are considered welcome files. When an HTTP(S) `get` request for a container is received, the server first checks if there is a resource in the container with any of these names. If so, then the contents of that file are sent, instead of a list of resources in the container.
`default-url-charset`	The character set in which an HTTP(S) protocol server assumes incoming URL is encoded when it is not encoded in UTF-8 or the Content-Type field Charset parameter of the request.
`allow-repository-anonymous-access`	Indication of whether or not anonymous HTTP access to Oracle XML DB Repository data is allowed using an unlocked `ANONYMOUS` user account. The default value is `false`, meaning that unauthenticated access to repository data is *blocked*. See "Anonymous Access to Oracle XML DB Repository using HTTP" on page 28-16.

Configuring Secure HTTP (HTTPS)

To enable Oracle XML DB Repository to use *secure* HTTP connections (HTTPS), a DBA must configure the database accordingly: configure parameters `http2-port` and `http2-protocol`, enable the HTTP Listener to use SSL, and enable launching of the TCPS Dispatcher. After doing this, the DBA must stop, then restart, the database and the listener.

> **See Also:** "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring Oracle XML DB parameters

Enable the HTTP Listener to Use SSL

A DBA must carry out the following steps, to configure the HTTP Listener for SSL.

1. *Create a wallet for the server and import a certificate* – Use Oracle Wallet Manager to do the following:
   a. Create a wallet for the server.
   b. If a valid certificate with distinguished name (DN) of the server is not available, create a certificate request and submit it to a certificate authority. Obtain a valid certificate from the authority.
   c. Import a valid certificate with the distinguished name (DN) of the server into the server.
   d. Save the new wallet in *obfuscated* form, so that it can be opened without a password.

   > **See Also:** *Oracle Database Advanced Security Administrator's Guide* for information about how to create a wallet

2. *Specify the wallet location to the server* – Use Oracle Net Manager to do this. Ensure that the configuration is saved to disk. This step updates files `sqlnet.ora` and `listener.ora`.
3. *Disable client authentication* at the server, since most Web clients do not have certificates. Use Oracle Net Manager to do this. This step updates file `sqlnet.ora`.
4. *Create a listening end point that uses TCP/IP with SSL* – Use Oracle Net Manager to do this. This step updates file `listener.ora`.

   > **See Also:** *Oracle Database Advanced Security Administrator's Guide* for detailed information regarding steps 1 through 4

Enable TCPS Dispatcher

A DBA must edit the database `pfile` to enable launching of a TCPS dispatcher during database startup. The following line must be added to the file, where *`SID`* is the SID of the database:

```
dispatchers=(protocol=tcps)(service=SIDxdb)
```

The database `pfile` location depends on your operating system, as follows:

- *MS Windows* – *`PARENT`*`/admin/orcl/pfile`, where *`PARENT`* is the parent folder of folder `ORACLE_HOME`
- *Unix, Linux* – `$ORACLE_HOME/admin/$ORACLE_SID/pfile`

Interaction with Oracle XML DB File-System Resources

The protocol specifications, RFC 959 (FTP), RFC 2616 (HTTP), and RFC 2518 (WebDAV) implicitly assume an abstract, hierarchical file system on the server side. This is mapped to Oracle XML DB Repository. The repository provides:

- Name resolution.

- Security based on access control lists (ACLs). An ACL is a list of access control entries that determine which principals have access to a given resource or resources. See also Chapter 27, "Repository Resource Security".
- The ability to store and retrieve any content. The repository can store both binary data input through FTP and XML schema-based documents.

See Also:

- http://www.ietf.org/rfc/rfc959.txt
- http://www.ietf.org/rfc/rfc2616.txt
- http://www.ietf.org/rfc/rfc2518.txt

Protocol Server Handles XML Schema-Based or Non-Schema-Based XML Documents

Oracle XML DB protocol server enhances the protocols by always checking if XML documents being inserted are based on XML schemas registered in Oracle XML DB Repository.

- If the incoming XML document specifies an XML schema, then the Oracle XML DB storage to use is determined by that XML schema. This functionality is especially useful when you must store XML documents object-relationally in the database using simple protocols like FTP or WebDAV instead of using SQL statements.
- If the incoming XML document is not XML schema-based, then it is stored as a binary document.

Event-Based Logging

In certain cases, it may be useful to log the requests received and responses sent by a protocol server. This can be achieved by setting event number `31098` to level `2`. To set this event, add the following line to your `init.ora` file and restart the database:

```
event="31098 trace name context forever, level 2"
```

Using FTP and Oracle XML DB Protocol Server

The following sections describe FTP features supported by Oracle XML DB.

Oracle XML DB Protocol Server: FTP Features

File Transfer Protocol (FTP) is one of the oldest and most popular protocols on the net. FTP is specified in RFC959 and provides access to heterogeneous file systems in a uniform manner. FTP works by providing well-defined commands (methods) for communication between the client and the server. The transfer of command messages and the return of status happens on a single connection. However, a new connection is opened between the client and the server for data transfer. With HTTP(S), commands and data are transferred using a single connection.

FTP is implemented by dedicated clients at the operating system level, file-system explorer clients, and browsers. FTP is typically session-oriented: a user session is created through an explicit logon, a number of files or directories are downloaded and browsed, and then the connection is closed.

Note: For security reasons, FTP is *disabled*, by default. This is because the IETF FTP protocol specification requires that passwords be transmitted in clear text. Disabling is done by configuring the FTP server port as zero (0). To enable FTP, set the `ftp-port` parameter to the FTP port to use, such as 2100.

See Also:

- RFC 959: FTP Protocol Specification – `http://www.ietf.org/rfc/rfc959.txt`
- "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring parameters

FTP Features That Are Not Supported

Oracle XML DB implements FTP, as defined by RFC 959, with the *exception* of the following optional features:

- Record-oriented files, for example, only the `FILE` structure of the `STRU` method is supported. This is the most widely used structure for transfer of files. It is also the default specified by the specification. Structure mount is not supported.
- Append.
- Allocate. This pre-allocates space before file transfer.
- Account. This uses the insecure Telnet protocol.
- Abort.

FTP Client Methods That Are Supported

For access to the repository, Oracle XML DB supports the following FTP client methods.

- `cdup` – change working directory to parent directory
- `cwd` – change working directory
- `dele` – delete file (not directory)
- `list`, `nlst` – list files in working directory
- `mkd` – create directory
- `noop` – do nothing (but timeout counter on connection is reset)
- `pasv`, `port` – establish a TCP data connection
- `pwd` – get working directory
- `quit` – close connection and quit FTP session
- `retr` – retrieve data using an established connection
- `rmd` – remove directory
- `rnfr`, `rnto` – rename file (two-step process: from file, to file)
- `stor` – store data using an established connection
- `syst` – get system version
- `type` – change data type: `ascii` or `image` binary types only

- `user`, `pass` – user login

  See Also:

  - "FTP Quote Methods" for supported FTP `quote` methods
  - "Using FTP with ASM Files" on page 28-11 for an example of using FTP method `proxy`

FTP Quote Methods

Oracle Database supports several FTP `quote` methods, which provide information directly to Oracle XML DB.

- **`rm_r`** – Remove file or folder *<resource_name>*. If a folder, recursively remove all files and folders contained in *<resource_name>*.

  ```
  quote rm_r <resource_name>
  ```

- **`rm_f`** – Forcibly remove a resource.

  ```
  quote rm_f <resource_name>
  ```

- **`rm_rf`** – Combines `rm_r` and `rm_f`: Forcibly and recursively removes files and folders.

  ```
  quote rm_rf <resource_name>
  ```

- **`set_nls_locale`** – Specify the character-set encoding (*<charset_name>*) to be used for file and directory names in FTP methods (including names in method responses).

  ```
  quote set_nls_locale {<charset_name> | NULL}
  ```

  Only IANA character-set names can be specified for *<charset_name>*. If `nls_locale` is set to `NULL` or is not set, then the database character set is used.

- **`set_charset`** – Specify the character set of the data to be sent to the server.

  ```
  quote set_charset  {<charset_name> | NULL}
  ```

  The `set_charset` method applies to only *text* files, not binary files, as determined by the file-extension mapping to MIME types that is defined in configuration file `xdbconfig.xml`.

  If the parameter provided to `set_charset` is ***<charset_name>*** (*not* `NULL`), then it specifies the character set of the data.

  If the parameter provided to `set_charset` is `NULL`, or if no `set_charset` command is given, then the *MIME type* of the data determines the character set for the data.

  – If the MIME type is *not* `text/xml`), then the data is not assumed to be XML. The database character set is used.

  – If the MIME type is **`text/xml`**, then the data represents an XML document.

  If a *byte order mark*[1] (BOM) is present in the XML document, then it determines the character set of the data.

  If there is *no* BOM, then:

[1] BOM is a Unicode-standard signature that indicates the order of the stream of bytes that follows it.

* If there is an *encoding declaration* in the XML document, then it determines the character set of the data.
* If there is *no* encoding declaration, then the UTF-8 character set is used.

Using FTP with ASM Files

Automatic Storage Management (ASM) organizes database files into disk groups for simplified management and added benefits such as database mirroring and I/O balancing. DBAs can use protocols and resource APIs to access ASM files in the Oracle XML DB repository *virtual folder* `/sys/asm`. All files in `/sys/asm` are binary.

Typical uses are listing, copying, moving, creating, and deleting ASM files and folders. Example 28–1 is an example of navigating the ASM virtual folder and listing the files in a subfolder.

Example 28–1 Navigating ASM Folders

The structure of the ASM virtual folder, `/sys/asm`, is described in Chapter 21, "Accessing Oracle XML DB Repository Data". In this example, the disk groups are `DATA` and `RECOVERY`; the database name is `MFG`; and the directories created for aliases are `dbs` and `tmp`. This example navigates to a subfolder, lists its files, and copies a file to the local file system.

```
ftp> open myhost 7777
ftp> user system
ftp> passwd dba
ftp> cd /sys/asm
ftp> ls
DATA
RECOVERY
ftp> cd DATA
ftp> ls
dbs
MFG
ftp> cd dbs
ftp> ls
t_dbl.f
t_axl.f
ftp> binary
ftp> get t_dbl.f, t_axl.f
ftp> put my_db2.f
```

In this example, after connecting to and logging onto database `myhost` (first three lines), FTP methods `cd` and `ls` are used to navigate and list folders, respectively. When in folder `/sys/asm/DATA/dbs`, FTP command `get` is used to copy files `t_db1.f` and `t_ax1.f` to the current folder of the local file system. Then, FTP command `put` is used to copy file `my_db2.f` from the local file system to folder `/sys/asm/DATA/dbs`.

DBAs can copy ASM files from *one database server to another*, as well as between the database and a local file system. Example 28–2 shows copying between two databases. For this, the `proxy` FTP client method can be used, if available. The `proxy` method provides a *direct* connection to two different remote FTP servers.

Example 28–2 Transferring ASM Files Between Databases with FTP proxy Method

This example copies an ASM file from one database to another. Terms with suffix `1` correspond to database `server1`; terms with suffix `2` correspond to database `server2`.

```
 1 ftp> open server1 port1
```

```
 2 ftp> user username1
 3 ftp> passwd password1
 4 ftp> cd /sys/asm/DATAFILE/MFG/DATAFILE
 5 ftp> proxy open server2 port2
 6 ftp> proxy user username2
 7 ftp> proxy passwd password2
 8 ftp> proxy cd /sys/asm/DATAFILE/MFG/DATAFILE
 9 ftp> proxy put dbs2.f tmp1.f
10 ftp> proxy get dbs1.f tmp2.f
```

In this example:

- Line 1 opens an FTP control connection to the Oracle XML DB FTP server, `server1`.
- Lines 2–3 log the DBA onto `server1`.
- Line 4 navigates to `/sys/asm/DATAFILE/MFG/DATAFILE` on `server1`.
- Line 5 opens an FTP control connection to the second database server, `server2`. At this point, the FTP command `proxy ?` could be issued to see the available FTP commands on the secondary connection. (This is not shown.)
- Lines 6–7 log the DBA onto `server2`.
- Line 8 navigates to `/sys/asm/DATAFILE/MFG/DATAFILE` on `server2`.
- Line 9 copies ASM file `dbs2.f` from `server2` to ASM file `tmp1.f` on `server1`.
- Line 10 copies ASM file `dbs1.f` from `server1` to ASM file `tmp2.f` on `server2`.

Using FTP on the Standard Port Instead of the Oracle XML DB Default Port

You can use the Oracle XML DB configuration file, `/xdbconfig.xml`, to configure FTP to listen on any port. By default, FTP listens on a nonstandard, unprotected port. To use FTP on the standard port, 21, your DBA must do the following:

1. (UNIX only) Use this shell command to ensure that the owner and group of executable file `tnslsnr` are `root`:

   ```
   % chown root:root $ORACLE_HOME/bin/tnslsnr
   ```

2. (UNIX only) Add the following entry to the listener file, `LISTENER.ora`, where *`hostname`* is your host name:

   ```
   (DESCRIPTION =
     (ADDRESS = (PROTOCOL = TCP) (HOST = hostname) (PORT = 21))
     (PROTOCOL_STACK = (PRESENTATION = FTP) (SESSION = RAW)))
   ```

3. (UNIX only) Stop, then restart the listener, using the following shell commands, where *`user_id`* and *`group_id`* are your UNIX user and group identifiers, respectively:

   ```
   % lsnrctl stop
   % tnslsnr LISTENER -user user_id -group group_id &
   ```

   Use the ampersand (`&`), to execute the second command in the background. Do not use `lsnrctl start` to start the listener.

4. Use PL/SQL procedure `DBMS_XDB.setftpport` with `SYS as SYSDBA` to set the FTP port number to 21 in the Oracle XML DB configuration file `/xdbconfig.xml`:

   ```
   SQL> exec DBMS_XDB.setFTPPort(21);
   ```

5. Force the database to reregister with the listener, using this SQL statement:

```
SQL> ALTER SYSTEM REGISTER;
```

6. Check that the listener is correctly configured, using this shell command:

```
% lsnrctl status
```

See Also:

- *Oracle Database Net Services Reference* for information about listener parameters and file `LISTENER.ora`
- *Oracle Database Net Services Reference*, section "Port Number Limitations" for information about running on privileged ports

FTP Server Session Management

Oracle XML DB protocol server also provides session management for this protocol. After a short wait for a new command, FTP returns to the protocol layer and the shared server is freed up to serve other connections. The duration of this short wait is configurable by changing parameter `call-timeOut` in the Oracle XML DB configuration file. For high traffic sites, `call-timeout` should be shorter, so that more connections can be served. When new data arrives on the connection, the FTP server is re-invoked with fresh data. So, the long running nature of FTP does not affect the number of connections which can be made to the protocol server.

See Also: "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring Oracle XML DB parameters

Handling Error 421. Modifying the Default Timeout Value of an FTP Session

If you are frequently disconnected from the server and have to reconnect and traverse the entire directory before doing the next operation, you may need to modify the default timeout value for FTP sessions. If the session is idle for more than this period, it gets disconnected. You can increase the timeout value (default = 6000 centiseconds) by modifying the configuration document as follows and then restart the database:

Example 28–3 Modifying the Default Timeout Value of an FTP Session

```
DECLARE
  newconfig XMLType;
BEGIN
  SELECT
    updateXML(
      DBMS_XDB.cfg_get(),
      '/xdbconfig/sysconfig/protocolconfig/ftpconfig/session-timeout/text()',
      123456789)
    INTO newconfig
    FROM DUAL;
  DBMS_XDB.cfg_update(newconfig);
END;
/
COMMIT;
```

FTP Client Failure in Passive Mode

Do not use FTP in *passive mode* to connect remotely to a server that has `HOSTNAME` configured in `Listener.ora` as `localhost` or `127.0.0.1`. If the `HOSTNAME`

specified in server file `Listener.ora` is `localhost` or `127.0.0.1`, then the server is configured for *local use only*. If you try to connect remotely to the server using FTP in passive mode, the FTP client will fail. This is because the server passes IP address `127.0.0.1` (derived from `HOSTNAME`) to the client, which makes the client try to connect to itself, not to the server.

Using HTTP(S) and Oracle XML DB Protocol Server

Oracle XML DB implements HyperText Transfer Protocol (HTTP), HTTP 1.1 as defined in the RFC2616 specification.

Oracle XML DB Protocol Server: HTTP(S) Features

The Oracle XML DB HTTP(S) component in the Oracle XML DB protocol server implements the RFC2616 specification with the *exception* of the following optional features:

- `gzip` and compress transfer encodings
- byte-range headers
- The `TRACE` method (used for proxy error debugging)
- Cache-control directives (these require you to specify expiration dates for content, and are not generally used)
- TE, Trailer, Vary & Warning headers
- Weak entity tags
- Web common log format
- Multi-homed Web server

> **See Also:** RFC 2616: HTTP 1.1 Protocol Specification—`http://www.ietf.org/rfc/rfc2616.txt`

HTTP(S) Features That Are Not Supported

Digest Authentication (RFC 2617) is *not* supported. Oracle XML DB supports Basic Authentication, where a client sends the user name and password in clear text in the Authorization header.

HTTP(S) Client Methods That Are Supported

For access to the repository, Oracle XML DB supports the following HTTP(S) client methods.

- `OPTIONS` – get information about available communication options
- `GET` – get document/data (including headers)
- `HEAD` – get headers only, without document body
- `PUT` – store data in resource
- `DELETE` – delete resource

The semantics of these HTTP(S) methods are in accordance with WebDAV. Servlets and Web services may support additional HTTP(S) methods, such as `POST`.

> **See Also:** "Supported WebDAV Client Methods" on page 28-19 for supported HTTP(S) client methods involving WebDAV

Using HTTP(S) on a Standard Port Instead of an Oracle XML DB Default Port

You can use the Oracle XML DB configuration file, `/xdbconfig.xml`, to configure HTTP(S) to listen on any port. By default, HTTP(S) listens on a nonstandard, unprotected port. To use HTTP or HTTPS on a standard port (80 for HTTP, 443 for HTTPS), your DBA must do the following:

1. (UNIX only) Use this shell command to ensure that the owner and group of executable file `tnslsnr` are `root`:

   ```
   % chown root:root $ORACLE_HOME/bin/tnslsnr
   ```

2. (UNIX only) Add the following entry to the listener file, `LISTENER.ora`, where *`hostname`* is your host name, and *`port_number`* is `80` for HTTP or `443` for HTTPS:

   ```
   (DESCRIPTION =
     (ADDRESS = (PROTOCOL = TCP) (HOST = hostname) (PORT = port_number))
     (PROTOCOL_STACK = (PRESENTATION = HTTP) (SESSION = RAW)))
   ```

3. (UNIX only) Stop, then restart the listener, using the following shell commands, where *`user_id`* and *`group_id`* are your UNIX user and group identifiers, respectively:

   ```
   % lsnrctl stop
   % tnslsnr LISTENER -user user_id -group group_id &
   ```

   Use the ampersand (`&`), to execute the second command in the background. Do not use `lsnrctl start` to start the listener.

4. Use PL/SQL procedure `DBMS_XDB.sethtpport` with `SYS as SYSDBA` to set the HTTP(S) port number to *`port_number`* in the Oracle XML DB configuration file `/xdbconfig.xml`, where *`port_number`* is `80` for HTTP or `443` for HTTPS:

   ```
   SQL> exec DBMS_XDB.setHTTPPort(port_number);
   ```

5. Force the database to reregister with the listener, using this SQL statement:

   ```
   SQL> ALTER SYSTEM REGISTER;
   ```

6. Check that the listener is correctly configured:

   ```
   % lsnrctl status
   ```

See Also:

- *Oracle Database Net Services Reference* for information about listener parameters and file `LISTENER.ora`
- *Oracle Database Net Services Reference*, section "Port Number Limitations" for information about running on privileged ports

HTTPS: Support for Secure HTTP

If properly configured, you can access Oracle XML DB Repository in a *secure* fashion, using HTTPS. See "Configuring Secure HTTP (HTTPS)" on page 28-6 for configuration information.

Note: If Oracle Database is installed on Microsoft Windows XP with *Service Pack 2* (SP2), then you must use HTTPS for WebDAV access to Oracle XML DB Repository, or else you must make appropriate modifications to the Windows XP Registry. For information about the latter, see http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.mspx#XSLTsection129121120120

Anonymous Access to Oracle XML DB Repository using HTTP

Configuration parameter `allow-repository-anonymous-access` controls whether or not anonymous HTTP access to Oracle XML DB Repository data is allowed using an unlocked `ANONYMOUS` user account. The default value is `false`, meaning that unauthenticated access to repository data is *blocked*. To allow anonymous HTTP access to the repository, you must set this parameter to `true`, and unlock the `ANONYMOUS` user account.

Caution: There is an inherent *security risk* associated with allowing anonymous access to the repository.

Parameter `allow-repository-anonymous-access` does *not* control anonymous access to the repository using *servlets*. Each servlet has its own `security-role-ref` parameter value to control its access.

See Also:

- Table 28–3 on page 28-5 for information about parameter `allow-repository-anonymous-access`
- "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring Oracle XML DB parameters
- "Configuring Oracle XML DB Servlets" on page 32-3 for information about parameter `security-role-ref`

Using Java Servlets with HTTP(S)

Oracle XML DB supports Java servlets. To use a Java servlet, it must be registered with a unique name in the Oracle XML DB configuration file, along with parameters to customize its action. It should be compiled, and loaded into the database. Finally, the servlet name must be associated with a pattern, which can be an extension such as `*.jsp` or a path name such as `/a/b/c` or `/sys/*`, as described in Java servlet application program interface (API) version 2.2.

While processing an HTTP(S) request, the path name for the request is matched with the registered patterns. If there is a match, then the protocol server invokes the corresponding servlet with the appropriate initialization parameters. For Java servlets, the existing Java Virtual Machine (JVM) infrastructure is used. This starts the JVM if need be, which in turn runs a Java method to initialize the servlet, create response, and request objects, pass these on to the servlet, and run it.

See Also: Chapter 32, "Writing Oracle XML DB Applications in Java"

Embedded PL/SQL Gateway

You can use the PL/SQL gateway to implement a Web application entirely in PL/SQL. There are two implementations of the PL/SQL gateway:

- *mod_plsql* – a plug-in of *Oracle HTTP Server* that lets you invoke PL/SQL stored procedures using HTTP(S). Oracle HTTP Server is a component of both Oracle Application Server and Oracle Database; it should not be confused with the HTTP component of the Oracle XML DB protocol server.
- the *embedded* PL/SQL gateway – a gateway implementation that runs in the Oracle XML DB HTTP listener.

With the PL/SQL gateway (either implementation), a Web browser sends an HTTP(S) request in the form of a URL that identifies a stored procedure and provides it with parameter values. The gateway translates the URL, calls the stored procedure with the parameter values, and returns output (typically HTML) to the Web-browser client.

Using the embedded PL/SQL gateway simplifies installation, configuration, and administration of PL/SQL based Web applications. The embedded gateway uses the Oracle XML DB protocol server, not Oracle HTTP Server. Its configuration is defined by the Oracle XML DB configuration file, `/xdbconfig.xml`. However, the *recommended* way to configure the embedded gateway is to use the procedures in PL/SQL package `DBMS_EPG`, *not* to edit file `/xdbconfig.xml`.

See Also:

- *Oracle Database Advanced Application Developer's Guide* for information on using and configuring the embedded PL/SQL gateway
- Chapter 34, "Administering Oracle XML DB" for information on the configuration definition of the embedded gateway in `/xdbconfig.xml`
- *Oracle Fusion Middleware Administrator's Guide for Oracle HTTP Server* for conceptual information about using the PL/SQL gateway
- *Oracle HTTP Server mod_plsql User's Guide* for information about mod_plsql

Sending Multibyte Data From a Client

When a client sends multibyte data in a URL, RFC 2718 specifies that the client should send the URL using the `%HH` format, where `HH` is the hexadecimal notation of the byte value in UTF-8 encoding. The following are URL examples that can be sent to Oracle XML DB in an HTTP(S) or WebDAV context:

```
http://urltest/xyz%E3%81%82%E3%82%A2
http://%E3%81%82%E3%82%A2
http://%E3%81%82%E3%82%A2/abc%E3%81%86%E3%83%8F.xml
```

Oracle XML DB processes the requested URL, any URLs within an `IF` header, any URLs within the `DESTINATION` header, and any URLs in the `REFERRED` header that contains multibyte data.

The `default-url-charset` configuration parameter can be used to accept requests from some clients that use other, nonconforming, forms of URL, with characters that are not ASCII. If a request with such characters fails, try setting this value to the native character set of the client environment. The character set used in such URL fields must be specified with an IANA charset name.

`default-url-charset` controls the encoding for nonconforming URLs. It is not required to be set unless a nonconforming client that does not send the `Content-Type` charset is used.

See Also:

- RFC 2616: HTTP 1.1 Protocol Specification, `http://www.ietf.org/rfc/rfc2616.txt`
- "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring Oracle XML DB parameters

Characters That Are Not ASCII In URLs

Characters that are not ASCII that appear in URLs passed to an HTTP server should be converted to `UTF-8` and escaped in the `%`*`HH`* format, where *`HH`* is the hexadecimal notation of the byte value. For flexibility, the Oracle XML DB protocol server interprets the incoming URLs by testing whether it is encoded in one of the following character sets in the order presented here:

- UTF-8
- Charset parameter of the `Content-Type` field of the request, if specified
- Character set, if specified, in the `default-url-charset` configuration parameter
- Character set of the database

See Also: "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for information about configuring Oracle XML DB parameters

Controlling Character Sets for HTTP(S)

The following sections describe how character sets are controlled for data transferred using HTTP(S).

Request Character Set The character set of the HTTP(S) request body is determined with the following algorithm:

- The Content-Type header is evaluated. If the Content-Type header specifies a charset value, the specified charset is used.
- The MIME type of the document is evaluated as follows:
  - If the MIME type is "`*/xml`", the character set is determined as follows:

    - If a BOM is present, then `UTF-16` is used.

    - If an encoding declaration is present, the specified encoding is used.

    - If neither a BOM nor an encoding declaration is present, `UTF-8` is used.
  - If the MIME type is text, `ISO8859-1` is used.
  - If the MIME type is neither "`*/xml`" nor `text`, the database character set is used.

There is a difference between HTTP(S) and SQL or FTP. For text documents, the default is ISO8859-1, as specified by the IETF.org *RFC 2616: HTTP 1.1 Protocol Specification*.

Response Character Set

The response generated by Oracle XML DB HTTP Server is in the character set specified in the `Accept-Charset` field of the request. `Accept-Charset` can have a list of character sets. Based on the q-value, Oracle XML DB chooses one that does not require conversion. This might not necessarily be the charset with the highest q-value. If Oracle XML DB cannot find one, then the conversion is based on the highest q-value.

Using WebDAV and Oracle XML DB

Web Distributed Authoring and Versioning (WebDAV) is an IETF standard protocol used to provide users with a file-system interface to Oracle XML Repository over the Internet. The most popular way of accessing a WebDAV server folder is through WebFolders on Microsoft Windows 2000 or Microsoft NT.

WebDAV is an extension to the HTTP 1.1 protocol that lets an HTTP server act as a file server. It lets clients perform remote Web content authoring through a coherent set of methods, headers, request body formats and response body formats. For example, a DAV-enabled editor can interact with an HTTP/WebDAV server as if it were a file system. WebDAV provides operations to store and retrieve resources, create and list contents of resource collections, lock resources for concurrent access in a coordinated manner, and to set and retrieve resource properties.

Oracle XML DB WebDAV Features

Oracle XML DB supports the following WebDAV features:

- Foldering, specified by RFC2518
- Access Control

WebDAV is a set of extensions to the HTTP(S) protocol that allow you to edit or manage your files on remote Web servers. WebDAV can also be used, for example, to:

- Share documents over the Internet
- Edit content over the Internet

> **See Also:** RFC 2518: WebDAV Protocol Specification, `http://www.ietf.org/rfc/rfc2518.txt`

WebDAV Features That Are Not Supported

Oracle XML DB supports the contents of RFC2518, with the following exceptions:

- Lock-`NULL` resources create zero-length resources in the file system, and cannot be converted to folders.
- The `COPY`, `MOVE` and `DELETE` methods comply with section 2 of the Internet Draft titled 'Binding Extensions to WebDAV'.
- Depth-infinity locks
- Only Basic Authentication is supported.

Supported WebDAV Client Methods

For access to the repository, Oracle XML DB supports the following HTTP(S)/WebDAV client methods.

- `PROPFIND` (WebDAV-specific) – get properties for a resource
- `PROPPATCH` (WebDAV-specific) – set or remove resource properties
- `LOCK` (WebDAV-specific) – lock a resource (create or refresh a lock)

- `UNLOCK` (WebDAV-specific) – unlock a resource (remove a lock)
- `COPY` (WebDAV-specific) – copy a resource
- `MOVE` (WebDAV-specific) – move a resource
- `MKCOL` (WebDAV-specific) – create a folder resource (collection)

See Also:

- "HTTP(S) Client Methods That Are Supported" on page 28-14 for additional supported HTTP(S) client methods
- "Access Privileges" on page 27-5 for information about WebDAV privileges
- "Using WebDAV PROPPATCH to Add Metadata" on page 29-8

Using WebDAV with Microsoft Windows XP SP2

If Oracle Database is installed on Microsoft Windows XP with *Service Pack 2* (SP2), then you must use a secure connection (HTTPS) for WebDAV access to Oracle XML DB Repository, or else you must make appropriate modifications to the Windows XP Registry.

See Also:

- `http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/sp2netwk.mspx#XSLTsection129121120120` for information about making necessary modifications to the Windows XP registry
- "Configuring Secure HTTP (HTTPS)" on page 28-6

Using Oracle XML DB and WebDAV: Creating a WebFolder in Windows 2000

To create a WebFolder in Windows 2000, follow these steps:

1. From your desktop, select **My Network Places**.
2. Double-click **Add Network Place**.
3. Type the location of the folder, for example:

   `http://`*`Oracle_server_name`*`:`*`HTTP_port_number`*

   See Figure 28–2.
4. Click **Next**.
5. Enter any name to identify this WebFolder
6. Click **Finish**.

You can now access Oracle XML DB Repository just like you access any Windows folder.

Figure 28–2 Creating a WebFolder in Windows 2000

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User-Defined Repository Metadata

This chapter describes how to create and use XML metadata, which you associate with XML data and store in Oracle XML DB Repository.

This chapter contains these topics:

Overview of Metadata and XML

Data that you use is often associated with additional information that is not part of the content. To process it in different ways, you can use such **metadata** to group or classify data. For example, you might have a collection of digital photographs, and you might associate metadata with each picture, such as information about the photographic characteristics (color composition, focal length) or context (location, kind of subject: landscape, people).

An Oracle XML DB repository **resource** is an XML document that contains both metadata and data; the data is the contents of element `Contents`; all other elements in the resource contain metadata. The data of a resource can be XML, but it need not be.

You can associate resources in the Oracle XML DB repository with metadata that you define. In addition to such *user-defined metadata*, each repository resource also has associated metadata that Oracle XML DB creates automatically and uses (transparently) to manage the resource. Such *system-defined metadata* includes properties such as the owner and creation date of each resource.

Except for system-defined metadata, you decide which resource information should be treated as data and which should be treated as metadata. For a photo resource, supplemental information about the photo is normally not considered to be part of the photo data, which is a binary image. For text, however, you sometimes have a choice of whether to include particular information in the resource contents (data) or keep it separate and associate it with the contents as metadata—that choice is often influenced by the applications that use or produce the data.

Kinds of Metadata – Uses of the Term

In addition to resource metadata (system-defined and user-defined), the term "metadata" is sometimes used to refer to the following:

- An XML *schema* is metadata that describes a class of XML documents.
- An XML *tag* (element or attribute name) is metadata that is used to label and organize the element content or attribute value.

You can associate metadata with an XML document that is the content of a repository resource in any of these ways:

- You can add additional XML elements containing the metadata information to the resource *contents*. For example, you could wrap digital image data in an XML document that also includes elements describing the photo. In this case, the data and its metadata are associated by being in the contents of the same resource. It is up to applications to separate the two and relate them correctly.
- You can add metadata information for a particular resource to the repository as the contents of a *separate resource*. In this case, it is up to applications to treat this resource as metadata and associate it with the data.
- You can add metadata information for a resource as repository *resource metadata*. In this case, Oracle XML DB recognizes the metadata as such. Applications can *discover* this metadata by querying the repository for it. They need not be informed separately of its existence and its association with the data.

See Also: "Oracle XML DB Resources" on page 21-4

User-Defined Resource Metadata

Of these different ways of considering metadata, this chapter is about only the last of those just listed: *user-defined resource metadata*. Such metadata is itself *represented as XML*: it is XML data that is associated with other XML data, describing it or providing supplementary, related information.

User-defined metadata for resources can be either XML schema-based or not:

- Resource metadata that is *schema-based* is stored in separate (out-of-line) tables. These are related to the resource table by the resource OID, which is stored in the hidden object column `RESID` of the metadata tables.
- Resource metadata that is *not* schema-based is stored in a `CLOB` column in the resource table.

You can take advantage of schema-based metadata, in particular, to perform efficient queries and DML operations on resources. In this chapter, you will learn how to perform the following tasks involving schema-based resource metadata:

- Create and register an *XML schema* that defines the metadata for a particular kind of resource.
- *Add* metadata to a repository resource, and *update* (modify) such metadata.
- *Query* resource metadata to find associated content.
- *Delete* specific metadata associated with a resource and *purge* all metadata associated with a resource.

In addition, you will learn how to add non-schema-based metadata to a resource.

You can generally use user-defined resource metadata just as you would use resource data. In particular, versioning and access control management apply.

Typical uses of resource metadata include workflow applications, enforcing user rights management, tracking resource ownership, and controlling resource validity dates.

Scenario: Metadata for a Photo Collection

To illustrate the use of schema-based resource metadata, we will consider metadata associated with photographic image files that are stored in repository resources. You can create any number of different kinds of metadata to be associated with the same resource. For image files, we will create metadata for information about both 1) the technical aspects of a photo and 2) the photo subject or the uses to which a photo might be put. We will use these two kinds of associated metadata to query photo resources.

XML Schemas to Define Resource Metadata

We first define the metadata that we want to associate with each photo resource. XML Schema is our tool for defining XML data: for each kind (technique, category) of metadata we define, we create and register an XML schema.

Example 29–1 Register an XML Schema for Technical Photo Information

The following XML schema defines metadata used to describe the technical aspects of a photo image file. We use procedure `DBMS_XMLSCHEMA.registerSchema` to register the XML schema. To identify this schema as defining repository resource *metadata*, we use the `ENABLE_HIERARCHY_RESMETADATA` value for the `enableHierarchy` parameter. Resource contents (data) are defined by using value `ENABLE_HIERARCHY_CONTENTS` (the default value), instead.

The properties we define here are the image height, width, color depth, title, and brief description.

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'imagetechnique.xsd',
    '<xsd:schema targetNamespace="inamespace"
                 xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                 xmlns:xdb="http://xmlns.oracle.com/xdb"
                 xmlns="inamespace">
       <xsd:element name="ImgTechMetadata"
                    xdb:defaultTable="IMGTECHMETADATATABLE">
         <xsd:complexType>
           <xsd:sequence>
             <xsd:element name="Height"      type="xsd:float"/>
             <xsd:element name="Width"       type="xsd:float"/>
             <xsd:element name="ColorDepth"  type="xsd:integer"/>
             <xsd:element name="Title"       type="xsd:string"/>
             <xsd:element name="Description" type="xsd:string"/>
           </xsd:sequence>
         </xsd:complexType>
        </xsd:element>
      </xsd:schema>',
    enableHierarchy=>DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

Example 29–2 Register an XML Schema for Photo Categorization

The following XML schema defines metadata used to categorize a photo image file: to describe its content or possible uses. In this simple example, we define a single, general property for classification, named `Category`.

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    'imagecategories.xsd',
    '<xsd:schema targetNamespace="cnamespace"
                 xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                 xmlns:xdb="http://xmlns.oracle.com/xdb"
                 xmlns="cnamespace">
       <xsd:element name="ImgCatMetadata"
                    xdb:defaultTable="IMGCATMETADATATABLE">
         <xsd:complexType>
           <xsd:sequence>
             <xsd:element name="Categories" type="CategoriesType"/>
           </xsd:sequence>
         </xsd:complexType>
        </xsd:element>
        <xsd:complexType name="CategoriesType">
          <xsd:sequence>
            <xsd:element name="Category" type="xsd:string" maxOccurs="unbounded"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:schema>',
    enableHierarchy=>DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

Notice that there is nothing in the XML schema definitions of metadata that restrict that information to being associated with any particular kind of data. You are free to associate any type of metadata with any type of resource. And multiple types of metadata can be associated with the same resource.

Notice, too, that the XML schema does not, by itself, define its associated data as being metadata—it is the schema *registration* that makes this characterization, through `enableHierarchy` value `ENABLE_HIERARCHY_RESMETADATA`. If the same schema were registered instead with `enableHierarchy` value `ENABLE_HIERARCHY_CONTENTS` (the default value), then it would define not metadata for resources, but resource *contents* with the same information. The same XML schema cannot be registered more than once under the same name.

Note: XML schema-based user-defined metadata is stored as a `CLOB`, by default. You can store it as binary XML, instead, by setting the `OPTIONS` parameter for XML schema registration to `REGISTER_BINARYXML`.

Adding, Updating, and Deleting Resource Metadata

You can add, update, and delete user-defined resource metadata in the following ways:

- use PL/SQL procedures in package `DBMS_XDB`:
  - `appendResourceMetadata` – add metadata to a resource
  - `updateResourceMetadata` – modify resource metadata

  - `deleteResourceMetadata` – delete specific metadata from a resource
  - `purgeResourceMetadata` – delete *all* metadata from a resource
- use SQL DML statements `INSERT`, `UPDATE`, and `DELETE` to update the resource directly
- use WebDAV protocol method `PROPPATCH`

Using the latter two methods, updating and deleting metadata are done in the same way as adding metadata. If you supply a complete `Resource` element for one of these operations, then keep in mind that each resource metadata property must be a child (not just a descendant) of element `Resource`—if you want multiple metadata elements of the same kind, you must collect them as children of a single parent metadata element. The order among such top-level user-defined resource metadata properties is unimportant and is not necessarily maintained by Oracle XML DB.

The separate PL/SQL procedures in package `DBMS_XDB` are similar in their use. Each can be used with either XML schema-based or non-schema-based metadata. Some forms (signatures) of some of the procedures apply only to schema-based metadata. Procedures `appendResourceMetadata` and `deleteResourceMetadata` are illustrated here with examples.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about the procedures in PL/SQL package `DBMS_XDB`

Using APPENDRESOURCEMETADATA to Add Metadata

You can use procedure `DBMS_XDB.appendResourceMetadata` to add user-defined metadata to resources.

Example 29–3 Add Metadata to a Resource – Technical Photo Information

This example creates a photo resource and adds XML schema-based metadata of type `ImgTechMetadata` to it, recording the technical information about the photo.

```
DECLARE
  returnbool BOOLEAN;
BEGIN
  returnbool := DBMS_XDB.createResource(
                  '/public/horse_with_pig.jpg',
                  bfilename('MYDIR', 'horse_with_pig.jpg'));
  DBMS_XDB.appendResourceMetadata(
    '/public/horse_with_pig.jpg',
    XMLType('<i:ImgTechMetadata
                 xmlns:i="inamespace"
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xsi:schemaLocation="inamespace imagetechnique.xsd">
               <Height>1024</Height>
               <Width>768</Width>
               <ColorDepth>24</ColorDepth>
               <Title>Pig Riding Horse</Title>
               <Description>Picture of a pig riding a horse on the beach,
taken outside hotel window.</Description>
             </i:ImgTechMetadata>'));
END;
/
```

Example 29–4 Add Metadata to a Resource – Photo Content Categories

This example adds metadata of type `ImgTechMetadata` to the same resource as Example 29–3, placing the photo in several user-defined content categories.

```
BEGIN
  DBMS_XDB.appendResourceMetadata(
    '/public/horse_with_pig.jpg',
    XMLType('<c:ImgCatMetadata
                xmlns:c="cnamespace"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="cnamespace imagecategories.xsd">
              <Categories>
                <Category>Vacation</Category>
                <Category>Animals</Category>
                <Category>Humor</Category>
                <Category>2005</Category>
              </Categories>
            </c:ImgCatMetadata>'));
END;
/

PL/SQL procedure successfully completed.

SELECT * FROM imgcatmetadatatable;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace" xmlns:xsi="http://www.w3.org/2001/XMLSche
ma-instance" xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

Using DELETERESOURCEMETADATA to Delete Metadata

You can use procedure `DBMS_XDB.deleteResourceMetadata` to delete specific metadata associated with a resource. To delete *all* of the metadata associated with a resource, you can use procedure `DBMS_XDB.purgeResourceMetadata`.

Example 29–5 Delete Specific Metadata from a Resource

This example deletes the category metadata that was added to the photo resource in Example 29–4. By default, both the resource link (`REF`) to the metadata and the metadata table identified by that link are deleted. An optional parameter can be used to specify that only the link is to be deleted; the metadata table is then left as is but becomes unrelated to the resource. In this example, the default behavior is used.

```
BEGIN
  DBMS_XDB.deleteResourceMetadata('/public/horse_with_pig.jpg',
                                  'cnamespace',
                                  'ImgCatMetadata');
END;
/
```

```
PL/SQL procedure successfully completed.

SELECT * FROM imgcatmetadatatable;

no rows selected
```

Using SQL DML to Add Metadata

An alternative to using procedure `DBMS_XDB.appendResourceMetadata` to add, update, or delete resource metadata is to update the `RESOURCE_VIEW` directly using DML statements `INSERT` and `UPDATE`. Adding resource metadata in this way is illustrated by Example 29–6.

Example 29–6 Add Metadata to a Resource Using DML with RESOURCE_VIEW

This example shows how to accomplish the same thing as Example 29–3 by inserting the metadata directly into `RESOURCE_VIEW` using SQL statement `UPDATE`. Other SQL DML statements may be used similarly.

```
UPDATE RESOURCE_VIEW
  SET RES =
        insertChildXML(
          RES,
          '/r:Resource',
          'c:ImgCatMetadata',
          XMLType('<c:ImgCatMetadata
                      xmlns:c="cnamespace"
                      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                      xsi:schemaLocation="cnamespace imagecategories.xsd">
                    <Categories>
                      <Category>Vacation</Category>
                      <Category>Animals</Category>
                      <Category>Humor</Category>
                      <Category>2005</Category>
                    </Categories>
                  </c:ImgCatMetadata>'),
          'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
           xmlns:c="cnamespace"')
  WHERE equals_path(RES, '/public/horse_with_pig.jpg') = 1;
/

SELECT * FROM imgcatmetadatatable;

SYS_NC_ROWINFO$
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace" xmlns:xsi="http://www.w3.org/2001/XMLSche
ma-instance" xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

The following query extracts the inserted metadata using `RESOURCE_VIEW`, rather than directly using metadata table `imgcatmetadatatable`. (The result is shown here pretty-printed, for clarity.)

```
SELECT extract(RES,
               '/r:Resource/c:ImgCatMetadata',
               'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                xmlns:c="cnamespace"')
  FROM RESOURCE_VIEW
  WHERE equals_path(RES, '/public/horse_with_pig.jpg') = 1;

EXTRACT(RES,'/R:RESOURCE/C:IMGCATMETADATA','XMLNS:R="HTTP://XMLNS.ORACLE.COM/XDB
--------------------------------------------------------------------------------
<c:ImgCatMetadata xmlns:c="cnamespace"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                  xsi:schemaLocation="cnamespace imagecategories.xsd">
  <Categories>
    <Category>Vacation</Category>
    <Category>Animals</Category>
    <Category>Humor</Category>
    <Category>2005</Category>
  </Categories>
</c:ImgCatMetadata>

1 row selected.
```

Using WebDAV PROPPATCH to Add Metadata

Another alternative to using procedure `DBMS_XDB.appendResourceMetadata` to add resource metadata is to use the `PROPPATCH` method of the WebDAV protocol. This is illustrated by Example 29–7. Metadata updates and deletions can be made similarly.

Example 29–7 Add Metadata with WebDAV PROPPATCH

This example shows how to accomplish the same thing as Example 29–4 by inserting the metadata using the WebDAV protocol `PROPPATCH` method. Using appropriate tools, your application creates such a `PROPPATCH` WebDAV request and sends it to the WebDAV server for processing.

To update user-defined metadata, you proceed in the same way. To *delete* user-defined metadata, the WebDAV request is similar, but it has `D:remove` in place of `D:set`.

```
PROPPATCH /public/horse_with_pig.jpg HTTP/1.1
Host: www.myhost.com
Content-Type: text/xml; charset="utf-8"
Content-Length: 609
Authorization: Basic dGRhZHhkYl9tZXRhOnRkYWR4ZGJfbWV0YQ==
Connection: close

<?xml version="1.0" encoding="utf-8" ?>
<D:propertyupdate xmlns:D="DAV:" xmlns:Z="http://www.w3.com/standards/z39.50/">
  <D:set>
    <D:prop>
      <c:ImgCatMetadata
          xmlns:c="cnamespace"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="cnamespace imagecategories.xsd">
        <Categories>
          <Category>Vacation</Category>
          <Category>Animals</Category>
          <Category>Humor</Category>
          <Category>2005</Category>
        </Categories>
      </c:ImgCatMetadata>
```

```
    </D:prop>
  </D:set>
</D:propertyupdate>
```

Querying Schema-Based Resource Metadata

When you register an XML schema using the `enableHierarchy` value `ENABLE_HIERARCHY_RESMETADATA`, an additional column, `RESID`, is added automatically to the `XMLType` tables used to store the metadata. This column stores the object identifier (OID) of the resource associated with the metadata. You can use column `RESID` when querying metadata, to join the metadata with the associated data.

You can query metadata in these ways:

- Query `RESOURCE_VIEW` for the metadata. For example:

```
SELECT COUNT(*) FROM RESOURCE_VIEW
  WHERE
    existsNode(RES,
               '/r:Resource/c:ImgCatMetadata/Categories/Category
                [text()="Vacation"]',
               'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                xmlns:c="cnamespace"') = 1;

  COUNT(*)
----------
         1

1 row selected.
```

- Query the XML schema-based table for the user-defined metadata directly, and join this metadata back to the resource table, identifying which resource to select. To do this, we use the `RESID` column of the metadata table. For example:

```
SELECT COUNT(*) FROM RESOURCE_VIEW rs, imgcatmetadatatable ct
  WHERE existsNode(RES,
                   '/r:Resource/c:ImgCatMetadata/Categories/Category
                    [text()="Vacation"]',
                   'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                    xmlns:c="cnamespace"') = 1
    AND rs.RESID = ct.RESID;

  COUNT(*)
----------
         1

1 row selected.
```

The latter method is recommended, for performance reasons. Direct queries of the `RESOURCE_VIEW` alone *cannot be optimized* using XPath rewrite, because there is no way to determine whether or not target elements like `Category` are stored in the `CLOB` value or in an out-of-line table.

To improve performance further, create an index on each metadata column you intend to query.

Example 29–8 Query XML Schema-Based Resource Metadata

This example queries both kinds of photo resource metadata, retrieving the paths to the resources that are categorized as vacation photos and have title "Pig Riding Horse".

```
SELECT ANY_PATH
  FROM RESOURCE_VIEW rs, imgcatmetadatatable ct, imgtechmetadatatable tt
  WHERE existsNode(RES,
                   '/r:Resource/c:ImgCatMetadata/Categories/Category
                    [text()="Vacation"]',
                   'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                    xmlns:c="cnamespace"') = 1
    AND existsNode(RES,
                   '/r:Resource/i:ImgTechMetadata/Title
                    [text()="Pig Riding Horse"]',
                   'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                    xmlns:i="inamespace"') = 1
    AND rs.RESID = ct.RESID
    AND rs.RESID = tt.RESID;

ANY_PATH
-------------------------
/public/horse_with_pig.jpg

1 row selected.
```

XML Image Metadata from Binary Image Metadata

In previous sections of this chapter we have used a simple user-defined XML schema that defines technical image metadata, `imagetechnique.xsd`, to illustrate ways of adding and changing repository resource metadata. That simple XML schema is not intended to be realistic with respect to technical photographic image information.

However, nearly all digital cameras now include image metadata as part of the binary image files they produce, and Oracle *inter*Media, which is part of Oracle Database, provides tools for extracting and converting this binary metadata to XML. Oracle *inter*Media XML schemas are automatically registered with Oracle XML DB Repository to convert binary image metadata of the followings kinds to XML data:

- EXIF – Exchangeable Image File Format
- IPTC-NAA IIM – International Press Telecommunications Council-Newspaper Association of America Information Interchange Model
- XMP – Extensible Metadata Platform

EXIF is the metadata standard for digital still cameras; EXIF metadata is stored in TIFF and JPEG image files. IPTC and XMP metadata is commonly embedded in image files by desktop image-processing software.

See Also:

- *Oracle Multimedia User's Guide* for information about working with digital image metadata, including examples of extracting binary image metadata and converting it to XML
- *Oracle Multimedia Reference* for information about the XML schemas supported by Oracle *inter*Media for use with image metadata

Adding Non-Schema-Based Resource Metadata

You store user-defined resource metadata that is *not* schema-based as a `CLOB` instance under the `Resource` element of the associated resource. The default XML schema for a resource has a top-level element **`any`** (declared with `maxOccurs= "unbounded"`),

which admits any valid XML data as part of the resource document; this metadata is stored in a CLOB column of the resource table.

The following skeleton shows the structure and position of non-schema-based resource metadata:

```
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd"
  <Owner>DESELBY</Owner>
  ... <!-- other system-defined metadata -->
  <!-- contents of the resource>
  <Contents>
    ...
  </Contents>
  <!-- User-defined metadata (appearing within different namespace) -->
  <MyOwnMetadata xmlns="http://www.example.com/custommetadata">
    <MyElement1>value1</MyElement1>
    <MyElement2>value2</MyElement2>
  </MyOwnMetadata>
</Resource>
```

You can set and access non-schema-based resource metadata belonging to namespaces other than XDBResource.xsd by using any of the methods described previously for schema-based resource metadata. Example 29–9 illustrates this for the case of SQL DML operations, adding user-defined metadata directly to the <RESOURCE> *document*.

Example 29–9 Add Non-Schema-Based Metadata to a Resource

This example shows how to add non-schema-based metadata to a resource using SQL DML.

```
DECLARE
  res BOOLEAN;
BEGIN
  res := DBMS_XDB.createResource('/public/NurseryRhyme.txt',
                                 bfilename('MYDIR',
                                           'tdadxdb-xdb_repos_meta-011.txt'),
                                 nls_charset_id('AL32UTF8'));
UPDATE RESOURCE_VIEW
  SET RES = insertChildXML(RES,
                           '/r:Resource',
                           'n:NurseryMetadata',
                           XMLType('<n:NurseryMetadata xmlns:n="nurserynamespace">
                                      <Author>Mother Goose</Author>
                                    <n:NurseryMetadata>'),
                           'xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                            xmlns:n="nurserynamespace"')
  WHERE equals_path(RES, '/public/NurseryRhyme.txt') = 1;
END;
/

PL/SQL procedure successfully completed.


SELECT rs.RES.getCLOBVal() FROM RESOURCE_VIEW rs
  WHERE equals_path(RES, '/public/NurseryRhyme.txt') = 1;

RS.RES.GETCLOBVAL()
--------------------------------------------------------------------------------
<Resource xmlns="http://xmlns.oracle.com/xdb/XDBResource.xsd" Hidden="false" Inv
alid="false" Container="false" CustomRslv="false" VersionHistory="false" StickyR
ef="true">
```

```
  <CreationDate>2005-05-24T13:51:48.043234</CreationDate>
  <ModificationDate>2005-05-24T13:51:48.290144</ModificationDate>
  <DisplayName>NurseryRhyme.txt</DisplayName>
  <Language>en-US</Language>
  <CharacterSet>UTF-8</CharacterSet>
  <ContentType>text/plain</ContentType>
  <RefCount>1</RefCount>
  <ACL>
    <acl description="Public:All privileges to PUBLIC" xmlns="http://xmlns.oracl
e.com/xdb/acl.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:sch
emaLocation="http://xmlns.oracle.com/xdb/acl.xsd                          http:
//xmlns.oracle.com/xdb/acl.xsd">
      <ace>
        <principal>PUBLIC</principal>
        <grant>true</grant>
        <privilege>
          <all/>
        </privilege>
      </ace>
    </acl>
  </ACL>
  <Owner>TDADXDB_META</Owner>
  <Creator>TDADXDB_META</Creator>
  <LastModifier>TDADXDB_META</LastModifier>
  <SchemaElement>http://xmlns.oracle.com/xdb/XDBSchema.xsd#text</SchemaElement>
  <Contents>
    <text>Mary had a little lamb
Its fleece was white as snow
and everywhere that Mary went
that lamb was sure to go
</text>
  </Contents>
  <n:NurseryMetadata xmlns:n="nurserynamespace">
    <Author xmlns="">Mother Goose</Author>
  </n:NurseryMetadata>
</Resource>

1 row selected.
```

PL/SQL Procedures Affecting Resource Metadata

The following PL/SQL procedures perform resource metadata operations:

- `DBMS_XMLSCHEMA.registerSchema` – Register an XML schema. Parameter `enableHierarchy` affects resource metadata.
- `DBMS_XDBZ.enable_hierarchy` – Enable repository support for an `XMLType` table or view. Use parameter `hierarchy_type` with a value of `DBMS_XDBZ.ENABLE_HIERARCHY_RESMETADATA` to enable resource metadata. This adds column `RESID` to track the resource associated with the metadata.
- `DBMS_XDBZ.disable_hierarchy` – Disable all repository support for an `XMLType` table or view.
- `DBMS_XDBZ.is_hierarchy_enabled` – Tests, using parameter `hierarchy_type`, whether the specified type of hierarchy is currently enabled for the specified `XMLType` table or view. Value `DBMS_XDBZ.IS_ENABLED_RESMETADATA` for `hierarchy_type` tests whether resource metadata is enabled.
- `DBMS_XDB.appendResourceMetadata` – Add metadata to a resource.

- `DBMS_XDB.deleteResourceMetadata` – Delete specified metadata from a resource.
- `DBMS_XDB.purgeResourceMetadata` – Delete all user-defined metadata from a resource. For schema-based resources, optional parameter `delete_option` can be used to specify whether or not to delete the metadata information, as well as unlink it.
- `DBMS_XDB.updateResourceMetadata` – Update the metadata for a resource.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about these PL/SQL procedures

30

Oracle XML DB Repository Events

This chapter describes repository events and how to use them. It contains these topics:

Overview of Repository Events

You can use Oracle XML DB Repository to store and access data of any kind in the form of repository resources: files and folders. Repository resource operations include creating, deleting, locking, unlocking, rendering, linking, unlinking, placing under version control, checking in, checking out, unchecking out, opening, and updating. You can access data in the repository from any application. Sometimes your application needs to perform certain actions whenever a particular repository operation occurs. For example, you might want to perform some move-to-wastebasket or other backup action whenever a resource is deleted.

Repository Events: Use Cases

The following are examples of cases where repository events can be used:

- *Wastebasket* – You can use an `UnLink` pre-event handler to effectively move a resource to a wastebasket instead of deleting it; that is, create a link in a wastebasket folder before removing the original link. The link in the wastebasket ensures that the resource will not be removed. When you subsequently undelete a resource from the waste basket, the original link can be created again and the wastebasket link removed. The wastebasket link name can be different from the name of the link being removed because a resource at a certain path could be unlinked more than once from that path. The wastebasket would then have multiple links corresponding to that path, with different link properties and possibly pointing to different resources.
- *Categorization* – An application might categorize the resources it manages based on MIME type or other properties. It might keep track of GIF, text, and XML files by maintaining links to them from repository folders `/my-app/gif`, `/my-app/txt`, and `/my-app/xml`. Three post-event handlers could be used here: `LinkIn`, `UnlinkIn`, and `Update`. The `LinkIn` post-event handler would examine the resource and create a link in the appropriate category folder, if not already present. The `UnlinkIn` post-event handler would remove the link from the category

folder. The `Update` post-event handler would effectively move the resource from one category folder to another if its category changes.

Repository Events and Database Triggers

Repository events are reminiscent of database triggers, but they offer additional functionality. You cannot use a database trigger to let your application react to repository operations. A given repository operation can consist of multiple database operations on multiple underlying, internal tables. Because these underlying tables are internal to Oracle XML DB, you cannot easily map them to specific repository operations. For example, internal table `XDB$H_INDEX` might be updated by either a database update operation, if an ACL is changed, or a link operation. Even in cases where you might be able to accomplish the same thing using database triggers, you would not want to do that: A repository event is a higher-level abstraction than would be a set of database triggers on the underlying tables.

When a repository event occurs, information associated with the operation, such as the resource path used, can be passed to the corresponding event handler. Such information is not readily available using database triggers.

Repository events and database triggers can both be applied to XML data. You can use triggers on `XMLType` tables, for instance. However, if an `XMLType` table is also a repository table (hierarchy-enabled), then you should not duplicate in an event handler any trigger code that applies to the table; otherwise, that code will be executed twice.

Repository Event Listeners and Event Handlers

Each repository operation is associated with one or more repository events. Your application can configure listeners for the events associated with resources it is concerned with. A repository **event listener** is a Java class or a PL/SQL package or object type. It comprises a set of PL/SQL procedures or Java methods, each of which is called an **event handler**. Each event handler processes a single event. A repository event listener can be configured for a particular resource or for the entire repository. A listener can be further restricted to apply only when a given node-existence precondition is met.

You associate a repository event listener with a resource by mapping a **resource configuration file** to the resource. You use PL/SQL package `DBMS_RESCONFIG` to manipulate resource configuration files, including associating them with the resources they configure. In particular, PL/SQL function `DBMS_RESCONFIG.getListeners` lists all event listeners for a given resource.

Repository Event Configuration

A given resource can be configured by multiple resource configuration files. These are stored in a **resource configuration list**, and they are processed in list order. The repository as a whole can also be configured by multiple resource configuration files; that is, the repository itself has a resource configuration list. Event handling that is configured for the repository as a whole takes effect before any resource-specific event handling; that is, all applicable repository-wide events are processed before any resource-specific events.

A given resource configuration file can define multiple event listeners for the resources it configures, and each event listener can define multiple event handlers.

See Also:

- "Configuring Repository Events" on page 30-8
- "Resource Configuration Files Configure a Resource" on page 22-1 for general information about resource configuration and resource configuration lists

Possible Repository Events

A rendering operation is associated with a single repository event. Except for rendering, all repository operations are associated with one or more *pairs* of events. For example, a resource creation is associated with three pairs of events, with the events occurring in this order:

1. Pre-creation event
2. Post-creation event
3. Pre-link-in event
4. Pre-link-to event
5. Post-link-to event
6. Post-link-in event

Table 30–1 lists the events associated with each repository operation; their order is indicated in the handler columns.

Table 30–1 Predefined Repository Events

Repository Event Type	Description	Pre Handler Execution	Post Handler Execution
`Render`	A `Render` event occurs only for *file* resources, never for folder resources. Occurs when resource contents are accessed using any of the following: ■ Protocols ■ `XDBURIType` methods `getCLOB()`, `getBLOB()`, and `getXML()` ■ JNDI methods `getContent*()` invoked from a stored procedure Does *not* occur when resource contents are accessed using any of the following: ■ `SELECT ... FROM RESOURCE_VIEW` ■ `XDBURIType` method `getResource()` Only one handler for a `Render` event can set the rendered output. The first handler to call `setRenderStream` or `setRenderPath` controls the rendering.	N/A	N/A
`Create`	Occurs when a resource is created. The pre and post handlers executed are those defined on the folder of the new resource.	After pre-parsing, after validating the parent resource ACL and locks, and before assigning default values to undefined properties.	After inserting the resource into the system resource table.
`Delete`	Occurs when the resource and its contents are removed from disk, that is, when the resource `REF` count is zero (0).	After validating the resource ACL and locks and before removing the resource from disk.	After removing the resource and its contents from disk and after touching the parent folder to update its last modifier and modification time.
`Update`	Occurs when a resource is updated on disk using any method.	After validating the resource ACL and locks and before updating the last modifier and modification time.	After writing the resource to disk.
`Lock`	Occurs during a lock-resource operation.	After validating the resource ACL and locks and before creating the new lock on the resource.	After creating the new lock.
`Unlock`	Occurs during an unlock-resource operation.	After validating the resource ACL and delete token.	After removing the lock.
`LinkIn`	Occurs before a `LinkTo` event during a link operation. The event target is the folder in which the link is created. Always accompanied by a `LinkTo` event.	After validating the resource ACL and locks and before creating the link.	After executing `LinkTo` post handler.
`LinkTo`	Occurs after a `LinkIn` event during a link operation. The event target is the resource that is the link destination.	After executing `LinkIn` pre handler and before creating the link.	After creating the link and after updating the last modifier and modification time of the parent folder.
`UnLinkIn`	Occurs before an `UnlinkFrom` event during an unlink operation. Always accompanied by an `UnlinkFrom` event.	After validating the resource ACL and locks and before removing the link.	After executing the `UnlinkFrom` post handler.
`UnlinkFrom`	Occurs after an `UnlinkIn` event during an unlink operation.	After executing the `UnlinkIn` pre handler.	After removing the link.

Table 30–1 (Cont.) Predefined Repository Events

Repository Event Type	Description	Pre Handler Execution	Post Handler Execution
`CheckIn`	Occurs during check-in of a resource.	After validating the resource ACL and locks and after verifying that the resource is version-controlled and has been checked out.	After checking in the resource.
`CheckOut`	Occurs during check-out of a resource.	After validating the resource ACL and locks and after verifying that the resource is version-controlled and is not already checked out.	After checking out the resource.
`UncheckOut`	Occurs during uncheck-out of a resource.	Before removing the record that the resource is checked out.	After unchecking out the resource.
`VersionControl`	Occurs when a version history is created for a resource. Note: You can call `DBMS_XDB.MakeVersioned()` multiple times, but the version history is created only at the first call; subsequent calls have no effect, so no `VersionControl` event occurs.	Before creating the version history for the resource.	After creating the first version of the resource.

For simplicity, the presentation in this chapter generally treats both members of a repository event pair together, referring, for example, to the `LinkIn` event type as shorthand for the pre-link-in and post-link-in event types. For the same reason, the event-type names used here are derived from the Java `XDBRepositoryEventListener` interface by dropping the prefixes `handlePre` and `handlePost`.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for the PL/SQL repository event types

Repository Operations and Events

The same repository event can occur with different Oracle XML DB Repository operations, and a given repository operation can produce more than one repository event. Table 30–2 lists the events that are associated with each repository operation. See Table 30–1 for the event order when multiple repository events occur for the same operations.

Table 30–2 Oracle XML DB Repository Operations and Events

Operation	Repository Events Occurring
Get binary representation of resource contents by path name	`Render`
Get XML representation of resource contents by path name	`Render`
Create or update a resource	If the resource already exists: `Create`, `LinkIn`, `LinkTo` If resource doe not yet exist (HTTP and FTP only): `Update`
Create a folder	`Create`, `LinkIn`, `LinkTo`
Create a link to an existing resource	`LinkIn` on the folder that will contain the link, `LinkTo` on the resource to be linked

Table 30–2 (Cont.) Oracle XML DB Repository Operations and Events

Operation	Repository Events Occurring
Unlink a file resource or an empty folder resource (decrement `RefCount`; if it is zero, then delete the resource from disk)	`UnlinkIn`, `UnlinkFrom`, and, if `RefCount` is zero, `Delete`
Forcibly delete a folder and its contents	Recursively produce events for unlinking a resource. Folder child resources are deleted recursively, then the folder is deleted.
Forcibly remove all links to a resource	Produce unlinking events for each link removed.
Update the contents, properties, or ACL of a resource by path name	`Update`
Put a depth-zero WebDAV lock on a resource	`Lock`
Remove a depth-zero WebDAV lock from a resource	`Lock`
Rename (move) a resource	`LinkIn` and `LinkTo` on the new location, `UnlinkIn` and `UnlinkFrom` on the old location
Copy a resource	`Create`, `LinkIn`, and `LinkTo` on the new location
Check out a resource	`CheckOut`
Check in a resource	`CheckIn`
Place a resource under version control	`VersionControl`
Uncheck out a resource	`UncheckOut`

All operations listed in Table 30–2 are atomic, except for these:

- Forced deletion of a folder and its contents
- Update of resource properties by path name using HTTP (only)
- Copy of a folder using HTTP (only)

> **See Also:** Table 21–3, " Accessing Oracle XML DB Repository: API Options" on page 21-15 for information on accessing resources using APIs and protocols

Repository Event Handler Considerations

This section mentions some things to keep in mind when you define handlers for Oracle XML DB Repository events.

- A repository event handler is passed an `XDBRepositoryEvent` object, which exists only during the current SQL statement or protocol operation. You can use PL/SQL procedures and Java methods on this object to obtain information about the resource, the event, and the associated event handlers.
- When an event handler performs operations that cause other repository events to occur, those cascading events occur immediately; they are not queued to occur after the handlers for the current event are finished. This means that each event fires in the context of its corresponding operation.
- Repository event handlers are called synchronously; they are executed in the process, session, and transaction context of the corresponding operation. However, handlers can use Oracle Streams Advanced Queueing (AQ) to queue repository events that are then handled asynchronously by some other process.

- Because a repository event handler is executed in the transaction context of its corresponding operation, any locks acquired by that operation, or by other operations run previously in the transaction, are still active. This means that an event handler must not start a separate session or transaction that tries to acquire such a lock; otherwise, the handler will hang.
- Repository event handlers are called in the order that they appear in a resource configuration file. If preconditions are defined for a resource configuration, then only those handlers are called for which the precondition is satisfied.
- Although handlers are called in the order they are defined in a configuration file, avoid letting your code depend upon this. If the user who is current when a handler is invoked has privilege `write-config`, then the handler invocation order could be changed inside an executing handler.
- The entire list of handlers applicable to a given repository event occurrence is determined before any of the handlers is invoked. This means, in particular, that the precondition for each handler is evaluated before any handlers are invoked.
- Oracle recommends that you develop only safe repository event handlers, that is, handlers that write only resource properties that are in namespaces owned by your application, never in the `xdb` namespace.
- The following considerations apply to *error handling* for repository events:
  - A pre-operation event handler is never invoked if access checks for the operation fail.
  - All handlers for a given event are checked before any of them are called. If any of them is not usable (for example, no longer exists), then *none* of them are called.
  - If an error is raised during event handling, then other, subsequent event handlers are not invoked for the same SQL statement or protocol operation. The current statement or operation is canceled and all of its changes are rolled back.
- The following considerations apply to *resource security* for repository events:
  - An event handler can have invoker rights or definer rights. You specify the execution rights of a PL/SQL package when you create the package. You specify the execution rights of Java classes when you load them into the database using the `loadjava` utility. If you specify invoker rights, but a given handler is not configured for invoker rights, then an insufficient-privilege error is raised.
  - Within an event handler, the current user privileges, whether obtained by invoker or definer rights, are determined in detail for a given resource by its ACL. These privileges determine what the handler can do with the resource. For example, if the current user has privileges `read-properties` and `read-contents` for a particular resource, then an event handler can read that resource.
- The following considerations apply to repository events for *linking* and *unlinking*:
  - After creating a link to a resource, if you want any resource configuration files of the parent folder to also apply to the linked resource, then use procedure `DBMS_RESCONFIG.appendResConfig` to add the configuration files to the linked resource. You can invoke this procedure from a `Post-LinkTo` event handler for the linked resource.

– After unlinking a resource, if you want to remove any such resource configuration files added when linking, then use procedure `DBMS_RESCONFIG.deleteResConfig` to remove them from the unlinked resource. You can invoke this procedure from a `Post-UnlinkFrom` event handler for the unlinked resource.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL functions and procedures for manipulating repository events
- *Oracle Database XML Java API Reference*, classes `XDBRepositoryEvent` and `XDBEvent` for information about Java methods for manipulating repository events
- "Configuring Repository Events" on page 30-8 for information about defining repository event handlers with invoker rights

Configuring Repository Events

You configure event treatment for Oracle XML DB Repository resources as you would configure any other treatment of repository resources—see "Configuring a Resource" on page 22-2.

Be default, repository events are enabled, but you can disable them by setting parameter `XML_DB_EVENTS` to `DISABLE`. To disable repository events at the session level, use the following SQL*Plus command. You must have role `XDBADMIN` to do this.

```
ALTER SESSION SET XML_DB_EVENTS = DISABLE;
```

To disable repository events at the system level, use the following SQL*Plus command, and then restart your database; repository events will be disabled for subsequent sessions. You must have privilege `ALTER SYSTEM` to do this.

```
ALTER SYSTEM SET XML_DB_EVENTS = DISABLE;
```

To enable repository events again, set the value of `XML_DB_EVENTS` to `ENABLE`.

The rest of this section describes the resource configuration file that you use as a resource to configure event processing for other resources.

A resource configuration file is an XML file that conforms to the XML schema `XDBResConfig.xsd`, which is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`. You use element `event-listeners`, child of element `ResConfig`, to configure repository event handling.

See Also: Chapter 22, "Configuring Oracle XML DB Repository" for general information about configuring repository resources

Configuration Element event-listeners

Each resource configuration file can have one `event-listeners` element, as a child of element `ResConfig`. This configures all event handling for the target resource. If the resource configuration file applies to the entire repository, not to a particular resource, then it defines event handling for all resources in the repository.

Element `event-listeners` has the following optional attributes:

- `set-invoker` – Set this to `true` to if the resource configuration defines one or more repository event handlers to have invoker rights. The default value is `false`, meaning that definer rights are used.

  To define an invoker-rights repository event handler, you must have database role `XDB_SET_INVOKER`. This role is granted to `DBA`, but not to `XDBADMIN`. Role `XDB_SET_INVOKER` is checked only when a resource configuration file is created or updated. Only attribute `set-invoker`, not role `XDB_SET_INVOKER`, is checked at runtime to ensure sufficient privilege.

  > **See Also:** "Repository Event Handler Considerations" on page 30-6 for information about insufficient-privilege errors

- `default-schema` – The default schema value, used for listeners for which no `schema` element is defined.
- `default-language` –The default language value, used for listeners for which no `language` element is defined.

Element `event-listeners` has a sequence of `listener` elements as children. These configure individual repository event listeners. The listeners are processed at runtime in the order of the `listener` elements.

Configuration Element listener

Each `listener` element has the following child elements. All of these are optional except `source`, and they can appear in any order (their order is irrelevant).

- `description` – Description of the listener.
- `schema` – Database schema for the Java or PL/SQL implementation of the repository event handlers. If neither this nor `default-schema` is defined, then an error is raised.
- `source` (required) – Name of the Java class, PL/SQL package, or object type that provides the handler methods. Java class names must be qualified with a package name. Use an empty `source` element to indicate that the repository event handlers are standalone PL/SQL stored procedures.
- `language` – Implementation language of the listener class (Java) or package (PL/SQL). If neither this nor `default-language` is defined, then an error is raised.
- `pre-condition` – Precondition to be met for any repository event handlers in this listener to be executed. This is identical to the `pre-condition` child of general resource configuration element `configuration` – see "Configuration Element defaultChildConfig" on page 22-3.
- `events` – Sequence of unique repository event type names: `Render`, `Pre-Create`, and so on. Only handlers for repository events of these types are enabled for the listener. See "Possible Repository Events" on page 30-3 for the list of possible repository event types. If element `events` is not present, then handlers of repository events of all types are enabled for the listener, which can be wasteful. Provide element `events` to eliminate handler invocations for insignificant repository events.

Repository Events Configuration Examples

Example 30–1 shows the content of a resource configuration file that defines two listeners. Each listener defines handlers for repository events of types `Post-LinkIn`,

Post-UnlinkIn, and Post-Update. It defines preconditions, the default language (Java) and default database schema.

Example 30–1 Resource Configuration File for Java Event Listeners With Preconditions

```
<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
           xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                               http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
  <event-listeners default-language="Java" default-schema="IFS">
    <listener>
      <description>Category application</description>
      <schema>CM</schema>
      <source>oracle.cm.category</source>
      <events>
        <Post-LinkIn/>
        <Post-UnlinkIn/>
        <Post-Update/>
      </events>
      <pre-condition>
        <existsNode>
          <XPath>/Resource[ContentType="image/gif"]</XPath>
        </existsNode>
      </pre-condition>
    </listener>
    <listener>
      <description>Check quota</description>
      <source>oracle.ifs.quota</source>
      <events>
        <Post-LinkIn/>
        <Post-UnlinkIn/>
        <Post-Update/>
      </events>
      <pre-condition>
        <existsNode>
          <XPath>r:/Resource/[ns:type="ifs-file"]</XPath>
          <namespace>xmlns:r="http://xmlns.oracle.com/xdb/XDBResource.xsd"
                     xmlns:ns="http://foo.xsd"
          </namespace>
        </existsNode>
      </pre-condition>
    </listener>
  </event-listeners>
  <defaultChildConfig>
    <configuration>
      <path>/sys/xdb/resconfig/user_rc.xml</path>
    </configuration>
  </defaultChildConfig>
  <applicationData>
    <foo:data xmlns:foo="http://foo.xsd">
      <foo:item1>1234</foo:item1>
    </foo:data>
  </applicationData>
</ResConfig>
```

The implementation of the handlers of the first listener is in Java class oracle.cm.quota defined in database schema CM. These handlers are invoked only for events on resources of ContentType image/gif.

The implementation of the handlers of the second listener is in Java class `oracle.ifs.quota` defined in database schema `IFS` (the default schema for this resource configuration file). These handlers are invoked only for events on resources of type `ifs-file` in namespace `http://foo.xsd`.

> **See Also:** "Configuration Element defaultChildConfig" on page 22-3 for a description of elements `defaultChildConfig` and `applicationData`

As a simple end-to-end illustration, suppose that an application needs to categorize the resources in folder `/public/res-app` according to their MIME types. It creates links to resources in folders `/public/app/XML-TXT`, `/public/app/IMG`, and `/public/app/FOLDER`, depending on whether the resource MIME type is `text/xml`, `image/gif`, or `application/octet-stream`, respectively. This is illustrated in Example 30–2, Example 30–3, and Example 30–5.

Example 30–2 shows the PL/SQL code to create the configuration file for this categorization illustration. It defines a single listener that handles events of types `Pre-UnlinkIn` and `Post-LinkIn`. It explicitly defines the language (PL/SQL) and database schema. No preconditions are defined.

Example 30–2 Resource Configuration File for PL/SQL Event Listeners With No Preconditions

```
DECLARE
  b BOOLEAN := FALSE;
BEGIN
  b := DBMS_XDB.createFolder('/public/resconfig');
  b := DBMS_XDB.createResource(
         '/public/resconfig/appcatg-rc1.xml',
         '<ResConfig xmlns="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
                     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                     xsi:schemaLocation="http://xmlns.oracle.com/xdb/XDBResConfig.xsd
                                         http://xmlns.oracle.com/xdb/XDBResConfig.xsd">
            <event-listeners>
              <listener>
                <description>Category application</description>
                <schema>APPCATGUSER1</schema>
                <source>APPCATG_EVT_PKG1</source>
                <language>PL/SQL</language>
                <events>
                  <Pre-UnlinkIn/>
                  <Post-LinkIn/>
                </events>
              </listener>
            </event-listeners>
            <defaultChildConfig>
              <configuration>
                <path>/public/resconfig/appcatg-rc1.xml</path>
              </configuration>
            </defaultChildConfig>
          </ResConfig>');
END;
/
BEGIN
  DBMS_RESCONFIG.appendResConfig('/public/res-app',
                                 '/public/resconfig/appcatg-rc1.xml',
                                 DBMS_RESCONFIG.APPEND_RECURSIVE);
END;
/
```

Example 30–3 shows the PL/SQL code that implements the event handlers that are configured in Example 30–2. The `Post-LinkIn` event handler creates a link to the `eventObject` resource in one of the folders `/public/app/XML-TXT`, `/public/app/IMG`, and `/public/app/FOLDER`, depending on the resource MIME type. The `Pre-UnlinkIn` event handler deletes the links that are created by the `Post-LinkIn` event handler.

Example 30–3 PL/SQL Code Implementing Event Listeners

```
CREATE OR REPLACE PACKAGE appcatg_evt_pkg1 AS

  PROCEDURE handlePreUnlinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent);
  PROCEDURE handlePostLinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent);

END;
/
CREATE OR REPLACE PACKAGE BODY appcatg_evt_pkg1 AS

  PROCEDURE handlePreUnlinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent) AS
      XDBResourceObj DBMS_XDBRESOURCE.XDBResource;
      ResDisplayName VARCHAR2(100);
      ResPath        VARCHAR2(1000);
      ResOwner       VARCHAR2(1000);
      ResDeletedBy   VARCHAR2(1000);
      XDBPathobj     DBMS_XEVENT.XDBPath;
      XDBEventobj    DBMS_XEVENT.XDBEvent;
      SeqChar        VARCHAR2(1000);
      LinkName       VARCHAR2(10000);
      ResType        VARCHAR2(100);
      LinkFolder     VARCHAR2(100);
    BEGIN
      XDBResourceObj := DBMS_XEVENT.getResource(eventObject);
      ResDisplayName := DBMS_XDBRESOURCE.getDisplayName(XDBResourceObj);
      ResOwner       := DBMS_XDBRESOURCE.getOwner(XDBResourceObj);
      XDBPathobj     := DBMS_XEVENT.getPath(eventObject);
      ResPath        := DBMS_XEVENT.getName(XDBPathObj);
      XDBEventobj    := DBMS_XEVENT.getXDBEvent(eventObject);
      ResDeletedBy   := DBMS_XEVENT.getCurrentUser(XDBEventobj);
      BEGIN
        SELECT XMLCast(
                 XMLQuery(
                   'declare namespace ns = "http://xmlns.oracle.com/xdb/XDBResource.xsd";
                    /ns:Resource/ns:ContentType'
                   PASSING r.RES RETURNING CONTENT) AS VARCHAR2(100))
          INTO ResType
          FROM PATH_VIEW r WHERE r.PATH=ResPath;
          EXCEPTION WHEN OTHERS THEN NULL;
      END;
      IF ResType = 'text/xml' THEN LinkFolder := '/public/app/XML-TXT/';
      END IF;
      IF ResType = 'image/gif' THEN LinkFolder := '/public/app/IMG/';
      END IF;
      IF ResType = 'application/octet-stream' THEN LinkFolder := '/public/app/FOLDER/';
      END IF;
      DBMS_XDB.deleteResource(LinkFolder || ResDisplayName);
  END;

  PROCEDURE handlePostLinkIn (eventObject DBMS_XEVENT.XDBRepositoryEvent) AS
      XDBResourceObj DBMS_XDBRESOURCE.XDBResource;
```

```
    ResDisplayName VARCHAR2(100);
    ResPath        VARCHAR2(1000);
    ResOwner       VARCHAR2(1000);
    ResDeletedBy   VARCHAR2(1000);
    XDBPathobj     DBMS_XEVENT.XDBPath;
    XDBEventobj    DBMS_XEVENT.XDBEvent;
    SeqChar        VARCHAR2(1000);
    LinkName       VARCHAR2(10000);
    ResType        VARCHAR2(100);
    LinkFolder     VARCHAR2(100);
  BEGIN
    XDBResourceObj := DBMS_XEVENT.getResource(eventObject);
    ResDisplayName := DBMS_XDBRESOURCE.getDisplayName(XDBResourceObj);
    ResOwner       := DBMS_XDBRESOURCE.getOwner(XDBResourceObj);
    XDBPathobj     := DBMS_XEVENT.getPath(eventObject);
    ResPath        := DBMS_XEVENT.getName(XDBPathObj);
    XDBEventobj    := DBMS_XEVENT.getXDBEvent(eventObject);
    ResDeletedBy   := DBMS_XEVENT.getCurrentUser(XDBEventobj);
    SELECT XMLCast(
             XMLQuery(
               'declare namespace ns = "http://xmlns.oracle.com/xdb/XDBResource.xsd";
                /ns:Resource/ns:ContentType'
               PASSING r.RES RETURNING CONTENT) AS VARCHAR2(100))
      INTO ResType
      FROM PATH_VIEW r WHERE r.PATH=ResPath;
    IF ResType = 'text/xml' THEN LinkFolder := '/public/app/XML-TXT';
    END IF;
    IF ResType = 'image/gif' THEN LinkFolder := '/public/app/IMG';
    END IF;
    IF ResType = 'application/octet-stream' THEN LinkFolder := '/public/app/FOLDER';
    END IF;
    DBMS_XDB.link(ResPath, LinkFolder, ResDisplayName);
  END;
END;
/
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XDBRESOURCE`
- *Oracle Database PL/SQL Packages and Types Reference* for information about PL/SQL package `DBMS_XEVENT`

A Java example would be configured the same as in Example 30–2, with the exception of these two lines, which would replace the elements with the same names in Example 30–2:

```
<source>category</source>
<language>Java</language>
```

Example 30–4 shows the Java code that implements the event handlers. The logic is identical to that in Example 30–3.

Example 30–4 Java Code Implementing Event Listeners

```
import oracle.xdb.event.*;
import oracle.xdb.spi.*;
import java.sql.*;
import java.io.*;
```

```
import java.net.*;
import oracle.jdbc.*;
import oracle.sql.*;
import oracle.xdb.XMLType;
import oracle.xdb.dom.*;

public class category
extends oracle.xdb.event.XDBBasicEventListener
{
  public Connection connectToDB() throws java.sql.SQLException
  {
    try
    {
      String strUrl="jdbc:oracle:kprb:";
      String strUname="appcatguser1";
      String strPwd="appcatguser1 ";
      Connection conn=null;
      OraclePreparedStatement stmt=null;
      DriverManager.registerDriver(new oracle.jdbc.OracleDriver());
      conn = DriverManager.getConnection(strUrl, strUname, strPwd);
      return conn;
    }
    catch(Exception e1)
    {
      System.out.println("Exception in connectToDB java function");
      System.out.println("e1:" + e1.toString());
      return null;
    }
  }
  public void handlePostLinkIn (XDBRepositoryEvent eventObject)
  {
    XDBPath objXDBPath = null;
    String strPathName="";
    objXDBPath = eventObject.getPath();
    strPathName = objXDBPath.getName();
    XDBResource objXDBResource1;
    objXDBResource1 = eventObject.getResource();
    String textResDisplayName = objXDBResource1.getDisplayName();
    String resType = objXDBResource1.getContentType();
    String linkFolder="";
    System.out.println("resType" + resType+"sumit");
    System.out.println("strPathName:" + strPathName);
    System.out.println("textResDisplayName:" + textResDisplayName);
    if (resType.equals("text/xml")) linkFolder = "/public/app/XML-TXT/";
    else if (resType.equals("image/gif")) linkFolder = "/public/app/IMG/";
    else if (resType.equals("application/octet-stream"))
            linkFolder = "/public/app/FOLDER/";
    System.out.println("linkFolder:" + linkFolder);
    try
    {
      Connection con1 = connectToDB();
      OraclePreparedStatement stmt=null;
      stmt = (OraclePreparedStatement)con1.prepareStatement(
                "CALL DBMS_XDB.link(?,?,?)");
      stmt.setString(1,strPathName);
      stmt.setString(2,linkFolder);
      stmt.setString(3,textResDisplayName);
      stmt.execute();
      stmt.close();
      con1.close();
```

```
    }
    catch(java.sql.SQLException ej1)
    {
      System.out.println("ej1:" + ej1.toString());
    }

  /* Make sure the link is not in the category folders.
     Then check the target resource's mime type and create a link
     in the appropriate category folder. */
  }
  public void handlePreUnlinkIn (XDBRepositoryEvent eventObject)
  {
    XDBPath objXDBPath = null;
    String strPathName="";
    objXDBPath = eventObject.getPath();
    strPathName = objXDBPath.getName();
    XDBResource objXDBResource1;
    objXDBResource1 = eventObject.getResource();
    String textResDisplayName = objXDBResource1.getDisplayName();
    String resType = objXDBResource1.getContentType();
    String linkFolder="";
    if (resType.equals("text/xml")) linkFolder = "/public/app/XML-TXT/";
    else if (resType.equals("image/gif")) linkFolder = "/public/app/IMG/";
    else if (resType.equals("application/octet-stream"))
            linkFolder = "/public/app/FOLDER/";
    try
    {
      Connection con1 = connectToDB();
      OraclePreparedStatement stmt=null;
      stmt = (OraclePreparedStatement)con1.prepareStatement(
               "CALL DBMS_XDB.deleteResource(?)");
      stmt.setString(1,linkFolder+textResDisplayName);
      stmt.execute();
      stmt.close();
      con1.close();
    }
    catch(java.sql.SQLException ej1)
    {
      System.out.println("ej1:" + ej1.toString());
    }
  }
}
```

Example 30–5 demonstrates the invocation of the event handlers that are implemented in Example 30–3 or Example 30–4.

Example 30–5 Invoking Event Handlers

```
DECLARE
  ret BOOLEAN;
BEGIN
  ret := DBMS_XDB.createResource('/public/res-app/res1.xml',
                                 '<name>TestForEventType-1</name>');
END;
/
DECLARE
  b BOOLEAN := FALSE;
  dummy_data CLOB := 'AAA';
BEGIN
  b := DBMS_XDB.createResource('/public/res-app/res2.gif', dummy_data);
```

```
END;
/
DECLARE
  b BOOLEAN := FALSE;
  dummy_data CLOB := 'AAA';
BEGIN
  b := DBMS_XDB.createFolder('/public/res-app/res-appfolder1');
END;

SELECT PATH FROM PATH_VIEW WHERE PATH LIKE '/public/app/%' ORDER BY PATH;

PATH
--------------------------------
/public/app/FOLDER
/public/app/FOLDER/res-appfolder1
/public/app/IMG
/public/app/IMG/res2.gif
/public/app/XML-TXT
/public/app/XML-TXT/res1.xml

6 rows selected.

-- Delete the /res-app resources. The /app resources are deleted also.
EXEC DBMS_XDB.deleteResource('/public/res-app/res2.gif');
EXEC DBMS_XDB.deleteResource('/public/res-app/res1.xml');
EXEC DBMS_XDB.deleteResource('/public/res-app/res-appfolder1');

SELECT PATH FROM PATH_VIEW WHERE PATH LIKE '/public/app/%' ORDER BY PATH;

PATH
-------------------
/public/app/FOLDER
/public/app/IMG
/public/app/XML-TXT

3 rows selected.
```

31

Using Oracle XML DB Content Connector

This chapter describes how to use Oracle XML DB Content Connector to access Oracle XML DB Repository.

Oracle XML DB Content Connector implements Content Repository API for Java (sometimes referred to as JCR), a Java API standard developed by the Java community as JSR-170.

This chapter contains these topics:

Overview of JCR and Oracle XML DB Content Connector

This section contains the following topics:

About the Content Repository API for Java (JCR)

JCR 1.0 defines a standard Java API for applications to interact with content repositories.

> **See Also:** Java Community Process, "Content Repository for Java technology API", `http://jcp.org/en/jsr/detail?id=170`. Chapter 4 of the JSR-170 specification provides a concise introduction to JCR 1.0

JCR models the data in a content repository as a tree of nodes. Each node may have one or more child nodes. Every node has exactly one parent node, except for the root node, which has no parent.

In addition to child nodes, a node may also have one or more properties. A property is a simple name/value pair. For example, a node representing a particular file in the content repository has a property named `jcr:created` whose value is the date the file was created.

Each property has a property type. For example, the `jcr:created` property has the `DATE` property type, requiring its value to be a valid date/time.

Similarly, each node has a node type. For example, a node representing a file has node type `nt:file`. The node type controls what child nodes and properties the node may have or must have. For example, all nodes of type `nt:file` must have a `jcr:created` property.

Because nodes and properties are named, they can be addressed by path. JCR supports both absolute and relative paths. For example, the absolute path

```
/My Documents/pictures/puppy.jpg/jcr:created
```

resolves to the `jcr:created` property of file `puppy.jpg`. This property can also be addressed relative to the `My Documents` folder by the following relative path:

```
pictures/puppy.jpg/jcr:created
```

Node and property names can be namespace qualified. Like XML, JCR uses colon-delimited namespace prefixes to express namespace-qualified names, for example, `jcr:created`. Unlike XML, JCR records the namespace prefix-to-URI mappings in a repository-wide namespace registry, which, for example, maps the `jcr` prefix to the URI `http://www.jcp.org/jcr/1.0`.

About Oracle XML DB Content Connector

Oracle XML DB Content Connector lets you access Oracle XML DB Repository using the JCR 1.0 Java API. Your applications can run either in a standalone Java Virtual Machine or a J2EE container.

> **Note:** For this release, using Oracle XML DB Content Connector in the database Oracle JVM (the Java Virtual Machine available within a database process) is not supported. To use the content connector in the database tier, you must use either a standalone Java Virtual Machine or a J2EE container.

Files and folders in Oracle XML DB Repository are represented as JCR nodes (and properties of those nodes). They can be created, retrieved, and updated using the JCR APIs.

How Oracle XML DB Repository Is Exposed in JCR

Oracle XML DB Content Connector represents data in Oracle XML DB Repository as JCR nodes and properties. Files and folders are represented as nodes of type `nt:file` and `nt:folder`, respectively. Their content and metadata is exposed as nodes of node type `nt:resource`.

This section contains the following topics:

An Example of How Files and Folders are Exposed in JCR

The folder `MyFolder` is stored in the root folder of Oracle XML DB Repository. It contains two files, `Address.xml` and `Car.jpg`.

File `Address.xml` has the following XML content:

```
<Address country="US">
  <name>Alice Smith</name>
  <street>123 Maple Street</street>
  <city>Mill Valley</city>
  <state>CA</state>
  <zip>90952</zip>
</Address>
```

File `Car.jpg` has binary content: a picture of an automobile. It also has the following user-defined XML metadata:

```
<i:ImageMetadata>
  <Height>640</Height>
  <Width>480</Width>
  <RGB R="44" G="123" B="74"/>
</i:ImageMetadata>
```

Oracle XML DB Content Connector exposes `MyFolder`, `Address.xml`, and `Car.jpg` as JCR nodes and properties. Example 31–1 shows folder `MyFolder` represented as a tree of JCR nodes and properties.

Example 31–1 JCR Node Representation of MyFolder

In this representation, **`bold`** type indicates a node, *`italic`* type indicates a node type, `regular` type indicates a property, and italic type with angle brackets (<>) indicates omitted data, such as binary data.

```
[root] (nt:folder)
  jcr:created="2001-01-01T00:00:00.000Z"
  jcr:content (nt:resource)
    jcr:data=null
    jcr:lastModified="2001-01-01T00:00:00.000Z"
    ojcr:owner="SYS"
    ojcr:creator="SYS"
    ojcr:lastModifier="SYS"
    ojcr:displayName=""
    ojcr:language="en-US"
  MyFolder (nt:folder)
    jcr:created="2001-01-01T00:00:00.000Z"
    jcr:content (nt:resource)
      jcr:data=null
      jcr:lastModified="2001-01-01T00:00:00.000Z"
      ojcr:owner="ALICE"
      ojcr:creator="BOB"
      ojcr:lastModifier="CHARLIE"
      ojcr:author="BOB"
      ojcr:comment="An application folder"
      ojcr:displayName="MyFolder"
      ojcr:language="en-US"
      ojcr:links (ojcr:links)
        ojcr:folderLink (ojcr:linkProperties)
          ojcr:linkType="Hard"
          ojcr:linkSource=<RESID of the root folder>
          ojcr:linkTarget=<RESID of folder MyFolder>
          ojcr:linkName="MyFolder"
```

```
Address.xml (nt:file)
  jcr:created="2005-09-01T12:34:56.789Z"
  jcr:content (nt:resource)
    jcr:encoding="UTF-8"
    jcr:mimeType="text/xml"
    jcr:data=<binary representation of the XML content>
    jcr:lastModified="2005-09-01T12:34:56.789Z"
    ojcr:owner="ALICE"
    ojcr:creator="BOB"
    ojcr:lastModifier="CHARLIE"
    ojcr:author="BOB"
    ojcr:displayName="Address.xml"
    ojcr:language="en-US"
    ojcr:xmlContent (nt:unstructured)
      Address
        country="US"
        name
          jcr:xmltext
            jcr:xmlcharacters="Alice Smith"
        street
          jcr:xmltext
            jcr:xmlcharacters="123 Maple Street"
        city
          jcr:xmltext
            jcr:xmlcharacters="Mill Valley"
        state
          jcr:xmltext
            jcr:xmlcharacters="CA"
        zip
          jcr:xmltext
            jcr:xmlcharacters="90952"
    ojcr:links (ojcr:links)
      ojcr:folderLink (ojcr:linkProperties)
        ojcr:linkType="Hard"
        ojcr:linkSource=<RESID of folder MyFolder>
        ojcr:linkTarget=<RESID of file Address.xml>
        ojcr:linkName="Address.xml"
Car.jpg (nt:file)
  jcr:created="2004-02-12T16:15:23.247Z"
  jcr:content (nt:resource)
    jcr:mimeType="image/jpeg"
    jcr:data=<binary content of file Car.jpg>
    jcr:lastModified="2004-02-12T17:20:25.314Z"
    ojcr:owner="ALICE"
    ojcr:creator="BOB"
    ojcr:lastModifier="CHARLIE"
    ojcr:author="BOB"
    ojcr:displayName="A shiny red car!"
    ojcr:language="en-US"
    i:ImageMetadata
      Height
        jcr:xmltext
          jcr:xmlcharacters="640"
      Width
        jcr:xmltext
          jcr:xmlcharacters="480"
      RGB
        R="44"
        G="123"
        B="74"
```

```
ojcr:links (ojcr:links)
  ojcr:folderLink (ojcr:linkProperties)
    ojcr:linkType="Hard"
    ojcr:linkSource=<RESID of folder MyFolder>
    ojcr:linkTarget=<RESID of file Car.jpg>
    ojcr:linkName="Car.jpg"
```

Oracle Extensions to JCR Node Types

Oracle XML DB Content Connector augments the definitions of node types `nt:file`, `nt:folder`, and `nt:resource` to include additional information held in Oracle XML DB Repository. Node type `ojcr:folder` is added as a supertype of `nt:folder`, and node type `ojcr:resource` is added as a supertype of `nt:resource`. All Oracle extensions are in the namespace `http://xmlns.oracle.com/jcr/1.0`, which is mapped to namespace prefix **`ojcr`**.

In addition, node type `mix:referenceable` is added as a supertype of `nt:file` and `nt:folder` to allow all files and folders to be accessed by their resource id.

Binary and XML Content

Property `jcr:data` contains the binary content of a file. Note that `jcr:data` is a property not of node `nt:file`, but rather of its child node `jcr:content`.

For files containing XML content, node `jcr:content` has a child node `ojcr:xmlContent`, under which the XML content can be accessed as a set of JCR nodes and properties. File `Address.xml`, referenced in Example 31–1 on page 31-3, is such a file. The XML content of an XML file in the repository is mapped to JCR nodes and properties using the **document view serialization** defined by JCR, in which:

- XML elements are exposed as JCR nodes.
- XML attributes are exposed as JCR properties.
- XML text is exposed as JCR properties named `jcr:xmlcharacters` within nodes named `jcr:xmltext`.

System-Defined Metadata

Oracle XML DB Repository maintains metadata for each repository file and folder. In database views `RESOURCE_VIEW` and `PATH_VIEW`, this metadata is represented as a set of XML elements within `XMLType` column `RES`. In JCR, this metadata is mapped to properties in namespaces `jcr` and `ojcr`. Table 31–1 describes this mapping.

Table 31–1 Oracle XML DB Resource to JCR Mappings

XPath	Relative Path From Node nt:file or nt:folder
`/Resource/CreationDate`	`jcr:created`
`/Resource/ModificationDate`	`jcr:content/jcr:lastModified`
`/Resource/Author`	`jcr:content/ojcr:author`
`/Resource/DisplayName`	`jcr:content/ojcr:displayName`
`/Resource/Comment`	`jcr:content/ojcr:comment`
`/Resource/Language`	`jcr:content/ojcr:language`
`/Resource/CharacterSet`	`jcr:content/jcr:encoding`

Table 31–1 (Cont.) Oracle XML DB Resource to JCR Mappings

XPath	Relative Path From Node nt:file or nt:folder
/Resource/ContentType	jcr:content/jcr:mimeType
/Resource/Owner	jcr:content/ojcr:owner
/Resource/Creator	jcr:content/ojcr:creator
/Resource/LastModifier	jcr:content/ojcr:lastModifier

User-Defined Metadata

User-defined XML metadata is exposed as JCR nodes and properties under the `jcr:content` child node of the repository file or folder. As with XML file content, XML metadata is mapped to JCR nodes and properties using the document view serialization that is defined by JCR. See "Binary and XML Content" on page 31-5 for a description of this serialization.

In Example 31–1, file `Car.jpg` has this user-defined metadata:

```
<i:ImageMetadata>
  <Height>640</Height>
  <Width>480</Width>
  <RGB R="44" G="123" B="74"/>
</i:ImageMetadata>
```

The following JCR path retrieves the `Width` value:

```
/My Folder/Car.jpg/jcr:content/i:ImageMetadata/
   Width/jcr:xmltext/jcr:xmlcharacters
```

Hard Links and Weak Links

In JCR, each node and property has exactly one parent node, except for the root node, which has no parent. Consequently, there is exactly one absolute path to each JCR node or property.

However, in Oracle XML DB Repository, a resource (file or folder) can be linked to more than one parent folder, either by hard links, which control the life span of the child, or by weak links, which do not. Consequently, there can be more than one path to a resource, and a resource can have more than one parent.

In resolving a path, Oracle XML DB Content Connector traverses both hard and weak links. If there is more than one path to a resource, JCR method `getPath()` returns the path by which that resource was first discovered, subsequent to the most recent call to either `save()` or `refresh(boolean)` by that session. Method `getParent()` returns the folder targeted by that path.

It is often useful to obtain a list of all parents of a resource, if the resource is the target of more than one link and therefore has more than one parent folder. Oracle XML DB Content Connector presents this as nodes of type `ojcr:linkProperties` with path `jcr:content/ojcr:links/ojcr:folderLink` relative to node `nt:file` or `nt:folder`. There is one `ojcr:folderLink` node for each parent of the resource.

Node `ojcr:folderLink` has the following properties:

- `ojcr:linkType`: Link type (`Hard` or `Weak`)
- `ojcr:linkSource`: Resource id of the parent folder
- `ojcr:linkTarget`: Resource id of the child file or folder

- `ojcr:linkName`: Name of the child file or folder in that parent

How to Use Oracle XML DB Content Connector

This section describes how to use Oracle XML DB Content Connector to access information in Oracle XML DB Repository. It has the following topics:

Setting CLASSPATH

Oracle XML DB Content Connector requires the following entries in the Java `CLASSPATH` variable:

- `$ORACLE_HOME/lib/jcr-1.0.jar`
- `$ORACLE_HOME/lib/ojcr.jar`
- `$ORACLE_HOME/lib/xmlparserv2.jar`
- `$ORACLE_HOME/jlib/xquery.jar`
- `$ORACLE_HOME/jdbc/lib/ojdbc14.jar`

Obtaining the JCR Repository Object

In Oracle XML DB Content Connector, `oracle.jcr.OracleRepository` implements the JCR interface `javax.jcr.Repository`, which provides the entry point to a JCR repository. The code fragment in Example 31–2 shows how to obtain a `Repository` object for Oracle XML DB Repository.

Example 31–2 Code Fragment Showing How to Get a Repository Object

```
import oracle.jcr.OracleRepository;
import oracle.jcr.OracleRepositoryFactory;
import oracle.jcr.xdb.XDBRepositoryConfiguration;
import oracle.jdbc.pool.OracleDataSource;
...
XDBRepositoryConfiguration configuration =
  new XDBRepositoryConfiguration();
OracleDataSource ods =
  (OracleDataSource)configuration.getDataSource();
// databaseURL is a JDBC database URL.
ods.setURL(databaseURL);
// OracleRepository implements javax.jcr.Repository.
OracleRepository repository =
  OracleRepositoryFactory.createOracleRepository(configuration);
```

`OracleRepository` implements both `java.io.Serializable` and `javax.naming.Referenceable`. This lets you create and configure an `OracleRepository` object upon application deployment, and store the ready-to-use

`OracleRepository` object in a JNDI directory. At run-time, your application can retrieve the preconfigured `OracleRepository` object from the JNDI directory. This approach, recommended by the JCR specification, separates deployment and run-time concerns.

In Oracle XML DB Content Connector, the set of prefix-to-URI mappings forming the JCR namespace registry is stored as part of the `OracleRepository` configuration.

> **See Also:** *Oracle Database XML Java API Reference*, package `oracle.jcr`

Sample Code to Upload File

Example 31–3 contains a Java program that uploads a file from the local file system to Oracle XML DB Repository using Oracle XML DB Content Connector. Compile and run this example from the command line. The program requires these command-line arguments:

- JDBC database URL
- User ID
- User password
- Folder in Oracle XML DB Repository into which to upload the file
- File to be uploaded
- MIME type

For example:

```
export CLASSPATH=.:$ORACLE_HOME/lib/jcr-1.0.jar:$ORACLE_HOME/lib/ojcr.jar:$ORACLE_
HOME/lib/xmlparserv2.jar:$ORACLE_HOME/jlib/xquery.jar:$ORACLE_
HOME/jdbc/lib/ojdbc14.jar

javac UploadFile.java

java UploadFile jdbc:oracle:oci:@ quine curry /public MyFile.txt text/plain
```

Example 31–3 Using Oracle XML DB Content Connector to Upload a File

```
import java.io.FileInputStream;

import javax.jcr.Node;
import javax.jcr.Session;
import javax.jcr.SimpleCredentials;

import oracle.jcr.OracleRepository;
import oracle.jcr.OracleRepositoryFactory;

import oracle.jcr.xdb.XDBRepositoryConfiguration;

import oracle.jdbc.pool.OracleDataSource;

public class UploadFile
{
  public static void main(String[] args)
    throws Exception
  {
    String databaseURL = args[0];
    String userName = args[1];
    String password = args[2];
```

```
    String parentPath = args[3];
    String fileName = args[4];
    String mimeType = args[5];

    // Get the JCR Repository object.
    XDBRepositoryConfiguration configuration =
      new XDBRepositoryConfiguration();

    OracleDataSource ods =
      (OracleDataSource)configuration.getDataSource();

    ods.setURL(databaseURL);

    OracleRepository repository =
      OracleRepositoryFactory.createOracleRepository(configuration);

    // Create a JCR Session.
    SimpleCredentials sc =
      new SimpleCredentials(userName, password.toCharArray());

    Session session = repository.login(sc);

    // Get the parent node.
    Node parentNode = (Node)session.getItem(parentPath);

    // Get the child contents.
    FileInputStream inputStream = new FileInputStream(fileName);

    // Create child node.
    Node node = parentNode.addNode(fileName, "nt:file");
    Node contentNode = node.getNode("jcr:content");
    contentNode.setProperty("jcr:mimeType", mimeType);
    contentNode.setProperty("jcr:data", inputStream);

    // Save changes and logout.
    session.save();
    session.logout();
  }
}

// EOF
```

Additional Code Samples

You can find additional sample code at the following location:

```
$ORACLE_HOME/xdk/demo/java/jcr
```

For each code sample, a `README` file describes its purpose and use.

Logging API for Oracle XML DB Content Connector

Oracle XML DB Content Connector uses the standard `java.util.logging` framework. You can use the logging API provided by that framework to control logging behavior. For example, the following Java code fragment disables all logging.

```
import java.util.logging.LogManager;
...
LogManager.getLogManager().reset();
```

Supported JCR Compliance Levels

The JSR-170 standard, which defines JCR version 1.0, defines two compliance levels and a set of optional features. Oracle XML DB Content Connector supports Level 1 (read functions) and Level 2 (write functions).

Oracle XML DB Content Connector Restrictions

This section describes certain restrictions of Oracle XML DB Content Connector.

Default Workspace Name

A single workspace is supported. In calling the `login(Credentials, String)` or `login(String)` methods of `javax.jcr.Repository`, the workspace name must be either an empty-string (`""`) or `NULL`.

Operations Restricted to Specific Node Types

Methods `save()` and `refresh()` of `javax.jcr.Item` can be called only on nodes whose type is `nt:file` or `nt:folder`. Method `move()` of `javax.jcr.Session` and methods `copy()` and `move()` of `javax.jcr.Workspace` can be called only on `nt:file` and `nt:folder` nodes.

Determining the State of Files or Folders

Methods `isNew()` and `isModified()` of `javax.jcr.Item` return the state of the file or folder containing the item, not the item itself. Method `isNew()` returns `true` if the file or folder has been created in the JCR transient layer but not saved. Method `isModified()` returns `true` if the file or folder has been changed in the transient layer but not saved.

Interaction Between Binary and XML Content

The `jcr:data` property contains the binary-format content of a file. If the file content is XML, there is also an `ojcr:xmlContent` node under which its XML content is exposed as JCR nodes and properties. Changes you make to the `ojcr:xmlContent` subtree are not reflected in the `jcr:data` property until those changes are saved. If you change both the `jcr:data` property and the `ojcr:xmlContent` subtree, then the `ojcr:xmlContent` subtree takes precedence when those changes are saved.

Order in Which Changes Are Saved

The `save` method of class `javax.jcr.Session` or class `javax.jcr.Item` saves changes made in the transient layer. If more than one node or property has been changed, then JCR does not specify the order in which the changes are stored. Oracle XML DB Content Connector saves changes in the following:

1. Apply updates to existing files and folders, in path-sorted order.
2. Create new files and folders, in path-sorted order.
3. Move existing files and folders, in reverse path-sorted order.
4. Delete existing files and folders, in reverse path-sorted order.

Undefined Properties

Properties that have definitions of type `UNDEFINED` are stored as `STRING` values.

Node Type nt:base Is Abstract

Node type `nt:base` is abstract and cannot be specified as the type of a new node.

Node jcr:content Is Created Automatically

When you create a node of type `nt:file` or `nt:folder`, a `jcr:content` node is created automatically as a child.

Saving Normalizes Node jcr:xmltext

Saving combines successive `jcr:xmltext` nodes, which represent text within XML content or user-defined metadata, into a single `jcr:xmltext` node.

Node Type mix:referenceable

Node types `nt:file`, `nt:folder`, and `nt:resource` are subtypes of mix-in node type `mix:referenceable`. Consequently, all `nt:file`, `nt:folder`, and `nt:resource` nodes can be referenced by UUID. You cannot add `mix:referenceable` to nodes of any type.

Full-Text Indexing

You can create a full-text index on file content using PL/SQL package `DBMS_XDBT`. This lets queries apply function `jcr:contains` to property `jcr:data` of a `jcr:content` node. Full-text indexes on other properties are not supported.

Using XML Schemas with JCR

Oracle XML DB Content Connector can create JCR node types from XML schemas.

This section has the following topics:

- Why Register XML Schemas for Use with JCR?
- How to Register an XML Schema with JCR
- How JCR Node Types are Generated from XML Schemas

Why Register XML Schemas for Use with JCR?

XML data can be stored in Oracle XML DB Repository as either file content or user-defined metadata. In either case, the XML data can be based on an XML schema. XML schema-based data is validated against an XML schema that has been registered with Oracle XML DB.

By default, the JCR nodes corresponding to XML document content and user-defined metadata are of node type `nt:unstructured`, a generic node type defined by JCR, even if the XML data is XML schema-based. Oracle XML DB Repository still validates any changes made through the Oracle XML DB Content Connector against the XML schema, but it is not possible to access or specify typing metadata through JCR.

However, Oracle XML DB Content Connector lets XML schemas be registered for use in JCR. This causes the content connector to generate JCR node types for the XML-schema simple types, complex types, and global element declarations in the registered XML schema.

In exposing XML data as JCR nodes, the content connector determines whether the XML data conforms to an XML schema registered for JCR use, based on the value of XML attribute `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation` of its root element. If the XML data conforms to a JCR registered XML schema, then the

XML data is exposed as JCR nodes of the node types generated from the XML schema, instead of using the generic node type `nt:unstructured`.

You can also use the generated JCR node types to create or update XML document content and user-defined metadata.

Example 31–4 shows an XML document with XML schema-based content.

Example 31–4 XML Document With XML Schema-Based Content

```
<Address country="US"
   xmlns:xsi=
     "http://www.w3.org/2001/XMLSchema-instance"
   xsi:noNamespaceSchemaLocation=
     "http://www.example.com/Address">
  <name>Alice Smith</name>
  <street>123 Maple Street</street>
  <city>Mill Valley</city>
  <state>CA</state>
  <zip>90952</zip>
</Address>
```

The content of Example 31–4 is valid with respect to the XML schema shown in Example 31–5.

Example 31–5 XML Schema

```
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:complexType name="USAddress">
    <xsd:sequence>
      <xsd:element name="name"   type="xsd:string"/>
      <xsd:element name="street" type="xsd:string"/>
      <xsd:element name="city"   type="xsd:string"/>
      <xsd:element name="state"  type="xsd:string"/>
      <xsd:element name="zip"    type="xsd:long"/>
    </xsd:sequence>
    <xsd:attribute name="country" type="xsd:NMTOKEN"
                   fixed="US"/>
  </xsd:complexType>
</xsd:schema>
```

Initially, this XML schema is not registered for JCR use. The JCR nodes and properties representing the XML content are shown in Example 31–6.

Example 31–6 JCR Representation of XML Content Not Registered for JCR Use

```
 ojcr:xmlContent (nt:unstructured)
   Address (nt:unstructured)
     country="US" (String)
     name (nt:unstructured)
       jcr:xmltext(ojcr:xmltext)
         jcr:xmlcharacters="Alice Smith" (String)
     street (nt:unstructured)
       jcr:xmltext(ojcr:xmltext)
         jcr:xmlcharacters="123 Maple Street" (String)
     city (nt:unstructured)
       jcr:xmltext(ojcr:xmltext)
         jcr:xmlcharacters="Mill Valley" (String)
     state (nt:unstructured)
       jcr:xmltext(ojcr:xmltext)
         jcr:xmlcharacters="CA" (String)
```

```
    zip (nt:unstructured)
      jcr:xmltext (ojcr:xmltext)
        jcr:xmlcharacters="90952" (String)
```

The XML schema is then registered for JCR use. The JCR nodes and properties are shown in Example 31–7.

Example 31–7 JCR Representation of XML Content Registered for JCR Use

```
ojcr:xmlContent (nt:unstructured)
  Address (USAddress)
    country="US" (String)
    name (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="Alice Smith" (String)
    street (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="123 Maple Street" (String)
    city (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="Mill Valley" (String)
    state (xsd:string)
      jcr:xmltext(ojcr:xmltext)
        jcr:xmlcharacters="CA" (String)
    zip (xsd:long)
      jcr:xmltext (ojcr:xmltext)
        jcr:xmlcharacters="90952" (Long)
```

Node `Address` now has node type `USAddress`. Similarly, nodes `name`, `street`, `city`, and `state` have node type `xsd:string`. Node `zip` has node type `xsd:long`, and the `jcr:xmlcharacters` property of its `jcr:xmltext` child is a `LONG` property type.

See Also: Chapter 29, "User-Defined Repository Metadata"

How to Register an XML Schema with JCR

Before you register an XML schema for use with JCR, you must register it for use with Oracle XML DB, using PL/SQL procedure `DBMS_XMLSCHEMA.registerSchema`. For example, to register an XML schema with location `http://www.example.com/Address`, first register it for use with Oracle XML DB, as shown in Example 31–8. Then, register it for use with JCR, using Oracle XML DB Content Connector Java APIs, as shown in Example 31–9.

Example 31–8 Registering an XML Schema for Use with Oracle XML DB

```
BEGIN
  DBMS_XMLSCHEMA.registerSchema(
    schemaurl=>'http://www.example.com/Address',
    schemadoc=>bfileContainingSchema,
    local=>false,
    enablehierarchy=>DBMS_XMLSCHEMA.ENABLE_HIERARCHY_RESMETADATA);
END;
/
```

Note: Only globally registered XML schemas (`local=>false`) can be used with JCR.

Example 31–9 Registering an XML Schema for Use with JCR

```
import oracle.jcr.nodetype.OracleNodeTypeManager;
...
OracleNodeTypeManager ntm = (OracleNodeTypeManager)
  session.getWorkspace().getNodeTypeManager();

ntm.registerXMLSchema("http://www.example.com/Address", null);
```

The list of XML schemas registered for use with JCR is stored in the `OracleRepository` object. You can save this registration data by storing the `OracleRepository` object in a JNDI directory, as recommended by the JCR specification.

JCR requires that each node type have a unique name. By default, Oracle XML DB Content Connector generates JCR nodes types that correspond to a registered XML schema in the target namespace of the XML schema. If you wish to register two XML schemas with the same namespace, and the XML schemas declare types with the same names, you can avoid a name clash by overriding the namespace into which the JCR node types are generated. Refer to the Javadoc of method `registerXMLSchema()` for details.

See Also:

- "Managing XML Schemas with DBMS_XMLSCHEMA" on page 6-6 for information on registering XML schemas with Oracle XML DB
- *Oracle Database XML Java API Reference*, package `oracle.jcr`, for information on Java method `registerXMLSchema()`

How JCR Node Types are Generated from XML Schemas

This section describes how Oracle XML DB Content Connector generates JCR node types from XML schemas that are registered for JCR use.

The type models of JCR and XML Schema are similar but not equivalent. Some aspects of XML Schema have no representation in JCR. For example, some constraining facets of an XML-schema simple type are not discoverable through JCR. They are enforced by Oracle XML DB Content Connector nonetheless.

More generally, the JCR node types generated from an XML schema do not augment, detract, or alter the XML schema validation performed when XML data that conforms to that XML schema is created or updated, whether through JCR or other interfaces.

Built-In Simple Types

A JCR node type is provided for each XML Schema built-in type. For example, the JCR node type `xsd:decimal` corresponds to the built-in type `xsd:decimal`.

The inheritance hierarchy of the JCR node types follows that of the built-in types. For example, `xsd:integer` is a subtype of `xsd:decimal`.

Each XML Schema built-in type maps to a JCR property value type, which is used to represent values of that type in JCR.

Table 31–2 XML Schema Built-In Types Mapped to JCR Property Value Types

XML Schema Built-in Type	JCR Property Value Type
`xsd:anySimpleType`	`STRING`

Table 31–2 (Cont.) XML Schema Built-In Types Mapped to JCR Property Value Types

XML Schema Built-in Type	JCR Property Value Type
xsd:anyURI	STRING
xsd:base64Binary	BINARY
xsd:boolean	BOOLEAN
xsd:byte	LONG
xsd:date	DATE (1)
xsd:dateTime	DATE (1)
xsd:decimal	DOUBLE (2)
xsd:double	DOUBLE
xsd:duration	STRING
xsd:ENTITIES	STRING (3)
xsd:ENTITY	STRING
xsd:float	DOUBLE
xsd:gDay	STRING
xsd:gMonth	STRING
xsd:gMonthDay	STRING
xsd:gYear	STRING
xsd:gYearMonth	STRING
xsd:hexBinary	BINARY
xsd:ID	STRING
xsd:IDREF	STRING
xsd:IDREFS	STRING (3)
xsd:int	LONG
xsd:integer	LONG (2)
xsd:language	STRING
xsd:long	LONG
xsd:Name	STRING
xsd:NCName	STRING
xsd:negativeInteger	LONG
xsd:NMTOKEN	STRING
xsd:NMTOKENS	STRING (3)
xsd:nonNegativeInteger	LONG
xsd:nonPositiveInteger	LONG
xsd:normalizedString	STRING
xsd:NOTATION	STRING
xsd:positiveInteger	LONG
xsd:QName	STRING
xsd:short	LONG

Table 31–2 (Cont.) XML Schema Built-In Types Mapped to JCR Property Value Types

XML Schema Built-in Type	JCR Property Value Type
xsd:string	STRING
xsd:time	DATE (1)
xsd:token	STRING
xsd:unsignedByte	LONG
xsd:unsignedInt	LONG
xsd:unsignedLong	LONG
xsd:unsignedShort	LONG

Notes for Table 31–2:

1. The JCR DATE property type is accessed using java.util.Calendar objects. Since Calendar requires all fields to be set, a mask of 1970-01-01T00:00:00.000+00:00 is used to supply default values for missing fields when Property.getDate() or Value.getDate() is called. This includes omitted hour/minute/second values (for xsd:date), year/month/day values (for xsd:time), or time-zone values (for xsd:date, xsd:time, and xsd:dateTime). Calling Property.getString() or Value.getString() returns the unparsed string representation. Similarly, Property.setValue(String) or Property.setValue(valueFactory.createValue(String)) may be used to set DATE properties without applying the mask.
2. The value space of xsd:decimal and xsd:integer exceeds that of the corresponding JCR types, DOUBLE and LONG (accessed as Java double and long values). Consequently, some xsd:decimal and xsd:integer values can only be accessed in JCR as strings. For example, bigIntegerProperty.getLong() will throw a javax.jcr.ValueFormatException, but bigIntegerProperty.getString() will return the unparsed string representation. Similarly, Property.setValue(String) or Property.setValue(valueFactory.createValue(String)) may be used to set DOUBLE or LONG properties to values outside the JCR value space.
3. xsd:ENTITIES, xsd:IDREFS, and xsd:NMTOKENS are represented in JCR as multi-valued STRING properties.

XML Schema-Defined Simple Types

A JCR node type is created for each simple type defined in an XML schema. The inheritance hierarchy of the JCR node types follows that of the XML schema types.

A derived-by-list simple type is represented by a multi-valued JCR property definition.

A derived-by-union simple type is represented by a JCR property definition with property type UNDEFINED.

The JCR node type corresponding to an anonymous simple type has a synthetic name anonymousNodeType#*sequenceNumber*. Your application should not rely on the synthesized name. It is not guaranteed to be the same across sessions, and it may change when an XML schema is registered or deregistered for JCR use or the definition of a registered XML schema is changed.

Complex Types

A JCR node type is created for each complex type defined in an XML schema. The inheritance hierarchy of the JCR node types follows that of the XML schema types.

For a JCR node type corresponding to an XML schema complex type:

- A property definition is created for each attribute declaration of the complex type. Attribute declarations or attribute groups referenced by name in a complex type are treated as though they were defined in line.
- A residual property definition is created if the complex type has an attribute wildcard.
- A child node definition is created for each uniquely-named element declaration in the complex type's content model. Element declarations or module groups referenced by name are treated as though they were defined in line. If an element declaration is the head of a substitution group, a child node definition is also created for each element declaration within the substitution group.
- A residual child node definition is created if the complex type has an element wildcard.
- A `jcr:xmltext` child node definition is created if the complex type permits XML text, either because `xsd:mixed=true` or it is an `xsd:simpleContent` definition.

The JCR node type for a complex type supports child node ordering.

It is not possible to determine whether a type was derived by extension or restriction using JCR.

The JCR node type corresponding to an anonymous complex type has a synthetic name `anonymousNodeType#`*`sequenceNumber`*. Your application should not rely on the synthesized name. It is not guaranteed to be the same across sessions, and it may change when an XML schema is registered or deregistered for JCR use or the definition of a registered XML schema is changed.

Global Element Declarations

A JCR node type is created for each global element declaration in an XML schema. The local name of the generated node type is formed by prepending an underscore (_) to the local name of the global element declaration. For example, in a namespace-qualified purchase order XML schema, a node type named `po:_purchaseOrder` is created for global element named `po:purchaseOrder`.

32

Writing Oracle XML DB Applications in Java

This chapter describes how to write Oracle XML DB applications in Java. It includes design guidelines for writing Java applications including servlets, and how to configure the Oracle XML DB servlets.

This chapter contains these topics:

Overview of Oracle XML DB Java Applications

Oracle XML DB provides two main architectures for the Java programmer:

- In the database using the Java Virtual Machine (VM)
- In a client or application server, using the thick JDBC driver. An application server is a server designed to host applications and their environments, permitting server applications to run. A typical example is Oracle Application Server, which is able to host Java, C, C++, and PL/SQL applications in cases where a remote client controls the interface. See also Oracle Application Server. The Oracle Application Server, that integrates all the core services and features required for building, deploying, and managing high-performance, n-tier, transaction-oriented Web applications within an open standards framework.

Because Java in the database runs in the context of the database server process, the methods of deploying your Java code are restricted to one of the following ways:

- You can run Java code as a stored procedure invoked from SQL or PL/SQL or
- You can run a Java servlet.

Stored procedures are easier to integrate with SQL and PL/SQL code, and require using Oracle Net Services as the protocol to access Oracle Database.

Servlets work better as the top-level entry point into Oracle Database, and require using HTTP(S) as the protocol to access Oracle Database.

Which Oracle XML DB APIs Are Available Inside and Outside the Database?

All Oracle XML DB application program interfaces (APIs) are available to applications running both in the server and outside the database, including:

- JDBC support for `XMLType`
- `XMLType` class
- Java DOM implementation

Design Guidelines: Java Inside or Outside the Database?

When choosing an architecture for writing Java Oracle XML DB applications, consider the following guidelines:

HTTP(S): Accessing Java Servlets or Directly Accessing XMLType Resources

If the downstream client wants to deal with XML in its textual representation, then using HTTP(S) to either access the Java servlets or directly access `XMLType` resources, will perform the best, especially if the XML node tree is not being manipulated much by the Java program.

The Java implementation in the server can natively move data from the database to the network without converting character data through UCS-2 Unicode (which is required by Java strings), and in many cases copies data directly from the database buffer cache to the HTTP(S) connection. There is no requirement to convert data from the buffer cache into the SQL serialization format used by Oracle Net Services, move it to the JDBC client, and then convert to XML. The load-on-demand and LRU cache for `XMLType` are most effective inside the database server.

Accessing Many XMLType Object Elements: Use JDBC XMLType Support

If the downstream client is an application that will programmatically access many or most of the elements of an `XMLType` instance using Java, then use JDBC `XMLType` support for best performance. It is often easier to debug Java programs outside of the database server, as well.

Use the Servlets to Manipulate and Write Out Data Quickly as XML

Oracle XML DB servlets are intended for writing HTTP stored procedures in Java that can be accessed using HTTP(S). They are not intended as a platform for developing an entire Internet application. In that case, the application servlet should be deployed in Oracle Application Server application server and access data in the database either using JDBC, or by using the `java.net.*` or similar APIs to get XML data through HTTP(S).

They are best used for applications that want to get into the database, manipulate the data, and write it out quickly as XML, not to format HTML pages for end-users.

Writing Oracle XML DB HTTP Servlets in Java

Oracle XML DB provides a protocol server that supports FTP, HTTP 1.1, WebDAV, and Java Servlets. The support for Java Servlets in this release is not complete, and

provides a subset designed for easy migration to full compliance in a following release. Currently, Oracle XML DB supports Java Servlet version 2.2, with the following exceptions:

- The servlet WAR file (`web.xml`) is not supported in its entirety. Some `web.xml` configuration parameters must be handled manually. For example, creating roles must be done using the `SQL CREATE ROLE` command.
- `RequestDispatcher` and associated methods are not supported.
- `HTTPServletRequest.getCookies()` method is not supported.
- Only one `ServletContext` (and one `web-app`) is currently supported.
- Stateful servlets (and thus the `HttpSession` class methods) are not supported. Servlets must maintain state in the database itself.

Configuring Oracle XML DB Servlets

Oracle XML DB servlets are configured using the `/xdbconfig.xml` file in Oracle XML DB Repository. Many of the XML elements in this file are the same as those defined by the Java Servlet 2.2 specification portion of Java 2 Enterprise Edition (J2EE), and have the same semantics. Table 32–1 lists the XML elements defined for the servlet deployment descriptor by the Java Servlet specification, along with extension elements supported by Oracle XML DB.

Table 32–1 XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`auth-method`	Java	no	Specifies an HTTP authentication method required for access	--
`charset`	Oracle	yes	Specifies an IANA character set name	For example: ISO8859, UTF-8
`charset-mapping`	Oracle	yes	Specifies a mapping between a filename extension and a charset	--
`context-param`	Java	no	Specifies a parameter for a Web application	Not yet supported
`description`	Java	yes	A string for describing a servlet or Web application	Supported for servlets
`display-name`	Java	yes	A string to display with a servlet or Web application	Supported for servlets
`distributable`	Java	no	Indicates whether or not this servlet can function if all instances are not running in the same Java virtual machine	All servlets running in Oracle Database MUST be distributable.
`errnum`	Oracle	yes	Oracle error number	See *Oracle Database Error Messages*
`error-code`	Java	yes	HTTP(S) error code	Defined by RFC 2616
`error-page`	Java	yes	Defines a URL to redirect to if an error is encountered.	Can be specified through an HTTP(S) error, an uncaught Java exception, or through an uncaught Oracle error message
`exception-type`	Java	yes	Classname of a Java exception mapped to an error page	--

Table 32–1 (Cont.) XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`extension`	Java	yes	A filename extension used to associate with MIME types, character sets, and so on.	--
`facility`	Oracle	yes	Oracle facility code for mapping error pages	For example: ORA, PLS, and so on.
`form-error-page`	Java	no	Error page for form login attempts	Not yet supported
`form-login-config`	Java	no	Config spec for form-based login	Not yet supported
`form-login-page`	Java	no	URL for the form-based login page	Not yet supported
`icon`	Java	Yes	URL of icon to associate with a servlet	Supported for servlets
`init-param`	Java	Yes	Initialization parameter for a servlet	--
`jsp-file`	Java	No	Java Server Page file to use for a servlet	Not supported
`lang`	Oracle	Yes	IANA language name	For example: en-US
`lang-mapping`	Oracle	Yes	Specifies a mapping between a filename extension and language content	--
`large-icon`	Java	Yes	Large sized icon for icon display	--
`load-on-startup`	Java	Yes	Specifies if a servlet is to be loaded on startup	--
`location`	Java	Yes	Specifies the URL for an error page	Can be a local path name or HTTP(S) URL
`login-config`	Java	No	Specifies a method for authentication	Not yet supported
`mime-mapping`	Java	Yes	Specifies a mapping between filename extension and the MIME type of the content	--
`mime-type`	Java	Yes	MIME type name for resource content	For example: text/xml or application/octet-stream
`OracleError`	Oracle	Yes	Specifies an Oracle error to associate with an error page	--
`param-name`	Java	Yes	Name of a parameter for a Servlet or `ServletContext`	Supported for servlets
`param-value`	Java	Yes	Value of a parameter	--
`realm-name`	Java	No	HTTP(S) realm used for authentication	Not yet supported
`role-link`	Java	Yes	Specifies a role a particular user must have to access a servlet	Refers to a database role name. Make sure to capitalize by default!
`role-name`	Java	Yes	A servlet name for a role	Just another name to call the database role. Used by the Servlet APIs

Table 32–1 (Cont.) XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
`security-role`	Java	No	Defines a role for a servlet to use	Not supported. You must manually create roles using the SQL `CREATE ROLE`
`security-role-ref`	Java	Yes	A reference between a servlet and a role	--
`servlet`	Java	Yes	Configuration information for a servlet	--
`servlet-class`	Java	Yes	Specifies the classname for the Java servlet	--
`servlet-language`	Oracle	Yes	Specifies the programming language in which the servlet is written.	Either Java, C, or PL/SQL. Currently, only Java is supported for customer-defined servlets.
`servlet-mapping`	Java	Yes	Specifies a filename pattern with which to associate the servlet	All of the mappings defined by Java are supported
`servlet-name`	Java	Yes	String name for a servlet	Used by servlet APIs
`servlet-schema`	Oracle	Yes	The Oracle Schema in which the Java class is loaded. If not specified, then the schema is searched using the default resolver specification.	If this is not specified, then the servlet must be loaded into the `SYS` schema to ensure that everyone can access it, or the default Java class resolver must be altered. Note that the servlet schema is capitalized unless the value is enclosed in double-quotes.
`session-config`	Java	No	Configuration information for an `HTTPSession`	`HTTPSession` is not supported
`session-timeout`	Java	No	Timeout for an HTTP(S) session	`HTTPSession` is not supported
`small-icon`	Java	Yes	Small icon to associate with a servlet	--
`taglib`	Java	No	JSP tag library	JSPs currently not supported
`taglib-uri`	Java	No	URI for JSP tag library description file relative to file `web.xml`	JSPs currently not supported
`taglib-location`	Java	No	Path name relative to the root of the Web application where the tag library is stored	JSPs currently not supported
`url-pattern`	Java	Yes	URL pattern to associate with a servlet	See Section 10 of Java Servlet 2.2 spec

Table 32–1 (Cont.) XML Elements Defined for Servlet Deployment Descriptors

XML Element Name	Defined By	Supported?	Description	Comment
web-app	Java	No	Configuration for a Web application	Only one Web application is currently supported
welcome-file	Java	Yes	Specifies a welcome-file name	--
welcome-file-list	Java	Yes	Defines a list of files to display when a folder is referenced through an HTTP GET request	Example: index.html

Note:

- The following parameters defined for the web.xml file by Java are usable only by J2EE-compliant Enterprise Java Bean containers, and are not required for Java Servlet Containers that do not support a full J2EE environment: env-entry, env-entry-name, env-entry-value, env-entry-type, ejb-ref, ejb-ref-type, home, remote, ejb-link, resource-ref, res-ref-name, res-type, res-auth.
- The following elements are used to define access control for resources: security-constraint, web-resource-collection, web-resource-name, http-method, user-data-constraint, transport-guarantee, auth-constrain. Oracle XML DB provides this functionality through access control lists (ACLs). An ACL is a list of access control entries (ACEs) that determines which principals have access to a given resource or resources. A future release will support using a web.xml file to generate ACLs.

See Also: Chapter 34, "Administering Oracle XML DB" for more information about configuring the /xdbconfig.xml file

HTTP Request Processing for Oracle XML DB Servlets

Oracle XML DB handles an HTTP request using the following steps:

1. If a connection has not yet been established, then Oracle Listener hands the connection to a shared server dispatcher.
2. When a new HTTP request arrives, the dispatcher wakes up a shared server.
3. The HTTP headers are parsed into appropriate structures.
4. The shared server attempts to allocate a database session from the Oracle XML DB session pool, if available, but otherwise will create a new session.
5. A new database call is started, as well as a new database transaction.
6. If HTTP(S) has included authentication headers, then the session will be authenticated as that database user (just as if the user logged into SQL*Plus). If no authentication information is included, and the request is GET or HEAD, then Oracle XML DB attempts to authenticate the session as the ANONYMOUS user. If that database user account is locked, then no unauthenticated access is allowed.

7. The URL in the HTTP request is matched against the servlets in the `xdbconfig.xml` file, as specified by the Java Servlet 2.2 specification.
8. The Oracle XML DB Servlet Container is invoked in the Java VM inside Oracle. If the specified servlet has not been initialized yet, then the servlet is initialized.
9. The Servlet reads input from the `ServletInputStream`, and writes output to the `ServletOutputStream`, and returns from the `service()` method.
10. If no uncaught Oracle error occurred, then the session is put back into the session pool.

See Also: Chapter 28, "Using Protocols to Access the Repository"

Session Pool and Oracle XML DB Servlets

Oracle Database keeps one Java VM for each database session. This means that a session reused from the session pool will have any state in the Java VM (Java static variables) from the last time the session was used.

This can be useful in caching Java state that is not user-specific, such as metadata, but Do not store secure user data in Java static memory. This could turn into a security hole inadvertently introduced by your application if you are not careful.

Native XML Stream Support

The `DOM` Node class has an Oracle-specific method called `write()`, that takes the following arguments, returning void:

- `java.io.OutputStream` stream: A Java stream to write the XML text to
- String `charEncoding`: The character encoding to write the XML text in. If `NULL`, then the database character set is used
- `Short indent` The number of characters to indent nested XML elements

This method has a shortcut implementation if the stream provided is the `ServletOutputStream` provided inside the database. The contents of the Node are written in XML in native code directly to the output socket. This bypasses any conversions into and out of Java objects or Unicode (required for Java strings) and provides very high performance.

Oracle XML DB Servlet APIs

The APIs supported by Oracle XML DB servlets are defined by the Java Servlet 2.2 specification, the `Javadoc` for which is available, as of the time of writing this, online at: `http://java.sun.com/products/servlet/2.2/javadoc/index.html`

Table 32–2 lists Java Servlet 2.2 methods that are not implemented. They result in runtime exceptions.

Table 32–2 Java 2.2 Methods That Are Not Implemented

Interface	Methods
`HttpServletRequest`	`getSession(), isRequestedSessionIdValid()`
`HttpSession`	all
`HttpSessionBindingListener`	all

Oracle XML DB Servlet Example

The following is a simple servlet example that reads a parameter specified in a URL as a path name, and writes out the content of that XML document to the output stream.

Example 32–1 Writing an Oracle XML DB Servlet

The servlet code looks like this:

```
/* test.java */
import javax.servlet.http.*;
import javax.servlet.*;
import java.util.*;
import java.io.*;
import javax.naming.*;
import oracle.xml.parser.v2.*;

public class test extends HttpServlet
{
  protected void doGet(HttpServletRequest req, HttpServletResponse resp)
    throws ServletException, IOException
  {
    OutputStream os = resp.getOutputStream();
    Hashtable    env = new Hashtable();
    XMLDocument  xt;

    try
    {
      env.put(Context.INITIAL_CONTEXT_FACTORY,
              "oracle.xdb.spi.XDBContextFactory");
      Context ctx = new InitialContext(env);
      String [] docarr  = req.getParameterValues("doc");
      String doc;
      if (docarr == null || docarr.length == 0)
        doc = "/foo.txt";
      else
        doc = docarr[0];
      xt = (XMLDocument)ctx.lookup(doc);
      resp.setContentType("text/xml");
      xt.print(os, "ISO8859");
    }
    catch (javax.naming.NamingException e)
    {
      resp.sendError(404, "Got exception: " + e);
    }
    finally
    {
      os.close();
    }
  }
}
```

Installing the Oracle XML DB Example Servlet

To install this servlet, compile it, and load it into Oracle Database using commands such as:

```
% loadjava -grant public -u quine/curry -r test.class
```

Configuring the Oracle XML DB Example Servlet

To configure Oracle XML DB servlet, update the `/xdbconfig.xml` file by inserting the following XML element tree in the `servlet-list` element:

```
<servlet>
  <servlet-name>TestServlet</servlet-name>
  <servlet-language>Java</servlet-language>
  <display-name>Oracle XML DB Test Servlet</display-name>
  <servlet-class>test</servlet-class>
  <servlet-schema>quine</servlet-schema>
</servlet>
```

and update the `/xdbconfig.xml` file by inserting the following XML element tree in the `<servlet-mappings>` element:

```
<servlet-mapping>
  <servlet-pattern>/testserv</servlet-pattern>
  <servlet-name>TestServlet</servlet-name>
</servlet-mapping>
```

You can edit the `/xdbconfig.xml` file with any WebDAV-capable text editor, or by using SQL function `updateXML`.

> **Note:** You cannot delete file `/xdbconfig.xml`, even `as SYS`.

Testing the Example Servlet

To test the example servlet, load an arbitrary XML file at `/foo.xml`, and type the following URL into your browser, replacing the `hostname` and port number as appropriate:

```
http://hostname:8080/testserv?doc=/foo.xml
```

33

Using Native Oracle XML DB Web Services

This chapter contains these topics:

Overview of Native Oracle XML DB Web Services

Web services provide a standard way for applications to exchange information over the Internet and access services that implement business logic. Your applications can access Oracle Database using native Oracle XML DB Web services. One available service lets you issue SQL and XQuery queries and receive results as XML data. Another service provides access to all PL/SQL stored functions and procedures. You can customize the input and output document formats when you use the latter service; the WSDL is automatically generated by the native database Web services engine.

SOAP 1.1 is the version supported by Oracle XML DB. Applications use the HTTP POST method to submit SOAP requests to native Oracle XML DB Web services. You can configure the locations of all native Oracle XML DB Web services and WSDL documents using the Oracle XML DB configuration file, `xdbconfig.xml`. You can also configure security settings for the Web services using the same configuration file.

You can use the `Accept-Charsets` field of the input HTTP header to specify the character set of Web-service responses. If this header field is omitted, then responses are in the database character set. The language of the input document and any error responses is the locale language of the database.

Error handling for native Oracle XML DB Web services uses the SOAP framework for faults.

See Also:

- http://www.w3.org/2002/ws/ for more information on Web services
- The W3C SOAP primer, http://www.w3.org/TR/2000/NOTE-SOAP-20000508, for more information on SOAP
- http://www.w3.org/TR/wsdl for information on the Web Services Description Language (WSDL)
- http://www.w3.org/TR/2003/REC-soap12-part0-20030624/#L11549 for information on SOAP fault handling
- "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5

Configuring and Enabling Web Services for Oracle XML DB

For security reasons, Oracle XML DB is not preconfigured with the native Web services enabled. To make native Oracle XML DB Web services available, you must explicitly add Web service configuration. Then, to allow specific users to use Web services, you must grant them appropriate roles.

1. Configure Web services – see "Configuring Web Services for Oracle XML DB".
2. Enable Web services for specific users, by granting them appropriate roles – "Enabling Web Services for Specific Users".

Configuring Web Services for Oracle XML DB

To make Web services available for Oracle XML DB, log on as user `SYS` and add the servlet configuration that is shown as the query output of Example 33–2 to your Oracle XML DB configuration file, `xdbconfig.xml`.

Note: You must either configure the servlet separately for each node of a Real Application Cluster (RAC) or configure it for one node and then restart the database instances on the other nodes. See "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5.

Example 33–1 shows how to use procedures in PL/SQL package `DBMS_XDB` to add the servlet. Example 33–2 shows how to verify that the servlet was added correctly.

Example 33–1 Adding a Web Services Configuration Servlet

```
DECLARE
  SERVLET_NAME VARCHAR2(32) := 'orawsv';
BEGIN
  DBMS_XDB.deleteServletMapping(SERVLET_NAME);
  DBMS_XDB.deleteServlet(SERVLET_NAME);
  DBMS_XDB.addServlet(NAME     => SERVLET_NAME,
                      LANGUAGE => 'C',
                      DISPNAME => 'Oracle Query Web Service',
                      DESCRIPT => 'Servlet for issuing queries as a Web Service',
                      SCHEMA   => 'XDB');
  DBMS_XDB.addServletSecRole(SERVNAME => SERVLET_NAME,
                             ROLENAME => 'XDB_WEBSERVICES',
                             ROLELINK => 'XDB_WEBSERVICES');
  DBMS_XDB.addServletMapping(PATTERN => '/orawsv/*',
```

```
                                        NAME     => SERVLET_NAME);
                END;
                /
```

Example 33–2 Verifying Addition of Web Services Configuration Servlet

```
XQUERY declare default element namespace "http://xmlns.oracle.com/xdb/xdbconfig.xsd"; (: :)
       (: This path is split over two lines for documentation purposes only.
          The path should actually be a single long line. :)
       for $doc in fn:doc("/xdbconfig.xml")/xdbconfig/sysconfig/protocolconfig/httpconfig/
        webappconfig/servletconfig/servlet-list/servlet[servlet-name='orawsv']
       return $doc
/

Result Sequence
------------------------------------------------------------------------
<servlet xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd">
  <servlet-name>orawsv</servlet-name>
  <servlet-language>C</servlet-language>
  <display-name>Oracle Query Web Service</display-name>
  <description>Servlet for issuing queries as a Web Service</description>
  <servlet-schema>XDB</servlet-schema>
  <security-role-ref>
    <description/>
    <role-name>XDB_WEBSERVICES</role-name>
    <role-link>XDB_WEBSERVICES</role-link>
  </security-role-ref>
</servlet>

1 item(s) selected.
```

> **See Also:** "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5 for more information about configuring Oracle XML DB with `xdbconfig.xml`

Enabling Web Services for Specific Users

To enable Web services for a specific user, log on as user `SYS` and grant the role `XDB_WEBSERVICES` to the user. This role enables use of Web services over HTTPS; it is *required* to be able to use Web services.

User `SYS` can, in *addition*, grant one or both of the following roles to the user:

- `XDB_WEBSERVICES_OVER_HTTP` – Enable use of Web services over HTTP (not just HTTPS).
- `XDB_WEBSERVICES_WITH_PUBLIC` – Enable access, using Web services, to database objects that are accessible to `PUBLIC`.

If a user is not granted `XDB_WEBSERVICES_WITH_PUBLIC`, then the user has access, using Web services, to all database objects (regardless of owner) that would normally be available to the user, *except* for `PUBLIC` objects. To make `PUBLIC` objects accessible to a user through Web services, `SYS` must grant role `XDB_WEBSERVICES_WITH_PUBLIC` to the user. With this role, a user can access any `PUBLIC` objects that would normally be available to the user if logged on to the database.

Querying Oracle XML DB Using a Web Service

The Oracle XML DB Web service for database queries is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**, where *`host`* and *`port`* are the host and HTTP(S) port

properties of your database. This Web service has a WSDL document associated with it that specifies the formats of the incoming and outgoing documents using XML Schema. This WSDL document is located at URL `http://host:port/orawsv?wsdl`.

Your application sends database queries to the Web service as XML documents that conform to the XML schema listed in Example 33–3.

Example 33–3 XML Schema for Database Queries To Be Processed by Web Service

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        targetNamespace="http://xmlns.oracle.com/orawsv">
  <element name="query">
    <complexType>
      <sequence>
        <element name="query_text">
          <complexType>
            <simpleContent>
              <extension base="string">
                <attribute name="type">
                  <simpleType>
                    <restriction base="NMTOKEN">
                      <enumeration value="SQL"/>
                      <enumeration value="XQUERY"/>
                    </restriction>
                  </simpleType>
                </attribute>
              </extension>
            </simpleContent>
          </complexType>
        </element>
        <choice maxOccurs="unbounded">
          <element name="bind">
            <complexType>
              <simpleContent>
                <extension base="string">
                  <attribute name="name" type="string"/>
                </extension>
              </simpleContent>
            </complexType>
          </element>
          <element name="bindXML" type="any"/>
        </choice>
        <element name="null_handling" minOccurs="0">
          <simpleType>
            <restriction base="NMTOKEN">
              <enumeration value="DROP_NULLS"/>
              <enumeration value="NULL_ATTR"/>
              <enumeration value="EMPTY_TAG"/>
            </restriction>
          </simpleType>
        </element>
        <element name="max_rows" type="positiveInteger" minOccurs="0"/>
        <element name="skip_rows" type="positiveInteger" minOccurs="0"/>
        <element name="pretty_print" type="boolean" minOccurs="0"/>
        <element name="indentation_width" type="positiveInteger" minOccurs="0"/>
        <element name="rowset_tag" type="string" minOccurs="0"/>
        <element name="row_tag" type="string" minOccurs="0"/>
        <element name="item_tags_for_coll" type="boolean" minOccurs="0"/>
```

```
      </sequence>
    </complexType>
  </element>
</schema>
```

This XML schema is contained in the WSDL document. The important parts of incoming query documents are as follows:

- `query_text` – The text of your query. Attribute `type` specifies the type of your query: either `SQL` or `XQUERY`.
- `bind` – A scalar bind-variable value. Attribute `name` names the variable.
- `bindXML` – An `XMLType` bind-variable value.
- `null_handling` – How `NULL` values returned by the query are to be treated:
  - `DROP_NULLS` – Put nothing in the output (no element). This is the default behavior.
  - `NULL_ATTR` – Use an empty element for `NULL`-value output. Use attribute `xsi:nil="true"` in the element.
  - `EMPTY_TAG` – Use an empty element for `NULL`-value output, without a `nil` attribute.
- `max_rows` – The maximum number of rows to output for the query. By default, all rows are returned.
- `skip_rows` – The number of query output rows to skip, before including rows in the data returned in the SOAP message. You can use this in connection with `max_rows` to provide paginated output. The default value is zero (`0`).
- `pretty_print` – Whether the output document should be formatted for pretty-printing. The default value is `true`, meaning that the document will be pretty-printed. When the value is `false`, no pretty-printing is done, and output rows are not broken with newline characters.
- `indentation_width` – The number of characters to indent nested elements that start a new line. The default value is one (`1`).
- `rowset_tag` – Name of the root element of the output document.
- `row_tag` – Name of the element whose value is a single row of query output.
- `item_tags_for_coll` – Whether to generate collection elements with name *`collection_name`*`_item`, where *`collection_name`* is the name of the collection.

These elements have the same meanings as corresponding parameters of procedures in PL/SQL package `DBMS_XMLGEN`.

Example 33–5 and Example 33–5 show the input and output of a simple SQL query.

Example 33–4 Input XML Document for SQL Query Using Query Web Service

```
<?xml version="1.0" ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/06/soap-envelope ">
  <env:Body>
    <query xmlns="http://xmlns.oracle.com/orawsv">
      <query_text type="SQL">
        <![CDATA[SELECT * FROM employees WHERE salary = :e]]>
      </query_text>
      <bind name="e">8300</bind>
      <pretty_print>false</pretty_print>
```

```
    </query>
  </env:Body>
</env:Envelope>
```

In Example 33–4, the query text is enclosed in `<![CDATA[...]]>`. Although not strictly necessary in this example, it is appropriate to do this generally, because queries often contain characters such as < and >. Element `bind` is used to bind a value (`8300`) to the bind variable named `e`. Element `pretty_print` turns off pretty-printing of the output.

Example 33–5 Output XML Document for SQL Query Using Query Web Service

```
<?xml version="1.0"?>
<soap:Envelope xmlns:soap="http://www.w3.org/2002/06/soap-envelope">
<soap:Body>
<ROWSET><ROW><EMPLOYEE_ID>206</EMPLOYEE_ID><FIRST_NAME>William</FIRST_NAME><LAST_NAME>G
ietz</LAST_NAME><EMAIL>WGIETZ</EMAIL><PHONE_NUMBER>515.123.8181</PHONE_NUMBER><HIRE_DATE>07-JUN-
94</HIRE_DATE><JOB_ID>AC_ACCOUNT</JOB_ID><SALARY>8300</SALARY><MANAGER_ID>205</MANAGER_ID
><DEPARTMENT_ID>110</DEPARTMENT_ID></ROW></ROWSET>
</soap:Body>
</soap:Envelope>
```

Accessing PL/SQL Stored Procedures Using a Web Service

The Oracle XML DB Web service for accessing PL/SQL stored functions and procedures is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`*`/`*`fn_or_proc`* or, for a function or procedure that is not in a package (standalone), `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`fn_or_proc`*. Here, *`host`* and *`port`* are the host and HTTP(S) port properties of your database, *`fn_or_proc`* is the stored function or procedure name, *`package`* is the package it is in, and *`dbschema`* is the database schema owning that package.

The input XML document must contain the inputs needed by the function or procedure. The output XML document contains the values of all `OUT` variables, as well as the return value.

The names of the XML elements in the input and output documents correspond to the variable names of the function or procedure. The generated WSDL document shows you the exact XML element names. This is the naming convention used:

- The XML element introducing the input to a PL/SQL function is named *`function-name`***`Input`**, where *`function-name`* is the name of the function (uppercase).
- The XML elements introducing input parameters for the function are named *`param-name`***`-`***`param-type`***`-`***`io-mode`**, where *`param-name`* is the name of the parameter (uppercase), *`param-type`* is its SQL data type, and *`io-mode`* is its input-output mode, as follows:
  - **`IN`** – `IN` mode
  - **`OUT`** – `OUT` mode
  - **`INOUT`** – `IN OUT` mode
- The XML element introducing the output from a PL/SQL function is named **`S`***`return-type`***`-`***`function-name`***`Output`**, where *`return-type`* is the SQL data type of the return value (uppercase), and *`function-name`* is the name of the function (uppercase).

- The XML elements introducing output parameters for the function are named the same as the output parameters themselves (uppercase). The element introducing the return value is named `RETURN`.

The return value of a function is in the `RETURN` element of the output document, which is always the first element in the document. This return-value position disambiguates it from any `OUT` parameter that might be named "`RETURN`".

Each stored function or procedure is associated with a separate, dynamic Web service that has its own, generated WSDL document. This WSDL document is located at URL `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`*`/`*`fn_or_proc`***`?wsdl`** or `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`fn_or_proc`***`?wsdl`**. In addition, you can optionally generate a single WSDL document to be used for all stored functions and procedures in a given package. The URL for that WSDL document is `http://`*`host`*`:`*`port`*`/`**`orawsv`**`/`*`dbschema`*`/`*`package`***`?wsdl`**.

Data types in the incoming and outgoing XML documents are mapped to SQL data types for use by the stored function or procedure, according to Table 33–1.

Table 33–1 Web Service Mapping Between XML and SQL Data Types

SQL Data Type	XML Schema Data Type
`CHAR`, `VARCHAR2`, `VARCHAR`	`xsd:string`
`DATE` – Dates must be in the database format.	`xsd:date`
`TIMESTAMP`, `TIMESTAMP WITH TIMEZONE`, `TIMESTAMP WITH LOCAL TIMEZONE`	`xsd:dateTime`
`INTERVAL YEAR TO MONTH`, `INTERVAL DAY TO SECOND`	`xsd:duration`
`NUMBER`, `BINARY_DOUBLE`, `BINARY_FLOAT`	`xsd:double`
PL/SQL `BOOLEAN`	`xsd:boolean`
Object types	`complexType`

An object type is represented in XML as a complex-type element named the same as the object type. The object attributes are represented as children of this element.

Example of Using a PL/SQL Function With a Web Service

This section presents a simple PL/SQL function and its access using a Web service. The function takes as input a department ID and name, and it returns the salary total of all employees in the department. It also returns, as in-out and output parameters, respectively, the department name and the number of employees in the department. The default value of the department ID is `20`. In this simple example, the input value of the in-out parameter `dept_name` is not actually used; it is ignored, and the correct name is returned.

Example 33–6 shows the function definition. Example 33–7 shows the WSDL document that is created automatically from this function definition. Example 33–8 shows an input document that invokes the stored function. Example 33–9 shows the resulting output document.

Example 33–6 Definition of PL/SQL Function Used for Web-Service Access

```
CREATE OR REPLACE PACKAGE salary_calculator AUTHID CURRENT_USER AS
  FUNCTION TotalDepartmentSalary (dept_id    IN     NUMBER DEFAULT 20,
                                  dept_name  IN OUT VARCHAR2,
                                  nummembers OUT    NUMBER)
```

```
    RETURN NUMBER;
  END salary_calculator;
  /
  CREATE OR REPLACE PACKAGE BODY salary_calculator AS
    FUNCTION TotalDepartmentSalary (dept_id    IN     NUMBER DEFAULT 20,
                                    dept_name  IN OUT VARCHAR2,
                                    nummembers OUT    NUMBER)
      RETURN NUMBER IS
        sum_sal NUMBER;
        BEGIN
          SELECT SUM(salary) INTO sum_sal FROM employees
            WHERE department_id = dept_id;
          SELECT department_name INTO dept_name FROM departments
            WHERE department_name = dept_name;
          SELECT count(*) INTO nummembers FROM employees
            WHERE department_id = dept_id;
      RETURN sum_sal;
    END;
  END;
  /
```

Example 33–7 WSDL Document Corresponding to a Stored PL/SQL Function

```
<definitions name="SALARY_CALCULATOR"
             targetNamespace="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
             xmlns="http://schemas.xmlsoap.org/wsdl/"
             xmlns:tns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
             xmlns:xsd="http://www.w3.org/2001/XMLSchema"
             xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/">
  <types>
    <xsd:schema targetNamespace="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR"
                elementFormDefault="qualified">
      <xsd:element name="SNUMBER-TOTALDEPARTMENTSALARYInput">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="NUMMEMBERS-NUMBER-OUT">
              <xsd:complexType/>
            </xsd:element>
            <xsd:element name="DEPT_NAME-VARCHAR2-INOUT" type="xsd:string"/>
            <xsd:element name="DEPT_ID-NUMBER-IN" type="xsd:double"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
      <xsd:element name="TOTALDEPARTMENTSALARYOutput">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="RETURN" type="xsd:double"/>
            <xsd:element name="NUMMEMBERS" type="xsd:double"/>
            <xsd:element name="DEPT_NAME" type="xsd:string"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
    </xsd:schema>
  </types>
  <message name="TOTALDEPARTMENTSALARYInputMessage">
    <part name="parameters" element="tns:SNUMBER-TOTALDEPARTMENTSALARYInput"/>
  </message>
  <message name="TOTALDEPARTMENTSALARYOutputMessage">
    <part name="parameters" element="tns:TOTALDEPARTMENTSALARYOutput"/>
  </message>
```

```
  <portType name="SALARY_CALCULATORPortType">
    <operation name="TOTALDEPARTMENTSALARY">
      <input message="tns:TOTALDEPARTMENTSALARYInputMessage"/>
      <output message="tns:TOTALDEPARTMENTSALARYOutputMessage"/>
    </operation>
  </portType>
 <binding name="SALARY_CALCULATORBinding" type="tns:SALARY_CALCULATORPortType">
    <soap:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
    <operation name="TOTALDEPARTMENTSALARY">
      <soap:operation soapAction="TOTALDEPARTMENTSALARY"/>
      <input>
        <soap:body parts="parameters" use="literal"/>
      </input>
      <output>
        <soap:body parts="parameters" use="literal"/>
      </output>
    </operation>
  </binding>
  <service name="SALARY_CALCULATORService">
    <documentation>Oracle Web Service</documentation>
    <port name="SALARY_CALCULATORPort" binding="tns:SALARY_CALCULATORBinding">
      <soap:address location="httpS://dlsun339:8088/orawsv/HR/SALARY_CALCULATOR"/>
     </port>
  </service>
</definitions>
```

Example 33–8 Input XML Document for PL/SQL Query Using Web Service

```
<?xml version="1.0" ?><soap:Envelope
xmlns:soap="http://www.w3.org/2002/06/soap-envelope"><soap:Body><SNUMBER-
TOTALDEPARTMENTSALARYinput
xmlns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR/TOTALDEPARTMENTSALARY">
<DEPT_ID-NUMBER-IN>30</DEPT_ID-NUMBER-IN><DEPT_NAME-VARCHAR2-INOUT>Purchasing
</DEPT_NAME-VARCHAR2-INOUT><NUMMEMBERS-NUMBER-OUT/></SNUMBER-
TOTALDEPARTMENTSALARYinput></soap:Body></soap:Envelope>
```

Example 33–9 Output XML Document for PL/SQL Query Using Web Service

```
<?xml version="1.0" ?>
<soap:Envelope xmlns:soap="http://www.w3.org/2002/06/soap-envelope">
  <soap:Body>
    <TOTALDEPARTMENTSALARYOutput
       xmlns="http://xmlns.oracle.com/orawsv/HR/SALARY_CALCULATOR/TOTALDEPARTMENTSALARY">
      <RETURN>24900</RETURN>
      <NUMMEMBERS>6</NUMMEMBERS>
      <DEPT_NAME>Purchasing</DEPT_NAME>
    </TOTALDEPARTMENTSALARYOutput>
  </soap:Body>
</soap:Envelope>
```

Part VI

Oracle Tools that Support Oracle XML DB

Part VI of this manual provides information about Oracle tools that you can use with Oracle XML DB. It describes tools for managing Oracle XML DB, loading XML data, and exchanging XML data.

Part VI contains the following chapters:

34

Administering Oracle XML DB

This chapter describes how to administer Oracle XML DB. It includes information about installing, upgrading, and configuring Oracle XML DB.

This chapter contains these topics:

- Installing and Reinstalling Oracle XML DB
- Upgrading an Existing Oracle XML DB Installation
- Using Oracle Enterprise Manager to Administer Oracle XML DB
- Configuring Oracle XML DB Using xdbconfig.xml

> **See Also:** "Configuring Resources for XLink and XInclude" on page 23-9 for information on configuring Oracle XML DB Repository resources for use with XLink and XInclude

Installing and Reinstalling Oracle XML DB

You are required to install Oracle XML DB manually under the following conditions:

- "Installing or Reinstalling Oracle XML DB From Scratch" on page 34-1
- "Upgrading an Existing Oracle XML DB Installation" on page 34-4

Installing or Reinstalling Oracle XML DB From Scratch

You can perform a new installation of Oracle XML DB with or without Database Configuration Assistant (DBCA). If Oracle XML DB is already installed, complete the steps in "Reinstalling Oracle XML DB" on page 34-3.

Installing a New Oracle XML DB With Database Configuration Assistant

Oracle XML DB is part of the seed database and installed by Database Configuration Assistant (DBCA) by default. No additional steps are required to install Oracle XML DB. However, if you select the Advanced database configuration, then you can configure Oracle XML DB tablespace and FTP, HTTP(S), and WebDAV port numbers.

By default, DBCA performs the following tasks during installation:

- Creates an Oracle XML DB tablespace for Oracle XML DB Repository
- Enables all protocol access

The Oracle XML DB tablespace holds the data stored in Oracle XML DB Repository, including data stored using:

- SQL, for example using `RESOURCE_VIEW` and `PATH_VIEW`

- Protocols such as FTP, HTTP(S), and WebDAV

You can store data in tables outside this tablespace and access the data through Oracle XML DB Repository by having REFs to that data stored in the tables in this tablespace.

Caution: The Oracle XML DB tablespace should *not* be dropped. If dropped, then it renders *all* Oracle XML DB Repository data *inaccessible*.

See Also: "Anonymous Access to Oracle XML DB Repository using HTTP" on page 28-16 for information about allowing unauthenticated access to the repository

Dynamic Protocol Registration of FTP and HTTP(S) Services with Local Listener

Oracle XML DB installation, includes a dynamic protocol registration that registers FTP and HTTP(S) services with the local Listener. You can perform start, stop, and query with `lsnrctl`. For example:

- start: `lsnrctl start`
- stop: `lsnrctl stop`
- query: `lsnrctl status`

Changing FTP or HTTP(S) Port Numbers To change FTP and HTTP(S) port numbers, update elements `<ftp-port>`, `<http-port>`, and `<http2-port>` in file `/xdbconfig.xml` in the Oracle XML DB Repository.

After updating the port numbers, dynamic protocol registration automatically stops FTP/HTTP(S) service on old port numbers and starts them on new port numbers if the local Listener is up. If local Listener is not up, restart the Listener after updating the port numbers.

Note: You must either configure the port separately for each node of a Real Application Cluster (RAC) or configure it for one node and then restart the database instances on the other nodes. See "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5.

See Also: Chapter 28, "Using Protocols to Access the Repository" for information about configuring protocols

Post-installation As explained in the previous section, Oracle XML DB uses dynamic protocol registration to setup FTP and HTTP Listener services with the local Listener. So, make certain that the Listener is up when accessing Oracle XML DB protocols.

Note: If the Listener is running on a port that is not standard (for example, not 1521), then, in order for the protocols to register with the correct listener, the `init.ora` file must contain a `local_listener` entry. This references a `TNSNAME` entry that points to the correct Listener. After editing the `init.ora` parameter you must regenerate the `SPFILE` entry using `CREATE SPFILE`.

Installing Oracle XML DB Manually Without DBCA

You can install Oracle XML DB manually, by running the `catqm` SQL script in directory `rdbms/admin` as database user `SYS`. Before running the script, you must installing the database and create a new tablespace for Oracle XML DB Repository. Here is the syntax for `catqm`:

```
catqm.sql <XDB_password> <XDB_TS_NAME> <TEMP_TS_NAME>
#Create the tables and views needed to run Oracle XML DB
```

For example:

```
catqm.sql change_on_install XDB TEMP
```

Note: Make sure that the database is started with Oracle9*i* release 2 (9.2.0) compatibility or higher and Java Virtual Machine (JVM) is installed.

Post-Installation

After the manual installation, carry out these tasks:

1. Add the following dispatcher entry to the `init.ora` file:

   ```
   dispatchers="(PROTOCOL=TCP) (SERVICE=<sid>XDB)"
   ```

2. Restart the database and listener to enable Oracle XML DB protocol access.

   See Also: "Anonymous Access to Oracle XML DB Repository using HTTP" on page 28-16 for information about allowing unauthenticated access to the repository

Reinstalling Oracle XML DB

Caution: *All* user data stored in Oracle XML DB Repository is *lost* if you drop user `XDB`.

To reinstall Oracle XML DB follow these steps:

1. Remove the dispatcher by removing the Oracle XML DB dispatcher entry from the `init.ora` file as follows:

   ```
   dispatchers="(PROTOCOL=TCP) (SERVICE=<sid>XDB)"
   ```

   If the server parameter file is used, run the following command when the instance is up and while logged in as `SYS`:

   ```
   ALTER SYSTEM RESET dispatchers scope=spfile sid='*';
   ```

2. Drop user `XDB` and tablespace `XDB`, by connecting as user `SYS` and running the following SQL script:

   ```
   @?/rdbms/admin/catnoqm.sql
   ALTER TABLESPACE <XDB_TS_NAME> offline;
   DROP TABLESPACE <XDB_TS_NAME> including contents;
   ```

3. Re-create tablespace `XDB`.

4. Execute `catnoqm.sql`.
5. Shut down, then restart the database instance.
6. Execute `catqm.sql`.
7. Install Oracle XML DB manually as described in "Installing Oracle XML DB Manually Without DBCA" on page 34-3.

> **See Also:** *Oracle Database 2 Day + Security Guide* for information about database schema `XDB`

Upgrading an Existing Oracle XML DB Installation

The following considerations apply to all upgrades to Oracle Database 11*g*:

- Run script `catproc.sql`, as always.
- As a post-upgrade step, if you want Oracle XML DB functionality, then you must install Oracle XML DB manually as described in "Installing Oracle XML DB Manually Without DBCA" on page 34-3.
- ACL security: In releases prior to Oracle Database 11*g* Release 1, conflicts among ACEs for the same principal and same privilege were resolved by giving priority to any ACE that had child `deny`, whether or not preceding ACEs had child `grant`, that is, ACE order did not matter. In Oracle Database 11*g* this `deny-trumps-grant` behavior is still available, but it is not the default behavior.

> **See Also:** "ACL Evaluation Rules" on page 27-4 for information about conflicts among ACEs

Validation of ACL Documents and Configuration File

Access control list (ACL) documents are stored in table `XDB$ACL`. The Oracle XML DB configuration file, `xdbconfig.xml`, is stored in table `XDB$CONFIG`. Starting with Oracle Database 11*g* Release 1, these tables use the post-parse (binary XML) storage model. This implies that ACL documents and the configuration file are fully validated against their respective XML schemas. Validation takes place during upgrade, using your existing ACL documents and configuration file and the corresponding existing XML schemas.

If an ACL document fails to validate during upgrade, then the document is moved to table `XDB$INVALID_ACL`.

If validation of configuration file `xdbconfig.xml` fails during upgrade, then the file is saved in table `XDB$INVALID_CONFIG`, the default configuration file replaces it in table `XDB$CONFIG`, and the `XDB` component of the database is marked invalid. You must then start the database in normal mode and fix the `XDB` component, before trying to use the database.

To fix the `XDB` component, you can fix the invalid files to make them valid, and then call PL/SQL procedure `RecoverUpgrade`. After validating, this procedure moves the fixed files to tables `XDB$ACL` and `XDB$CONFIG`, and marks the `XDB` component valid.

As an option, you can call procedure `RecoverUpgrade` with parameter `use_default` set to `TRUE`, to abandon any invalid files. In this case, any valid files are moved to tables `XDB$ACL` and `XDB$CONFIG`, and any remaining invalid files are deleted. Default files are used in place of any invalid files: for ACLs, the default ACL document is used; for the configuration file, the default `xdbconfig.xml` is used (in which ACE order matters).

Caution: Use a `TRUE` value for parameter `use_default` *only* if you are certain that you no longer need the old ACL files or configuration file that are invalid. These files will be *deleted*.

Using Oracle Enterprise Manager to Administer Oracle XML DB

Oracle Enterprise Manager is a graphical tool supplied with Oracle Database that lets you perform database administration tasks easily. You can use it to perform the following tasks related to Oracle XML DB:

- Configure Oracle XML DB. View or edit parameters for the Oracle XML DB configuration file, `/xdbconfig.xml`.

  For information about configuring Oracle XML DB without using Oracle Enterprise Manager, see "Configuring Oracle XML DB Using xdbconfig.xml" on page 34-5.

- Search, create, edit, undelete Oracle XML DB Repository *resources* and their associated *access control lists* (ACLs).

  For information about creating and managing resources without using Oracle Enterprise Manager, see Part V, "Oracle XML DB Repository".

- Search, create, edit, and delete `XMLType` *tables* and *views*.

- Search, create, register, and delete *XML schemas*.

  For information about manipulating XML schemas without using Oracle Enterprise Manager, see Chapter 6, "XML Schema Storage and Query: Basic".

- Create *function-based indexes* based on XPath expressions.

  For information about creating function-based indexes without using Oracle Enterprise Manager, see Chapter 5, "Indexing XMLType Data".

  See Also: The online help available with Oracle Enterprise Manager, for information about using Enterprise Manager to perform these tasks

Configuring Oracle XML DB Using xdbconfig.xml

Oracle XML DB is managed internally through a configuration file, `/xdbconfig.xml`, which is stored as a resource in Oracle XML DB Repository. As an alternative to using Oracle Enterprise Manager to configure Oracle XML DB, you can configure it directly using the Oracle XML DB configuration file.

The configuration file can be modified at runtime. Updating the configuration file creates a new version of this repository resource. At the start of each session, the current version of the configuration file is bound to that session. The session uses this configuration-file version for its duration, unless you make an explicit call to refresh the session to the latest version.

Caution: You must update `xdbconfig.xml` separately for each node of a Real Application Cluster (RAC). Changes you make to `xdbconfig.xml` on one node are not automatically propagated to the other nodes of a cluster. You must propagate them yourself, which you can do in either of these ways:

- Update `xdbconfig.xml` on one node, and then restart the database instances on all other nodes.
- Update `xdbconfig.xml` separately on each node.

Oracle XML DB Configuration File, xdbconfig.xml

The configuration of Oracle XML DB is defined and stored in an Oracle XML DB Repository resource, `/xdbconfig.xml`, which conforms to the Oracle XML DB configuration XML schema: `http://xmlns.oracle.com/xdb/xdbconfig.xsd`. To configure or reconfigure Oracle XML DB, update file `/xdbconfig.xml`. Its structure is described in the following sections. You need administrator privileges to access file `/xdbconfig.xml`.

> **See Also:** "xdbconfig.xsd: XML Schema for Configuring Oracle XML DB" on page A-16 for a complete listing of the Oracle XML DB configuration XML schema

<xdbconfig> (Top-Level Element)

Element `<xdbconfig>` is the top-level element. Its structure is as follows:

```
<xdbconfig>
    <sysconfig> ... </sysconfig>
    <userconfig> ... </userconfig>
</xdbconfig>
```

Element `<sysconfig>` defines system-specific, built-in parameters. Element `<userconfig>` lets you store new custom parameters.

<sysconfig> (Child of <xdbconfig>)

Element `<sysconfig>` is a child of `<xdbconfig>`. Its structure is as follows:

```
<sysconfig>
    general parameters
    <protocolconfig> ... </protocolconfig>
</sysconfig>
```

Element `<sysconfig>` includes as content several general parameters that apply to all of Oracle XML DB, such as the maximum age of an access control list (ACL) and whether or not Oracle XML DB is case sensitive. Child `<protocolconfig>` contains protocol-specific parameters.

<userconfig> (Child of <xdbconfig>)

Element `<userconfig>` is a child of `<xdbconfig>`. It contains any parameters that you may want to add.

<protocolconfig> (Child of <sysconfig>)

Element `<protocolconfig>` is a child of `<sysconfig>`. Its structure is as follows:

```
<protocolconfig>
```

```
  <common> ... </common>
  <ftpconfig> ... </ftpconfig>
  <httpconfig> ... </httpconfig>
</protocolconfig>
```

Under <common>, Oracle Database stores parameters that apply to all protocols, such as MIME-type information. Parameters that are specific to protocols FTP and HTTP(S) are in elements <ftpconfig> and <httpconfig>, respectively.

> **See Also:** Chapter 28, "Using Protocols to Access the Repository", Table 28–1, Table 28–2, and Table 28–3, for a list of protocol configuration parameters

<httpconfig> (Child of <protocolconfig>)

Element <httpconfig> is a child of <protocolconfig>. Its structure is as follows:

```
<httpconfig>
  ...
  <webappconfig>
    ...
    <servletconfig>
      ...
      <servlet-list>
        <servlet> ... </servlet>
        ...
      </servlet-list>
    </servletconfig>
  </webappconfig>
  ...
  <plsql> ... </plsql>
</httpconfig>
```

Element <httpconfig> has the following child elements, in addition to others:

- <webappconfig> – used to configure Web-based applications. This includes Web application-specific parameters, such as icon name, display name for the application, and a list of servlets.

  Element <servletconfig> is a child of <webappconfig> that is used to define servlets. It has child <servlet-list>, which has child <servlet> (see "<servlet> (Descendant of <httpconfig>)" on page 34-8).

- <plsql>[1] – used to define global configuration parameters when configuring the *embedded PL/SQL gateway*. Each global parameter is defined with a child element of <plsql>. The element name is the same as the global parameter name; the element content is the same as the parameter value.

  The recommended way to configure the embedded PL/SQL gateway is to use the procedures in PL/SQL package DBMS_EPG, *not* to edit file xdbconfig.xml.

[1] There are two different <plsql> elements that are used to configure the embedded PL/SQL gateway. One is a child of <httpconfig>; it defines *global parameters*. The other is a child of <servlet>; it defines *DAD attributes*.

See Also:

- Chapter 28, "Using Protocols to Access the Repository", Table 28–1, Table 28–2, and Table 28–3, for a list of protocol configuration parameters
- *Oracle Database Advanced Application Developer's Guide*, for complete information on configuring and using the embedded PL/SQL gateway
- *Oracle Fusion Middleware Administrator's Guide for Oracle HTTP Server* for information about mod_plsql and conceptual information about using the PL/SQL gateway
- *Oracle Database PL/SQL Packages and Types Reference*, for information about package `DBMS_EPG`

<servlet> (Descendant of <httpconfig>)

An optional `<plsql>` element, child of `<servlet>`, configures the embedded PL/SQL gateway servlet. However, the *recommended* way to configure the embedded gateway is to use the procedures in PL/SQL package `DBMS_EPG`, *not* to edit file `xdbconfig.xml`.

Element `<plsql>` has a child element for each embedded PL/SQL DAD attribute[2] that is needed to configure the embedded gateway; all such children are optional. The element name is the same as the DAD attribute name; the element content is the same as the DAD-attribute value.

Element `<servlet>` is a descendent of `<httpconfig>` – see "<httpconfig> (Child of <protocolconfig>)" on page 34-7. It is used to configure servlets, including Java servlets and embedded PL/SQL gateway servlets.

See Also:

- Chapter 32, "Writing Oracle XML DB Applications in Java" for information about configuring Java servlets
- *Oracle Database Advanced Application Developer's Guide*, for complete information on configuring and using the embedded PL/SQL gateway
- *Oracle Database Application Express User's Guide*, for information about Oracle Application Express
- *Oracle Database PL/SQL Packages and Types Reference*, for information about package `DBMS_EPG`

Oracle XML DB Configuration File Example

The following is a sample Oracle XML DB configuration file:

Example 34–1 Oracle XML DB Configuration File

```
<xdbconfig xmlns="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="http://xmlns.oracle.com/xdb/xdbconfig.xsd
                                    http://xmlns.oracle.com/xdb/xdbconfig.xsd">
   <sysconfig>
```

[2] DAD is an abbreviation for Database Access Descriptor; DAD attributes are parameters that define such a descriptor.

```
<acl-max-age>900</acl-max-age>
<acl-cache-size>32</acl-cache-size>
<invalid-pathname-chars>,</invalid-pathname-chars>
<case-sensitive>true</case-sensitive>
<call-timeout>300</call-timeout>
<max-link-queue>65536</max-link-queue>
<max-session-use>100</max-session-use>
<persistent-sessions>false</persistent-sessions>
<default-lock-timeout>3600</default-lock-timeout>
<xdbcore-logfile-path>/sys/log/xdblog.xml</xdbcore-logfile-path>
<xdbcore-log-level>0</xdbcore-log-level>
<resource-view-cache-size>1048576</resource-view-cache-size>

<protocolconfig>
    <common>
       <extension-mappings>
          <mime-mappings>
            <mime-mapping>
              <extension>au</extension>
              <mime-type>audio/basic</mime-type>
            </mime-mapping>
            <mime-mapping>
              <extension>avi</extension>
              <mime-type>video/x-msvideo</mime-type>
            </mime-mapping>
            <mime-mapping>
              <extension>bin</extension>
              <mime-type>application/octet-stream</mime-type>
            </mime-mapping>
          </mime-mappings>

          <lang-mappings>
            <lang-mapping>
              <extension>en</extension>
              <lang>english</lang>
            </lang-mapping>
          </lang-mappings>

          <charset-mappings>
          </charset-mappings>

          <encoding-mappings>
            <encoding-mapping>
              <extension>gzip</extension>
              <encoding>zip file</encoding>
            </encoding-mapping>
            <encoding-mapping>
              <extension>tar</extension>
              <encoding>tar file</encoding>
            </encoding-mapping>
          </encoding-mappings>
       </extension-mappings>

       <session-pool-size>50</session-pool-size>
       <session-timeout>6000</session-timeout>
    </common>

    <ftpconfig>
      <ftp-port>2100</ftp-port>
      <ftp-listener>local_listener</ftp-listener>
```

```
      <ftp-protocol>tcp</ftp-protocol>
      <logfile-path>/sys/log/ftplog.xml</logfile-path>
      <log-level>0</log-level>
      <session-timeout>6000</session-timeout>
      <buffer-size>8192</buffer-size>
    </ftpconfig>

    <httpconfig>
      <http-port>8080</http-port>
      <http-listener>local_listener</http-listener>
      <http-protocol>tcp</http-protocol>
      <max-http-headers>64</max-http-headers>
      <session-timeout>6000</session-timeout>
      <server-name>XDB HTTP Server</server-name>
      <max-header-size>16384</max-header-size>
      <max-request-body>2000000000</max-request-body>
      <logfile-path>/sys/log/httplog.xml</logfile-path>
      <log-level>0</log-level>
      <servlet-realm>Basic realm="XDB"</servlet-realm>
      <webappconfig>
        <welcome-file-list>
          <welcome-file>index.html</welcome-file>
          <welcome-file>index.htm</welcome-file>
        </welcome-file-list>
        <error-pages>
        </error-pages>
        <servletconfig>
          <servlet-mappings>
            <servlet-mapping>
              <servlet-pattern>/oradb/*</servlet-pattern>
              <servlet-name>DBURIServlet</servlet-name>
            </servlet-mapping>
          </servlet-mappings>

          <servlet-list>
            <servlet>
              <servlet-name>DBURIServlet</servlet-name>
              <display-name>DBURI</display-name>
              <servlet-language>C</servlet-language>
              <description>Servlet for accessing DBURIs</description>
              <security-role-ref>
                <role-name>authenticatedUser</role-name>
                <role-link>authenticatedUser</role-link>
              </security-role-ref>
            </servlet>
          </servlet-list>
        </servletconfig>
      </webappconfig>
    </httpconfig>
  </protocolconfig>
  <xdbcore-xobmem-bound>1024</xdbcore-xobmem-bound>
  <xdbcore-loadableunit-size>16</xdbcore-loadableunit-size>
 </sysconfig>
</xdbconfig>
```

Oracle XML DB Configuration API

You can access the Oracle XML DB configuration file, `xdbconfig.xml`, the same way you access any other XML schema-based resource in the hierarchy. It can be accessed

using FTP, HTTP(S), WebDAV, Oracle Enterprise Manager, or any of the resource and Document Object Model (DOM) APIs for Java, PL/SQL, or C (OCI).

For convenience, you can use PL/SQL package `DBMS_XDB` package for configuration access. It exposes the following functions and procedures:

- `cfg_get` – Returns the configuration information for the current session.
- `cfg_refresh` – Refreshes the session configuration information using the current configuration file. Typical uses of `cfg_refresh` include the following:
  - You have modified the configuration and now want the session to pick up the latest version of the configuration information.
  - It has been a long running session, the configuration has been modified by a concurrent session, and you want the current session to pick up the latest version of the configuration information.
- `cfg_update` – Updates the configuration information, writing the configuration file. A `COMMIT` is performed.

Example 34–2 Updating the Configuration File Using CFG_UPDATE and CFG_GET

This example updates parameters `ftp-port` and `http-port` in the configuration file.

```
DECLARE
  v_cfg XMLType;
BEGIN
  SELECT updateXML(DBMS_XDB.cfg_get(),
                   '/xdbconfig/descendant::ftp-port/text()',
                   '2121',
                   '/xdbconfig/descendant::http-port/text()',
                   '19090')
    INTO v_cfg FROM DUAL;
  DBMS_XDB.cfg_update(v_cfg);
  COMMIT;
END;
/
```

If you have many parameters to update, then it can be easier to use FTP, HTTP(S), or Oracle Enterprise Manager to update the configuration.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Configuring Default Namespace to Schema Location Mappings

Oracle XML DB identifies schema-based `XMLType` instances by pre-parsing the input XML document. If the appropriate `xsi:schemaLocation` or `xsi:noNamespaceSchemaLocation` attribute is found, then the specified schema location URL is used to consult the registered schema. If the appropriate `xsi:` attribute is not found, the XML document is considered to be non-schema-based.

Oracle XML DB provides a mechanism to configure default schema location mappings. If the appropriate `xsi:` attribute is not specified in the XML document, the default schema location mappings will be used. Element `schemaLocation-mappings` of the Oracle XML DB configuration XML schema, `xdbconfig.xsd`, can be used to specify the mapping between *`(namespace, element)`* pairs and the default schema location. If the *`element`* value is empty, the mapping applies to all global elements in the specified namespace. If the *`namespace`* value is empty, it corresponds to the null namespace.

The definition of the `schemaLocation-mappings` element is as follows:

```
<element name="schemaLocation-mappings"
         type="xdbc:schemaLocation-mapping-type" minOccurs="0"/>

<complexType name="schemaLocation-mapping-type"><sequence>
     <element name="schemaLocation-mapping"
              minOccurs="0" maxOccurs="unbounded">
     <complexType><sequence>
       <element name="namespace" type="string"/>
       <element name="element" type="string"/>
       <element name="schemaURL" type="string"/>
     </sequence></complexType>
     </element></sequence>
</complexType>
```

The schema location used depends on mappings in the Oracle XML DB configuration file for the namespace used and the root document element. For example, assume that the document does not have the appropriate `xsi:` attribute to indicate the schema location. Consider a document root element *R* in namespace *N*. The algorithm for identifying the default schema location is as follows:

1. If the Oracle XML DB configuration file has a mapping for *N* and *R*, the corresponding schema location is used.
2. If the configuration file has a mapping for *N*, but not *R*, the schema location for *N* is used.
3. If the document root *R* does not have any namespace, the schema location for *R* is used.

For example, suppose that your Oracle XML DB configuration file includes the following mapping:

```
<schemaLocation-mappings>
   <schemaLocation-mapping>
      <namespace>http://www.oracle.com/example</namespace>
      <element>root</element>
      <schemaURL>http://www.oracle.com/example/sch.xsd</schemaURL>
   </schemaLocation-mapping>
   <schemaLocation-mapping>
      <namespace>http://www.oracle.com/example2</namespace>
      <element></element>
      <schemaURL>http://www.oracle.com/example2/sch.xsd</schemaURL>
   </schemaLocation-mapping>
   <schemaLocation-mapping>
     <namespace></namespace>
     <element>specialRoot</element>
     <schemaURL>http://www.oracle.com/example3/sch.xsd</schemaURL>
   </schemaLocation-mapping>
</schemaLocation-mappings>
```

The following schema locations are used:

- Namespace = `http://www.oracle.com/example`
  Root Element = `root`
  Schema URL = `http://www.oracle.com/example/sch.xsd`

  This mapping is used when the instance document specifies:

  ```
  <root xmlns="http://www.oracle.com/example">
  ```

- Namespace = `http://www.oracle.com/example2`
  Root Element = `null` (any global element in the namespace)
  Schema URL = `http://www.oracle.com/example2/sch.xsd`

  This mapping is used when the instance document specifies:

  ```
  <root xmlns="http://www.oracle.example2">
  ```

- Namespace = `null` (i.e null namespace)
  Root Element = `specialRoot`
  Schema URL = `http://www.oracle.com/example3/sch.xsd`

  This mapping is used when the instance document specifies:

  ```
  <specialRoot>
  ```

> **Note:** This functionality is available only on the server side, that is, when XML is parsed on the server. If XML is parsed on the client side, the appropriate `xsi:` attribute is still required.

Configuring XML File Extensions

Oracle XML DB Repository treats certain files as XML documents, based on their file extensions. When such files are inserted into the repository, Oracle XML DB pre-parses them to identify the schema location (or uses the default mapping if present) and inserts the document into the appropriate default table.

By default, the following extensions are considered as XML file extensions: **`xml`**, **`xsd`**, **`xsl`**, **`xlt`**. In addition, Oracle XML DB provides a mechanism for applications to specify other file extensions as XML file extensions. The **`xml-extensions`** element is defined in the configuration schema, `http://xmlns.oracle.com/xdb/xdbconfig.xsd`, as follows:

```
<element name="xml-extensions"
         type="xdbc:xml-extension-type" minOccurs="0"/>


<complexType name="xml-extension-type"><sequence>
     <element name="extension" type="xdbc:exttype"
              minOccurs="0" maxOccurs="unbounded">
     </element></sequence>
 </complexType>
```

For example, the following fragment from the Oracle XML DB configuration file, `xdbconfig.xml`, specifies that files with extensions `vsd`, `vml`, and `svgl` should be treated as XML files:

```
<xml-extensions>
  <extension>vsd</extension>
  <extension>vml</extension>
  <extension>svgl</extension>
</xml-extensions>
```

35

Loading XML Data Using SQL*Loader

This chapter describes how to load XML data into Oracle XML DB with a focus on SQL*Loader.

This chapter contains these topics:

- Overview of Loading XMLType Data Into Oracle Database
- Using SQL*Loader to Load XMLType Data
- Loading Very Large XML Documents into Oracle Database

See Also: Chapter 3, "Using Oracle XML DB"

Overview of Loading XMLType Data Into Oracle Database

In Oracle9*i* release 1 (9.0.1) and higher, the Export-Import utility and SQL*Loader support `XMLType` as a column type. Starting with Oracle Database 10*g*, SQL*Loader also supports loading `XMLType` tables. You can load `XMLType` data with SQL*Loader using either the conventional method or the direct-path method, regardless of how it is stored (structured, unstructured, or binary XML storage).

Note: For *structured storage* of XML data, if the data involves *inheritance* (extension or restriction) of XML Schema types, then SQL*Loader does *not* support direct-path loading.

That is, if an XML schema contains a `complexType` element that extends or restricts another `complexType` element (the base type), then this results in some SQL types being defined in terms of other SQL types. In this case, direct-path loading is not supported for object-relational storage.

See Also: *Chapter 36, "Exporting and Importing XMLType Tables"* and *Oracle Database Utilities*

Oracle XML DB Repository information is *not* exported when user data is exported. This means that neither the resources nor any information are exported.

Using SQL*Loader to Load XMLType Data

XML columns are columns declared to be of type `XMLType`.

SQL*Loader treats XMLType columns and tables like object-relational columns and tables. All methods described in the following sections for loading LOB data from the primary datafile or from a LOBFILE value also apply to loading XMLType columns and tables when the XMLType data is stored as a LOB.

See Also: *Oracle Database Utilities*

Note: You cannot specify a SQL string for LOB fields. This is true even if you specify LOBFILE_spec.

XMLType data can be present in a control file or in a LOB file. In the former case, the LOB file name is present in the control file.

Because XMLType data can be quite large, SQL*Loader can load LOB data from either a primary datafile (in line with the rest of the data) or from LOB files, independent of how the data is stored (the underlying storage can, for example, still be object-relational). This section addresses the following topics:

- Loading XMLType Data from a Primary Datafile
- Loading XMLType Data from an External LOBFILE (BFILE)
- Loading XMLType Data from LOBFILEs
- Loading XMLType Data from a Primary Datafile

Using SQL*Loader to Load XMLType Data in LOBs

To load internal LOBs, Binary Large Objects (BLOBs), Character Large Objects (CLOBs), and National Character Large Object (NCLOBs), or XMLType columns and tables from a primary datafile, use the following standard SQL*Loader formats:

- Predetermined size fields
- Delimited fields
- Length-value pair fields

These formats are described in the following sections and in more detail in *Oracle Database Utilities.*

Loading LOB Data in Predetermined Size Fields

This is a very fast and conceptually simple format to load LOBs.

Note: Because the LOBs you are loading might not be of equal size, you can use whitespace to pad the LOB data to make the LOBs all of equal length within a particular data field.

Loading LOB Data in Delimited Fields

This format handles LOBs of different sizes within the same column (datafile field) without problem. However, this added flexibility can affect performance, because SQL*Loader must scan through the data, looking for the delimiter string.

As with single-character delimiters, when you specify string delimiters, you should consider the character set of the datafile. When the character set of the datafile is different than that of the control file, you can specify the delimiters in hexadecimal (that is, hexadecimal string). If the delimiters are specified in hexadecimal notation,

then the specification must consist of characters that are valid in the character set of the input datafile. In contrast, if hexadecimal specification is not used, then the delimiter specification is considered to be in the client (that is, the control file) character set. In this case, the delimiter is converted into the datafile character set before SQL*Loader searches for the delimiter in the datafile.

Loading XML Columns Containing LOB Data from LOBFILEs

LOB data can be lengthy enough so that it makes sense to load it from a LOBFILE instead of from a primary datafile. In LOBFILEs, LOB data instances are still considered to be in fields (predetermined size, delimited, length-value), but these fields are not organized into records (the concept of a record does not exist within LOBFILEs). Therefore, the processing overhead of dealing with records is avoided. This type of organization of data is ideal for LOB loading.

There is no requirement that a LOB from a LOBFILE fit in memory. SQL*Loader reads LOBFILEs in 64 KB chunks.

In LOBFILEs the data can be in any of the following types of fields, any of which can be used to load XML columns:

- A single LOB field into which the entire contents of a file can be read
- Predetermined size fields (fixed-length fields)
- Delimited fields (that is, `TERMINATED BY` or `ENCLOSED BY`)

  The clause `PRESERVE BLANKS` is not applicable to fields read from a LOBFILE.
- Length-value pair fields (variable-length fields).

  To load data from this type of field, use the `VARRAY`, `VARCHAR`, or `VARCHAR2` SQL*Loader data types.

Specifying LOBFILEs

You can specify LOBFILEs either statically (you specify the name of the file) or dynamically (you use a FILLER field as the source of the filename). In either case, when the EOF of a LOBFILE is reached, the file is closed and additional attempts to read data from that file produce results equivalent to reading data from an empty field.

You should not specify the same LOBFILE as the source of two different fields. If you do so, then typically, the two fields will read the data independently.

Using SQL*Loader to Load XMLType Data Directly From the Control File

`XMLType` data can be loaded directly from the control file itself. In this release, SQL*Loader treats `XMLType` data like any other scalar type. For example, consider a table containing a `NUMBER` column followed by an `XMLType` column stored object-relationally. The control file used for this table can contain the value of the `NUMBER` column followed by the value of the `XMLType` instance.

SQL*Loader also accommodates `XMLType` instances that are very large. In this case you also have the option to load the data from a LOB file.

Loading Very Large XML Documents into Oracle Database

You can use SQL*Loader to load large amounts of XML data into Oracle Database.

See Also: Chapter 3, "Using Oracle XML DB", "Loading Large XML Files Using SQL*Loader" on page 3-9

Example 35–1 illustrates how to load XMLType data into Oracle Database.

Example 35–1 Loading Very Large XML Documents Into Oracle Database Using SQL*Loader

This example uses the control file, load_data.ctl to load XMLType data into table foo. The code registers the XML schema, person.xsd, in Oracle XML DB, and then creates table foo. You can alternatively create the table within the XML schema registration process.

```
CREATE TYPE person_t AS OBJECT(name VARCHAR2(100), city VARCHAR2(100));
/
BEGIN
  -- Delete schema if it already exists (else error)
  DBMS_XMLSCHEMA.deleteSchema('http://www.oracle.com/person.xsd', 4);
END;
/
BEGIN
  DBMS_XMLSCHEMA.registerschema('http://www.oracle.com/person.xsd',
    '<schema xmlns="http://www.w3.org/2001/XMLSchema"' ||
           ' xmlns:per="http://www.oracle.com/person.xsd"' ||
           ' xmlns:xdb="http://xmlns.oracle.com/xdb"' ||
           ' elementFormDefault="qualified"' ||
           ' targetNamespace="http://www.oracle.com/person.xsd">' ||
     ' <element name="person" type="per:persontype"' ||
             ' xdb:SQLType="PERSON_T"/>' ||
     ' <complexType name="persontype" xdb:SQLType="PERSON_T">' ||
       ' <sequence>' ||
         ' <element name="name" type="string" xdb:SQLName="NAME"' ||
                 ' xdb:SQLType="VARCHAR2"/>' ||
         ' <element name="city" type="string" xdb:SQLName="CITY"' ||
                 ' xdb:SQLType="VARCHAR2"/>' ||
       ' </sequence>' ||
     ' </complexType>' ||
   ' </schema>',
    TRUE,
    FALSE,
    FALSE);
END;
/
CREATE TABLE foo OF XMLType
  XMLSCHEMA "http://www.oracle.com/person.xsd" ELEMENT "person";
```

Here is the content of the control file, load_data.ctl, for loading XMLType data using the registered XML schema, person.xsd:

```
LOAD DATA
INFILE *
INTO TABLE foo TRUNCATE
XMLType(xmldata)
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"'
(
xmldata
)
BEGINDATA
<person xmlns="http://www.oracle.com/person.xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

```
xsi:schemaLocation="http://www.oracle.com/person.xsd
http://www.oracle.com/person.xsd"> <name> xyz name 2</name> </person>
```

Here is the SQL*Loader command for loading the XML data into Oracle Database:

```
sqlldr [username]/[password] load_data.ctl (optional: direct=y)
```

In `load_data.ctl`, the data is present in the control file itself, and a record spanned only one line (it is split over several lines here, for printing purposes).

In the following example, the data is present in a separate file, `person.dat`, from the control file, `lod2.ctl`. File `person.dat` contains more than one row, and each row spans more than one line. Here is the control file, `lod2.ctl`:

```
LOAD DATA
INFILE *
INTO TABLE foo TRUNCATE
XMLType(xmldata)
FIELDS(fill filler CHAR(1),
       xmldata LOBFILE (CONSTANT person.dat)
       TERMINATED BY '<!-- end of record -->')
BEGINDATA
0
0
0
```

The three zeroes (`0`) after `BEGINDATA` indicate that three records are present in the data file, `person.dat`. Each record is terminated by `<!-- end of record -->`. The contents of `person.dat` are as follows:

```
<person xmlns="http://www.oracle.com/person.xsd"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.oracle.com/person.xsd
                            http://www.oracle.com/person.xsd">
  <name>xyz name 2</name>
</person>
<!-- end of record -->
<person xmlns="http://www.oracle.com/person.xsd"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.oracle.com/person.xsd
                            http://www.oracle.com/person.xsd">
  <name> xyz name 2</name>
</person>
<!-- end of record -->
<person xmlns="http://www.oracle.com/person.xsd"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.oracle.com/person.xsd
                            http://www.oracle.com/person.xsd">
  <name>xyz name 2</name>
</person>
<!-- end of record -->
```

Here is the SQL*Loader command for loading the XML data into Oracle Database:

```
sqlldr [username]/[password] lod2.ctl (optional: direct=y)
```

36

Exporting and Importing XMLType Tables

This chapter describes how you can export and import `XMLType` tables for use with Oracle XML DB using Oracle Data Pump.

> **Note:** The original Export and Import utilities are still supported in Oracle Database 11g Release 1 (11.1) for migrating data from release 11.1 to versions prior to it.

This chapter discusses the following topics:

Overview of Oracle Data Pump

Oracle Data Pump technology enables high-speed movement of data and metadata from one database to another. Oracle Data Pump has two command-line clients, `expdp` and `impdp`, that invoke Data Pump Export utility and Data Pump Import utility, respectively. The `expdp` and `impdp` clients use procedures provided in PL/SQL package `DBMS_DATAPUMP` to execute export and import commands, passing the parameters entered at the command-line. These parameters enable the exporting and importing of data and metadata for a complete database or subsets of a database.

The new Data Pump Export and Import utilities (invoked with `expdp` and `impdp` commands, respectively) have a similar look and feel to the original Export (`exp`) and Import (`imp`) utilities, but they are completely separate.

> **See Also:** "Original Export and Import" in Oracle Database Utilities, for information about situations in which you should still use the original Export and Import utilities.

Data Pump Export utility (invoked with `expdp`) unloads data and metadata into a set of operating system files called a *dump file set*. The dump file set can be imported only by the Data Pump Import utility (invoked with `impdp`).

EXPORT/IMPORT Support in Oracle XML DB

Oracle XML DB supports export and import of `XMLType` tables and columns that store XML data.

You can export and import this data regardless of the `XMLType` storage format (structured, unstructured, or binary XML). However, Data Pump exports and imports XML data as text or binary XML data only. The underlying object-relational tables and columns used for structured storage of `XMLType` are thus not exported. Instead, they are converted to binary form and then exported as self-describing binary XML data. `XMLType` data stored as `CLOB` instances (unstructured storage) is exported as text.

> **Note:** Oracle Data Pump for Oracle Database 11g Release 1 (11.1) does not support the export of XML schemas, XML schema-based `XMLType` columns, or binary XML data to database releases prior to 11.1.

Regardless of the export format, the format of the dump file will be either `CLOB` or self-describing binary XML with a token map preamble. How Oracle Data Pump stores this data in the dump file depends on the value of the export parameter, `data_options` (the only valid value for this parameter is `xml_clobs`.) If you specify this value on the export command line, all `XMLType` data will be stored in text format in the dump file. If you do not specify the `xml_clobs` parameter in the `expdp` command, then the format of the `XMLType` columns in the table determines the format of the data in the dump file. Table 36–1 shows the format of the `XMLType` columns in the table with the corresponding format of the dump file.

Table 36–1 Format of the XMLType columns in the table with the corresponding format of the dump file

Storage Model of XMLType Columns	Dump File Format of XML Data
Unstructured storage	Text
Structured storage, binary XML storage, or hybrid storage (a mixture of unstructured and structured storage)	Self-describing binary XML

Since `XMLType` data is exported and imported as XML data, the source and target databases can use different `XMLType` storage models for that data. This means that you can export data from a database that stores `XMLType` data one way and import it into a database that stores `XMLType` data a different way.

Exporting XML Schema-Based XMLType Tables

You can export `XMLType` tables, whether they are XML schema-based or not. If a table is XML schema-based, then it depends on the XML schema used to define its data. This XML schema can also have dependencies on SQL object types that are used to store the data, in the case of structured storage. Therefore, exporting a user who has XML schema-based `XMLType` tables also exports the following:

- SQL objects types (if structured storage was used)
- XML schemas
- XML tables

Exporting Hierarchy-Enabled (Repository) Tables

The following guidelines apply to exporting hierarchy-enabled tables, that is, tables that underly Oracle XML DB Repository data:

- The row-level security (RLS) policies and path-index triggers are not exported for hierarchy-enabled tables. When these tables are imported, they are *not* hierarchy-enabled.
- Hidden columns `ACLOID` and `OWNERID` are *not* exported for these tables. In an imported database the values of these columns could be different, so they should be reinitialized.

> **See Also:** "Interaction with Database Table Security" on page 27-7 for information about RLS policies and path-index triggers

Exporting and Importing Transportable Tablespaces

Using the *transportable tablespace* feature, you can move a set of tablespaces from one Oracle database to another, whether it is XML schema-based or non-schema-based. When you export using transportable tablespaces mode, only the metadata for tables (and their dependent objects) within a specified set of tablespaces are unloaded. You can then copy the tablespace data files to another Oracle database and perform a transport tablespace import. This is generally very fast, because it involves only copying the tablespace and re-creating the tablespace metadata.

Use `TRANSPORT_TABLESPACES` parameter in `expdp` to specify a list of tablespace names for which the object metadata will be exported from the source database to the target database.

You cannot export transportable tablespaces and import them to a database at a lower release level. The target database must be at the same or higher release level as the source database.

When *exporting*, Oracle XML DB Repository hierarchy information is lost (see "Exporting Hierarchy-Enabled (Repository) Tables" on page 36-3). When *importing*, any XML schemas referenced by the data to be imported are also imported.

Repository Resources and Foldering Support

Oracle XML DB supports a *foldering mechanism* that helps store content in the database in hierarchical structures, as opposed to traditional relational database structures. Foldering lets you use path names and URIs to refer to data (repository resources), rather than table names, column names, and so on. This foldering mechanism is not entirely supported using `expdp/impdp`.

However, for resources based on a registered XML schema, the `XMLType` tables storing the data can be exported and imported. During export, only the XML data is exported, the relationship in the Oracle XML DB foldering hierarchy is lost.

Full Database Export

Oracle XML DB stores the metadata (and data unrelated to XML Schema) for Oracle XML DB Repository in database schema (user account) `XDB`. Because Oracle Database does not export the repository structure, these metadata tables and structures are not exported during a full database export.

The entire database schema (user) `XDB` is skipped during a full database export, and any database objects owned by user `XDB` are not exported.

Exporting and Importing with Different Character Sets

As with other database objects, XML data is exported in the character set of the exporting server. During import, the data gets converted to the character set of the importing server.

Export/Import Syntax and Examples

Export and import using Oracle Data Pump is described in *Oracle Database Utilities*. This section includes additional guidelines and examples for using `expdp/impdp` with `XMLType` data. For tables with `XMLType` data stored as `CLOB`, Oracle Data Pump exports and imports the tables in the same way as it would do for any table.

Performing a Table-Mode Export /Import

An `XMLType` table has a dependency on the XML schema that was used to define it. Similarly, the XML schema has dependencies on the SQL object types created or specified for it. Importing an `XMLType` table requires the existence of the XML schema and the SQL object types. When a `TABLE` mode export is used, only the table related metadata and data are exported. To be able to import this data successfully, the user needs to ensure that both the XML schema and object types have been created.

The examples here assume that you are using a database with the following features:

- A database with a sample schema
- A table `foo` with an `XMLType` column in unstructured (`CLOB`) storage format
- A directory object `dpump_dir`, for which `READ` and `WRITE` privileges have been granted to the sample schema

Example 36–1 shows a table-mode export, specified using the `TABLES` parameter. It exports table `foo` to `foo.dmp` dump file.

Example 36–1 Exporting XMLType Data in TABLE Mode

```
expdp system/manager directory=dpump_dir dumpfile=foo.dmp tables=foo
```

> **Note:** In table-mode, if you do not specify a schema prefix in the `expdp` command, the schema of the exporter is used by default.

Example 36–2 shows a table-mode import. It imports table `foo` from the `foo.dmp` dump file.

Example 36–2 Importing XMLType Data in TABLE Mode

```
impdp system/manager tables=foo directory=dpump_dir dumpfile=foo.dmp table_exists_action=append
```

If a table by the name `foo` already exists at the time of this import, then parameter `table_exists_action` appends rows at the end of the existing table. When you use `APPEND`, the data is always loaded into new space; existing space, even if available, is not reused. For this reason, you might need to compress your data after the load.

> **Note:** See, "Oracle Database Utilities", for more information about Oracle Data Pump and its command-line clients, `expdp` and `impdp`.

Performing a Schema-Mode Export/Import

When performing a Schema mode export, if you have role EXP_FULL_DATABASE, then you can export a database schema, the database schema definition, and the system grants and privileges of that database schema.

The example here assumes that you are using a database with the following features:

- User x4a has created a table po2.
- User x4a has a registered XML schema, ipo, which created two ordered collection tables item_oct2 and sitem_nt2.

User x4a creates table po2 as shown in Example 36–3.

Example 36–3 Creating Table po2

```
CREATE TABLE po2(po XMLType)
  XMLTYPE COLUMN po
  XMLSCHEMA "ipo.xsd"
  ELEMENT "purchaseOrder"
  VARRAY po.XMLDATA."items"."item"
    STORE AS TABLE item_oct2 ((PRIMARY KEY(NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
      NESTED TABLE po.XMLDATA."shippedItems"."item" STORE AS sitem_nt2;
```

Table po2 is then populated and exported, as shown in Example 36–4.

Example 36–4 Exporting XMLType Data in SCHEMA Mode

```
expdp x4a/x4a directory=tkxm_xmldir dumpfile=x4a.dmp
```

Example 36–4 exports all of the following:

- All data types that were generated during registration of XML schema ipo.
- XML schema ipo.
- Table po2 and the ordered collection tables item_oct2 and sitem_nt2, which were generated during registration of XML schema ipo.
- All data in all of those tables.

Example 36–5 Importing XMLType Data in SCHEMA Mode

```
impdp x4a/x4a directory=tkxm_xmldir dumpfile=x4a.dmp
```

Example 36–5 imports all of the data in x4a.dmp to another database, in which the user x4a already exists.

Example 36–6 does the same thing as Example 36–5, but it also remaps the database schema from user x4a to user quine.

Example 36–6 Importing XMLType Data in SCHEMA Mode, Remapping Schema

```
impdp x4a/x4a directory=tkxm_xmldir dumpfile=x4a.dmp remap_schema=x4a:quine
```

Example 36–6 imports all of the data in x4a.dmp (exported from the database schema of user x4a) into database schema quine. To remap the database schema, user x4a must have been granted role IMP_FULL_DATABASE on the local database and role EXP_FULL_DATABASE on the source database. REMAP_SCHEMA loads all of the objects from the source schema into the target schema.

37

Exchanging XML Data with Oracle Streams AQ

Oracle Streams Advanced Queuing (AQ) provides database integrated message queuing functionality:

- It enables and manages asynchronous communication of two or more applications using messages
- It supports point-to-point and publish/subscribe communication models

Integration of message queuing with Oracle Database brings the integrity, reliability, recoverability, scalability, performance, and security features of Oracle Database to message queuing. It also facilitates the extraction of intelligence from message flows.

This chapter describes how XML data can be exchanged using AQ. It contains these topics:

How Do AQ and XML Complement Each Other?

XML has emerged as a standard format for business communications. XML is being used not only to represent data communicated between business applications, but also, the business logic that is encapsulated in the XML.

In Oracle Database, AQ supports native XML messages and also lets AQ operations be defined in the XML-based Internet-Data-Access-Presentation (iDAP) format. iDAP, an extensible message invocation protocol, is built on Internet standards, using HTTP(S) and email protocols as the transport mechanism, and XML as the language for data presentation. Clients can access AQ using this.

AQ and XML Message Payloads

Figure 37–1 shows an Oracle Database using AQ to communicate with three applications, with XML as the message payload. The general tasks performed by AQ in this scenario are:

- Message flow using subscription rules
- Message management
- Extracting business intelligence from messages
- Message transformation

This is an *intra*- and *inter*-business scenario where XML messages are passed asynchronously among applications using AQ.

- Intra-business. Typical examples of this kind of scenario include sales order fulfillment and supply-chain management.
- Inter-business processes. Here multiple integration hubs can communicate over the Internet backplane. Examples of inter-business scenarios include travel reservations, coordination between manufacturers and suppliers, transferring of funds between banks, and insurance claims settlements, among others.

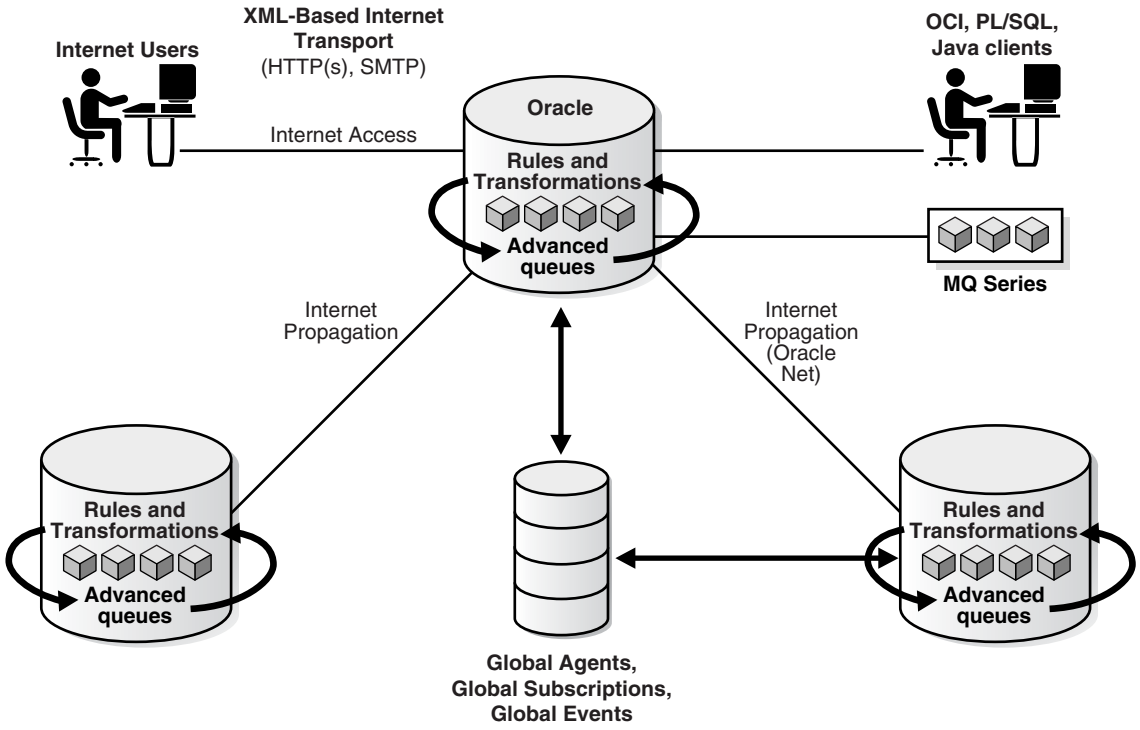
  Oracle uses this in its enterprise application integration products. XML messages are sent from applications to an Oracle AQ hub. This serves as a message server for any application that wants the message. Through this hub-and-spoke architecture, XML messages can be communicated asynchronously to multiple loosely coupled receiving applications.

Figure 37–1 shows XML payload messages transported using AQ in the following ways:

- Web-based application that uses an AQ operation over an HTTP(S) connection using iDAP
- An application that uses AQ to propagate an XML message over a Net* connection
- An application that uses AQ to propagate an Internet or XML message directly to the database over HTTP(S) or SMTP

The figure also shows that AQ clients can access data using OCI, Java, or PL/SQL.

Figure 37–1 Oracle Streams Advanced Queuing and XML Message Payloads



AQ Enables Hub-and-Spoke Architecture for Application Integration

A critical challenge facing enterprises today is application integration. Application integration means getting multiple departmental applications to cooperate, coordinate, and synchronize to carry out complex business transactions.

AQ enables hub-and-spoke architecture for application integration. It makes integrated solution easy to manage, easy to configure, and easy to modify with changing business needs.

Messages Can Be Retained for Auditing, Tracking, and Mining

Message management provided by AQ is not only used to manage the flow of messages between different applications, but also, messages can be retained for future auditing and tracking, and extracting business intelligence.

Viewing Message Content with SQL Views

AQ also provides SQL views to look at the messages. These SQL views can be used to analyze the past, current, and future trends in the system.

Advantages of Using AQ

AQ provides the flexibility of *configuring communication* between different applications.

Oracle Streams and AQ

Oracle Streams (Streams) enables you to share data and events in a stream. The stream can propagate this information within a database or from one database to another. The stream routes specified information to specified destinations. This provides greater

functionality and flexibility than traditional solutions for capturing and managing events, and sharing the events with other databases and applications.

Streams enables you to break the cycle of trading off one solution for another. It enable you to build and operate distributed enterprises and applications, data warehouses, and high availability solutions. You can use all the capabilities of Oracle Streams at the same time.

You can use Streams to:

- *Capture changes at a database.* You can configure a background capture process to capture changes made to tables, database schemas, or the entire database. A capture process captures changes from the redo log and formats each captured change into a logical change record (LCR). The database where changes are generated in the redo log is called the source database.
- *Enqueue events into a queue.* Two types of events may be staged in a Streams queue: LCRs and user messages. A capture process enqueues LCR events into a queue that you specify. The queue can then share the LCR events within the same database or with other databases. You can also enqueue user events explicitly with a user application. These explicitly enqueued events can be LCRs or user messages.
- *Propagate events from one queue to another.* These queues may be in the same database or in different databases.
- *Dequeue events.* A background apply process can dequeue events. You can also dequeue events explicitly with a user application.
- *Apply events at a database.* You can configure an apply process to apply all of the events in a queue or only the events that you specify. You can also configure an apply process to call your own PL/SQL subprograms to process events.

  The database where LCR events are applied and other types of events are processed is called the destination database. In some configurations, the source database and the destination database may be the same.

Streams Message Queuing

Streams lets user applications:

- Enqueue messages of different types
- Propagate messages are ready for consumption
- Dequeue messages at the destination database

Streams introduces a new type of queue that stages messages of `SYS.AnyData` type. Messages of almost any type can be wrapped in a `SYS.AnyData` wrapper and staged in `SYS.AnyData` queues. Streams interoperates with Advanced Queuing (AQ), which supports all the standard features of message queuing systems, including multiconsumer queues, publishing and subscribing, content-based routing, internet propagation, transformations, and gateways to other messaging subsystems.

> **See Also:** *Oracle Streams Concepts and Administration,* and its Appendix A, "XML Schema for LCRs".

XMLType Attributes in Object Types

You can create queues that use Oracle object types containing `XMLType` attributes. These queues can be used to transmit and store messages that are XML documents. Using `XMLType`, you can do the following:

- Store any type of message in a queue
- Store documents internally as `CLOB` values
- Store more than one type of payload in a queue
- Query `XMLType` columns using functions like `existsNode`
- Specify the operators in subscriber rules or dequeue selectors

Internet Data Access Presentation (iDAP)

You can access AQ over the Internet by using SOAP. Internet Data Access Presentation (iDAP) is the SOAP specification for AQ operations. iDAP defines XML message structure for the body of the SOAP request. An iDAP-structured message is transmitted over the Internet using transport protocols such as HTTP(S) and SMTP.

iDAP uses the `text/xml` content type to specify the body of the SOAP request. XML provides the presentation for iDAP request and response messages as follows:

- All request and response tags are scoped in the SOAP namespace.
- AQ operations are scoped in the iDAP namespace.
- The sender includes namespaces in iDAP elements and attributes in the SOAP body.
- The receiver processes iDAP messages that have correct namespaces; for the requests with incorrect namespaces, the receiver returns an invalid request error.
- The SOAP namespace has this value:
  `http://schemas.xmlsoap.org/soap/envelope/`
- The iDAP namespace has this value:
  `http://ns.oracle.com/AQ/schemas/access`

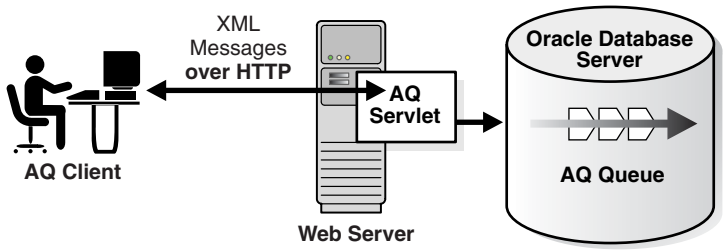
See Also: *Oracle Streams Advanced Queuing User's Guide*

iDAP Architecture

Figure 37–2 shows the following components needed to send HTTP(S) messages:

- A client program that sends XML messages, conforming to iDAP format, to the AQ Servlet. This can be any HTTP client, such as Web browsers.
- The Web server or `ServletRunner` which hosts the AQ servlet that can interpret the incoming XML messages, for example, Apache/Jserv or Tomcat.
- Oracle Server/Database. Oracle Streams AQ servlet connects to Oracle Database to perform operations on your queues.

Figure 37–2 iDAP Architecture for Performing AQ Operations Using HTTP(S)



XMLType Queue Payloads

You can create queues with payloads that contain `XMLType` attributes. These can be used for transmitting and storing messages that contain XML documents. By defining Oracle objects with `XMLType` attributes, you can do the following:

- Store more than one type of XML document in the same queue. The documents are stored internally as `CLOB` instances.
- Selectively dequeue messages with `XMLType` attributes using the SQL functions such as `existsNode` and `extract`.
- Define transformations to convert Oracle objects to `XMLType`.
- Define rule-based subscribers that query message content using `XMLType` methods such as `existsNode()` and `extract()`.

Example 37–1 XMLType and AQ: Creating a Table and Queue, and Transforming Messages

In the BooksOnline application, assume that the Overseas Shipping site represents an order using `SYS.XMLType`. The Order Entry site represents an order as an Oracle object, `ORDER_TYP`.

The Overseas queue table and queue are created as follows:

```
BEGIN
  DBMS_AQADM.create_queue_table(
    queue_table        => 'OS_orders_pr_mqtab',
    comment            => 'Overseas Shipping MultiConsumer Orders queue table',
    multiple_consumers => TRUE,
    queue_payload_type => 'SYS.XMLTtype',
    compatible         => '8.1');
END;
BEGIN
  DBMS_AQADM.create_queue(queue_name   => 'OS_bookedorders_que',
                          queue_table  => 'OS_orders_pr_mqtab');
END;
```

Because the representation of orders at the overseas shipping site is different from the representation of orders at the order-entry site, a transformation is applied before messages are propagated from the order entry site to the overseas shipping site.

```
/* Add a rule-based subscriber for overseas shipping to the booked-orders
   queues with transformation. Overseas Shipping handles orders outside the US. */
DECLARE
  subscriber AQ$_AGENT;
BEGIN
  subscriber := AQ$_AGENT('Overseas_Shipping', 'OS.OS_bookedorders_que', null);
  DBMS_AQADM.add_subscriber(
```

```
    queue_name     => 'OE.OE_bookedorders_que',
    subscriber     => subscriber,
    rule           => 'tab.user_data.orderregion = ''INTERNATIONAL''',
    transformation => 'OS.OE2XML');
END;
```

For more details on defining transformations that convert the type used by the order entry application to the type used by Overseas Shipping, see *Oracle Streams Advanced Queuing User's Guide* the section on Creating Transformations in Chapter 8.

Example 37–2 XMLType and AQ: Dequeuing Messages

Assume that an application processes orders for customers in Canada. This application can dequeue messages using the following procedure:

```
/* Create procedure to enqueue into single-consumer queues: */
CREATE OR REPLACE PROCEDURE get_canada_orders() AS
  deq_msgid             RAW(16);
  dopt                  DBMS_AQ.dequeue_options_t;
  mprop                 DBMS_AQ.message_properties_t;
  deq_order_data        SYS.XMLTtype;
  no_messages           EXCEPTION;
  PRAGMA EXCEPTION_INIT (no_messages, -25228);
  new_orders            BOOLEAN := TRUE;
BEGIN
  dopt.wait := 1;
  /* Specify dequeue condition to select Orders for Canada */
  dopt.deq_condition :=
    'tab.user_data.extract(
       ''/ORDER_TYP/CUSTOMER/COUNTRY/text()'').getStringVal()=''CANADA''';
  dopt.consumer_name : = 'Overseas_Shipping';
  WHILE (new_orders) LOOP
    BEGIN
      DBMS_AQ.dequeue(queue_name         => 'OS.OS_bookedorders_que',
                      dequeue_options    => dopt,
                      message_properties => mprop,
                      payload            => deq_order_data,
                      msgid              => deq_msgid);
      COMMIT;
      DBMS_OUTPUT.put_line('Order for Canada - Order: ' ||
                           deq_order_data.getStringVal());
    EXCEPTION
      WHEN no_messages THEN
        DBMS_OUTPUT.put_line (' ---- NO MORE ORDERS  ---- ');
        new_orders := FALSE;
    END;
  END LOOP;
END;
CREATE TYPE mypayload_type as OBJECT (xmlDataStream CLOB, dtd CLOB, pdf BLOB);
```

Guidelines for Using XML and Oracle Streams Advanced Queuing

This section describes guidelines for using XML and Oracle Streams Advanced Queuing.

Storing Oracle Streams AQ XML Messages with Many PDFs as One Record?

You can exchange XML documents between businesses using Oracle Streams Advanced Queuing, where each message received or sent includes an XML header,

XML attachment (XML data stream), DTDs, and PDF files, and store the data in a database table, such as a `queuetable`. You can enqueue the messages into Oracle queue tables as one record or piece. Or you can enqueue the messages as multiple records, such as one record for XML data streams as `CLOB` type, one record for PDF files as `RAW` type, and so on. You can also then dequeue the messages.

You can achieve this in the following ways:

- By defining an object type with (`CLOB`, `RAW`,...) attributes, and storing it as a single message.
- By using the AQ message grouping feature and storing it in multiple messages. Here the message properties are associated with a group. To use the message grouping feature, all messages must be the same payload type.

To specify the payload, first create an object type, for example:

```
CREATE TYPE mypayload_type as OBJECT (xmlDataStream CLOB, dtd CLOB, pdf BLOB);
```

then store it as a single message.

Adding New Recipients After Messages Are Enqueued

You can use the queue table to support message assignments. For example, when other businesses send messages to a specific company, they do not know who should be assigned to process the messages, but they know the messages are for Human Resources (HR) for example. Hence all messages will go to the HR supervisor. At this point, the message is enqueued in the queue table. The HR supervisor is the only recipient of this message, and the entire HR staff have been pre-defined as subscribers for this queue.

You cannot change the recipient list after the message is enqueued. If you do not specify a recipient list then subscribers can subscribe to the queue and dequeue the message. Here, new recipients must be subscribers to the queue. Otherwise, you have to dequeue the message and enqueue it again with new recipients.

Enqueuing and Dequeuing XML Messages?

Oracle Streams AQ supports enqueuing and dequeuing objects. These objects can have an attribute of type `XMLType` containing an XML document, as well as other interested "factored out" metadata attributes that may be useful to send along with the message. Refer to the latest AQ document, *Oracle Streams Advanced Queuing User's Guide* to get specific details and see more examples.

Parsing Messages with XML Content from Oracle Streams AQ Queues

You may want to parse messages with XML content, from an Oracle Streams AQ queue and then update tables and fields in an ODS (Operational Data Store), in other words you may want to retrieve and parse XML documents, then map specific fields to database tables and columns. To get metadata such as AQ enqueue or dequeue times, JMS header information, and so on, based on queries on certain XML tag values, the easiest way is by using Oracle XML Parser for Java and Java Stored Procedures in tandem with Oracle Streams AQ (inside Oracle Database).

- If you store XML as CLOBs then you can definitely search the XML using Oracle Text but this only helps you find a particular message that matches a criteria.

- To do aggregation operations over the metadata, view the metadata from existing relational tools, or use normal SQL predicates on the metadata, then having the data only stored as XML in a CLOB will not be good enough.

You can combine Oracle Text XML searching with some redundant metadata storage as factored out columns and use SQL that combines normal SQL predicates with an Oracle Text `contains` expression to have the best of both of these options.

See Also: Chapter 11, "Full-Text Search Over XML Data".

Preventing the Listener from Stopping Until the XML Document Is Processed

When receiving XML messages from clients as messages you may be required to process them as soon as they come in. Each XML document could take say about 15 seconds to process. For PL/SQL, one procedure starts the listener and dequeues the message and calls another procedure to process the XML document and the listener could be held up until the XML document is processed. Meanwhile messages accumulate in the queue.

After receiving the message, you can submit a job using the `DBMS_JOB` package. The job will be invoked asynchronously in a different database session.

Oracle Database added PL/SQL callbacks in the Oracle Streams AQ notification framework. This lets you register a PL/SQL callback that is invoked asynchronously when a message shows up in a queue.

Using HTTPS with AQ

To send XML messages to suppliers using HTTPS and get a response back, you can use Oracle Streams AQ Internet access functionality. You can enqueue and dequeue messages over HTTP(S) securely and transactionally using XML.

See Also: *Oracle Streams Advanced Queuing User's Guide*

Storing XML in Oracle Streams AQ Message Payloads

You can store XML in Oracle Streams AQ message payloads natively other than having an ADT as the payload with `sys.xmltype` as part of the ADT. In Oracle9*i* release 2 (9.2) and higher you can create queues with payloads and attributes as `XMLType`.

Comparing iDAP and SOAP

iDAP is the SOAP specification for AQ operations. iDAP is the XML specification for Oracle Streams AQ operations. SOAP defines a generic mechanism to invoke a service. iDAP defines these mechanisms to perform AQ operations.

iDAP in addition has the following key properties not defined by SOAP:

- Transactional behavior. You can perform AQ operations in a transactional manner. You transaction can span multiple iDAP requests.
- Security. All the iDAP operations can be done only by authorized and authenticated users.

Part VII

Appendixes

Part VII of this manual provides background material as a set of appendixes:

- Appendix A, "Oracle-Supplied XML Schemas and Examples"
- Appendix B, "Oracle XML DB Restrictions"

A

Oracle-Supplied XML Schemas and Examples

This appendix includes the definition and structure of `RESOURCE_VIEW` and `PATH_VIEW` and the Oracle XML DB-supplied XML schemas. It also includes a full listing of the purchase-order XML schemas used in various examples, and the C example for loading XML content into Oracle XML DB.

This appendix contains these topics:

XDBResource.xsd: XML Schema for Oracle XML DB Resources

Here is the complete listing for the Oracle XML DB supplied XML schema, `XDBResource.xsd`, which is used to represent Oracle XML DB resources.

XDBResource.xsd

```
<schema xdb:schemaURL="http://xmlns.oracle.com/xdb/XDBResource.xsd"
        targetNamespace="http://xmlns.oracle.com/xdb/XDBResource.xsd"
        version="1.0" xdb:numProps="72" elementFormDefault="qualified"
        xdb:flags="23" xdb:mapStringToNCHAR="false" xdb:mapUnboundedStringToLob="false"
        xdb:storeVarrayAsTable="false" xdb:schemaOwner="XDB">
  <simpleType name="OracleUserName">
    <restriction base="string">
      <minLength value="1" fixed="false"/>
      <maxLength value="4000" fixed="false"/>
    </restriction>
  </simpleType>
  <simpleType name="ResMetaStr">
    <restriction base="string">
      <minLength value="1" fixed="false"/>
```

```
    <maxLength value="128" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="SchElemType">
  <restriction base="string">
    <minLength value="1" fixed="false"/>
    <maxLength value="4000" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="GUID">
  <restriction base="hexBinary">
    <minLength value="8" fixed="false"/>
    <maxLength value="32" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="LocksRaw">
  <restriction base="hexBinary">
    <minLength value="0" fixed="false"/>
    <maxLength value="2000" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockModeType">
  <restriction base="string">
    <enumeration value="exclusive" fixed="false"/>
    <enumeration value="shared" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockTypeType">
  <restriction base="string">
    <enumeration value="read-write" fixed="false"/>
    <enumeration value="write" fixed="false"/>
    <enumeration value="read" fixed="false"/>
  </restriction>
</simpleType>
<simpleType name="lockDepthType">
  <restriction base="string">
    <enumeration value="0" fixed="false"/>
    <enumeration value="infinity" fixed="false"/>
  </restriction>
</simpleType>
<complexType name="lockType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="768" name="LockOwner" type="string" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="769" name="Mode" type="xdb:lockModeType" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="770" name="Type" type="xdb:lockTypeType" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="771" name="Depth" type="xdb:lockDepthType" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
```

```
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
    <element xdb:propNumber="772" name="Expiry" type="dateTime" xdb:memType="180"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="TimeStamp" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <choice minOccurs="0" maxOccurs="unbounded">
      <element xdb:propNumber="773" name="Token" type="string" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
      <element xdb:propNumber="774" name="NodeId" type="string" xdb:memType="1"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="String" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    </choice>
  </sequence>
</complexType>
<complexType name="locksType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="767" name="Lock" type="xdb:lockType" xdb:memType="258"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType" xdb:global="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      minOccurs="0" maxOccurs="2147483647"/>
  </sequence>
</complexType>
<complexType name="ResContentsType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="736" name="ContentsAny" xdb:memType="258" xdb:system="false"
      xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="1"/>
  </sequence>
</complexType>
<complexType name="ResAclType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="737" name="ACLAny" xdb:memType="258" xdb:system="false"
      xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="1"/>
  </sequence>
</complexType>
<complexType name="AttrCopyType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <any xdb:propNumber="748" name="AttrCopyAny" xdb:memType="258" xdb:system="false"
      xdb:mutable="false" xdb:JavaType="XMLType" minOccurs="0" maxOccurs="65535"/>
  </sequence>
</complexType>
<complexType name="RCListType" abstract="false" mixed="false">
  <sequence minOccurs="1" maxOccurs="1">
    <element xdb:propNumber="755" name="OID" type="hexBinary" xdb:memByteLength="22"
      xdb:memType="23" xdb:system="false" xdb:mutable="false" xdb:SQLName="OID"
      xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false"
      xdb:SQLCollType="XDB$OID_LIST_T" xdb:SQLCollSchema="XDB" xdb:hidden="false"
      nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
      xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
      xdb:numCols="1" minOccurs="1" maxOccurs="65535"/>
  </sequence>
</complexType>
<complexType name="ResourceType" abstract="false" mixed="false">
```

```
<sequence minOccurs="1" maxOccurs="1">
  <element xdb:propNumber="709" name="CreationDate" type="dateTime" xdb:memType="180"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="CREATIONDATE"
    xdb:SQLType="TIMESTAMP" xdb:JavaType="TimeStamp" xdb:global="false"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="710" name="ModificationDate" type="dateTime"
    xdb:memType="180" xdb:system="false" xdb:mutable="false"
    xdb:SQLName="MODIFICATIONDATE" xdb:SQLType="TIMESTAMP" xdb:JavaType="TimeStamp"
    xdb:global="false" nillable="false" abstract="false" xdb:SQLInline="true"
    xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
    xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="711" name="Author" type="xdb:ResMetaStr" xdb:memType="1"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="AUTHOR" xdb:SQLType="VARCHAR2"
    xdb:JavaType="String" xdb:global="false" nillable="false" abstract="false"
    xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
    maxOccurs="1"/>
  <element xdb:propNumber="712" name="DisplayName" type="xdb:ResMetaStr"
    xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:SQLName="DISPNAME"
    xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false" nillable="false"
    abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
    maxOccurs="1"/>
  <element xdb:propNumber="713" name="Comment" type="xdb:ResMetaStr" xdb:memType="1"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="RESCOMMENT"
    xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false" nillable="false"
    abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
    maxOccurs="1"/>
  <element xdb:propNumber="714" name="Language" type="xdb:ResMetaStr" xdb:memType="1"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="LANGUAGE"
    xdb:SQLType="VARCHAR2" xdb:JavaType="String" default="en" xdb:global="false"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="715" name="CharacterSet" type="xdb:ResMetaStr"
    xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:SQLName="CHARSET"
    xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false" nillable="false"
    abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
    maxOccurs="1"/>
  <element xdb:propNumber="716" name="ContentType" type="xdb:ResMetaStr"
    xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:SQLName="CONTYPE"
    xdb:SQLType="VARCHAR2" xdb:JavaType="String" xdb:global="false" nillable="false"
    abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
    maxOccurs="1"/>
  <element xdb:propNumber="717" name="RefCount" type="nonNegativeInteger"
    xdb:memByteLength="4" xdb:memType="68" xdb:system="false" xdb:mutable="true"
    xdb:SQLName="REFCOUNT" xdb:SQLType="RAW" xdb:JavaType="long" xdb:global="false"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="718" name="LockBuf" type="xdb:LocksRaw" xdb:memType="23"
    xdb:system="false" xdb:mutable="true" xdb:SQLName="LOCKS" xdb:SQLType="RAW"
    xdb:JavaType="byteArray" xdb:global="false" nillable="false" abstract="false"
    xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
```

```
  maxOccurs="1"/>
<element xdb:propNumber="732" name="ACL" type="xdb:ResAclType" xdb:memType="258"
  xdb:system="false" xdb:mutable="false" xdb:JavaType="XMLType" xdb:global="false"
  xdb:hidden="false" xdb:transient="generated" xdb:baseProp="false" nillable="false"
  abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
  xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:JavaClassname="oracle.xdb.ResAclTypeBean"
  xdb:beanClassname="oracle.xdb.ResAclTypeBean" xdb:numCols="0" minOccurs="0"
  maxOccurs="1"/>
<element xdb:propNumber="719" name="ACLOID" type="hexBinary" xdb:memType="23"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="ACLOID" xdb:SQLType="RAW"
  xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="720" name="Owner" type="xdb:OracleUserName" xdb:memType="1"
  xdb:system="false" xdb:mutable="false" xdb:JavaType="String" xdb:global="false"
  xdb:hidden="false" xdb:transient="generated" xdb:baseProp="false" nillable="false"
  abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
  xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0"
  maxOccurs="1"/>
<element xdb:propNumber="721" name="OwnerID" type="xdb:GUID" xdb:memType="23"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="OWNERID" xdb:SQLType="RAW"
  xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="722" name="Creator" type="xdb:OracleUserName"
  xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:JavaType="String"
  xdb:global="false" xdb:hidden="false" xdb:transient="generated"
  xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="723" name="CreatorID" type="xdb:GUID" xdb:memType="23"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="CREATORID" xdb:SQLType="RAW"
  xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="724" name="LastModifier" type="xdb:OracleUserName"
  xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:JavaType="String"
  xdb:global="false" xdb:hidden="false" xdb:transient="generated"
  xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="725" name="LastModifierID" type="xdb:GUID" xdb:memType="23"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="LASTMODIFIERID"
  xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true"
  xdb:baseProp="true" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="726" name="SchemaElement" type="xdb:SchElemType"
  xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:JavaType="String"
  xdb:global="false" xdb:hidden="false" xdb:transient="generated"
  xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="727" name="ElNum" type="nonNegativeInteger"
  xdb:memByteLength="4" xdb:memType="3" xdb:system="false" xdb:mutable="false"
  xdb:SQLName="ELNUM" xdb:SQLType="INTEGER" xdb:JavaType="long" xdb:global="false"
```

```
    xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
    xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
    maxOccurs="1"/>
  <element xdb:propNumber="728" name="SchOID" type="hexBinary" xdb:memType="23"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="SCHOID" xdb:SQLType="RAW"
    xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
  <element xdb:propNumber="733" name="Contents" type="xdb:ResContentsType"
    xdb:memType="258" xdb:system="false" xdb:mutable="false" xdb:JavaType="XMLType"
    xdb:global="false" xdb:hidden="false" xdb:transient="manifested"
    xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
    xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
    xdb:defaultTableSchema="XDB" xdb:JavaClassname="oracle.xdb.ResContentsTypeBean"
    xdb:beanClassname="oracle.xdb.ResContentsTypeBean" xdb:numCols="0" minOccurs="0"
    maxOccurs="1"/>
  <element xdb:propNumber="729" name="XMLRef" type="REF" xdb:memType="110"
    xdb:system="false" xdb:mutable="true" xdb:SQLName="XMLREF" xdb:SQLType="REF"
    xdb:JavaType="Reference" xdb:global="false" xdb:hidden="true" xdb:baseProp="false"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="730" name="XMLLob" type="hexBinary" xdb:memType="113"
    xdb:system="false" xdb:mutable="true" xdb:SQLName="XMLLOB" xdb:SQLType="BLOB"
    xdb:JavaType="String" xdb:global="false" xdb:hidden="true" xdb:baseProp="false"
    nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
    xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
    xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
  <element xdb:propNumber="731" name="Flags" type="nonNegativeInteger"
    xdb:memByteLength="4" xdb:memType="3" xdb:system="false" xdb:mutable="true"
    xdb:SQLName="FLAGS" xdb:SQLType="RAW" xdb:JavaType="long" xdb:global="false"
    xdb:hidden="true" xdb:baseProp="true" nillable="false" abstract="false"
    xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
    maxOccurs="1"/>
  <element xdb:propNumber="740" name="VCRUID" type="xdb:GUID" xdb:memType="23"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="VCRUID" xdb:SQLType="RAW"
    xdb:JavaType="byteArray" xdb:global="false" nillable="false" abstract="false"
    xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="1"
    maxOccurs="1"/>
  <element xdb:propNumber="741" name="Parents" type="hexBinary" xdb:memType="23"
    xdb:system="false" xdb:mutable="false" xdb:SQLName="PARENTS" xdb:SQLType="RAW"
    xdb:JavaType="Reference" xdb:global="false"
    xdb:SQLCollType="XDB$PREDECESSOR_LIST_T" xdb:SQLCollSchema="XDB" nillable="false"
    abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
    xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0"
    maxOccurs="1000"/>
  <element xdb:propNumber="745" name="SBResExtra" type="REF" xdb:memType="110"
    xdb:system="false" xdb:mutable="true" xdb:SQLName="SBRESEXTRA" xdb:SQLType="REF"
    xdb:JavaType="Reference" xdb:global="false"
    xdb:SQLCollType="XDB$XMLTYPE_REF_LIST_T" xdb:SQLCollSchema="XDB" xdb:hidden="true"
    xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
    xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
    xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
    maxOccurs="2147483647"/>
  <element xdb:propNumber="746" name="Snapshot" type="hexBinary" xdb:memType="23"
    xdb:system="false" xdb:mutable="true" xdb:SQLName="SNAPSHOT" xdb:SQLType="RAW"
```

```
  xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="747" name="AttrCopy" type="xdb:AttrCopyType"
  xdb:memType="258" xdb:system="false" xdb:mutable="true" xdb:SQLName="ATTRCOPY"
  xdb:SQLType="BLOB" xdb:JavaType="XMLType" xdb:global="false" xdb:hidden="true"
  xdb:baseProp="true" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="749" name="CtsCopy" type="hexBinary" xdb:memType="113"
  xdb:system="false" xdb:mutable="true" xdb:SQLName="CTSCOPY" xdb:SQLType="BLOB"
  xdb:JavaType="String" xdb:global="false" xdb:hidden="true" xdb:baseProp="false"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="false" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="750" name="NodeNum" type="hexBinary" xdb:memType="23"
  xdb:system="false" xdb:mutable="true" xdb:SQLName="NODENUM" xdb:SQLType="RAW"
  xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true" xdb:baseProp="true"
  nillable="false" abstract="false" xdb:SQLInline="true" xdb:JavaInline="false"
  xdb:MemInline="true" xdb:maintainDOM="false" xdb:defaultTableSchema="XDB"
  xdb:numCols="1" minOccurs="1" maxOccurs="1"/>
<element xdb:propNumber="751" name="ContentSize" type="integer"
  xdb:memByteLength="8" xdb:memType="3" xdb:system="false" xdb:mutable="false"
  xdb:JavaType="long" xdb:global="false" xdb:hidden="true" xdb:transient="generated"
  xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="752" name="SizeOnDisk" type="nonNegativeInteger"
  xdb:memByteLength="8" xdb:memType="3" xdb:system="false" xdb:mutable="false"
  xdb:SQLName="SIZEONDISK" xdb:SQLType="INTEGER" xdb:JavaType="long"
  xdb:global="false" xdb:hidden="true" xdb:baseProp="true" nillable="false"
  abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="true"
  xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
  maxOccurs="1"/>
<element xdb:propNumber="754" name="RCList" type="xdb:RCListType" xdb:memType="258"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="RCLIST"
  xdb:SQLType="XDB$RCLIST_T" xdb:SQLSchema="XDB" xdb:JavaType="XMLType"
  xdb:global="true" xdb:hidden="true" xdb:baseProp="true" nillable="false"
  abstract="false" xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
  xdb:maintainDOM="false" xdb:defaultTable="00" xdb:defaultTableSchema="XDB"
  xdb:JavaClassname="oracle.xdb.RCListBean"
  xdb:beanClassname="oracle.xdb.RCListBean" xdb:numCols="1" minOccurs="0"
  maxOccurs="1"/>
<element xdb:propNumber="762" name="Branch" type="string" xdb:memType="1"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="BRANCH" xdb:SQLType="VARCHAR2"
  xdb:JavaType="String" xdb:global="false" xdb:hidden="false"
  xdb:transient="generated" xdb:baseProp="false" nillable="false" abstract="false"
  xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
  xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
  maxOccurs="1"/>
<element xdb:propNumber="763" name="CheckedOutBy" type="xdb:OracleUserName"
  xdb:memType="1" xdb:system="false" xdb:mutable="false" xdb:JavaType="String"
  xdb:global="false" xdb:hidden="false" xdb:transient="generated"
  xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
  xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
  xdb:defaultTableSchema="XDB" xdb:numCols="0" minOccurs="0" maxOccurs="1"/>
<element xdb:propNumber="764" name="CheckedOutByID" type="xdb:GUID" xdb:memType="23"
  xdb:system="false" xdb:mutable="false" xdb:SQLName="CHECKEDOUTBYID"
  xdb:SQLType="RAW" xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="true"
```

```
      xdb:baseProp="true" nillable="false" abstract="false" xdb:SQLInline="true"
      xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
      xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="765" name="BaseVersion" type="hexBinary" xdb:memType="23"
      xdb:system="false" xdb:mutable="false" xdb:SQLName="BASEVERSION" xdb:SQLType="RAW"
      xdb:JavaType="byteArray" xdb:global="false" xdb:hidden="false"
      xdb:baseProp="false" nillable="false" abstract="false" xdb:SQLInline="true"
      xdb:JavaInline="false" xdb:MemInline="true" xdb:maintainDOM="false"
      xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
    <element xdb:propNumber="766" name="Locks" type="xdb:locksType" xdb:memType="258"
      xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType" xdb:global="false"
      xdb:hidden="true" xdb:transient="generated" nillable="false" abstract="false"
      xdb:SQLInline="true" xdb:JavaInline="false" xdb:MemInline="false"
      xdb:maintainDOM="false" xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0"
      maxOccurs="1"/>
    <any xdb:propNumber="735" name="ResExtra" xdb:memType="258" xdb:system="false"
      xdb:mutable="false" xdb:SQLName="RESEXTRA" xdb:SQLType="CLOB"
      xdb:JavaType="XMLType" namespace="##other" minOccurs="0" maxOccurs="65535"/>
  </sequence>
  <attribute xdb:propNumber="705" name="Hidden" type="boolean" xdb:memByteLength="1"
      xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
      default="false" xdb:hidden="false" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="706" name="Invalid" type="boolean" xdb:memByteLength="1"
      xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
      default="false" xdb:hidden="false" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="707" name="VersionID" type="integer" xdb:memByteLength="4"
      xdb:memType="3" xdb:system="false" xdb:mutable="false" xdb:SQLName="VERSIONID"
      xdb:SQLType="INTEGER" xdb:JavaType="long"/>
  <attribute xdb:propNumber="708" name="ActivityID" type="integer" xdb:memByteLength="4"
      xdb:memType="3" xdb:system="false" xdb:mutable="false" xdb:SQLName="ACTIVITYID"
      xdb:SQLType="INTEGER" xdb:JavaType="long"/>
  <attribute xdb:propNumber="738" name="Container" type="boolean" xdb:memByteLength="1"
      xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
      default="false" xdb:hidden="false" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="739" name="CustomRslv" type="boolean" xdb:memByteLength="1"
      xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
      default="false" xdb:hidden="false" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="742" name="VersionHistory" type="boolean"
      xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
      xdb:JavaType="boolean" default="false" xdb:hidden="false"
      xdb:transient="generated" xdb:baseProp="false"/>
  <attribute xdb:propNumber="743" name="StickyRef" type="boolean" xdb:memByteLength="1"
      xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
      default="false" xdb:hidden="false" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="744" name="HierSchmResource" type="boolean"
      xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
      xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="753" name="SizeAccurate" type="boolean"
      xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
      xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
      xdb:baseProp="false"/>
  <attribute xdb:propNumber="756" name="IsVersionable" type="boolean"
      xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
      xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
```

```
        xdb:baseProp="false"/>
    <attribute xdb:propNumber="757" name="IsCheckedOut" type="boolean"
        xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
        xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
        xdb:baseProp="false"/>
    <attribute xdb:propNumber="758" name="IsVersion" type="boolean" xdb:memByteLength="1"
        xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
        default="false" xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
    <attribute xdb:propNumber="759" name="IsVCR" type="boolean" xdb:memByteLength="1"
        xdb:memType="252" xdb:system="false" xdb:mutable="false" xdb:JavaType="boolean"
        default="false" xdb:hidden="true" xdb:transient="generated" xdb:baseProp="false"/>
    <attribute xdb:propNumber="760" name="IsVersionHistory" type="boolean"
        xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
        xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
        xdb:baseProp="false"/>
    <attribute xdb:propNumber="761" name="IsWorkspace" type="boolean"
        xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
        xdb:JavaType="boolean" default="false" xdb:hidden="true" xdb:transient="generated"
        xdb:baseProp="false"/>
    <attribute xdb:propNumber="776" name="HasUnresolvedLinks" type="boolean"
        xdb:memByteLength="1" xdb:memType="252" xdb:system="false" xdb:mutable="false"
        xdb:JavaType="boolean" default="false" xdb:hidden="false"
        xdb:transient="generated" xdb:baseProp="false"/>
  </complexType>
  <element xdb:propNumber="734" name="Resource" type="xdb:ResourceType" xdb:memType="258"
        xdb:system="false" xdb:mutable="false" xdb:SQLName="RESOURCE"
        xdb:SQLType="XDB$RESOURCE_T" xdb:SQLSchema="XDB" xdb:JavaType="XMLType"
        xdb:global="true" nillable="false" abstract="false" xdb:SQLInline="false"
        xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
        xdb:defaultTable="XDB$RESOURCE" xdb:defaultTableSchema="XDB"
        xdb:JavaClassname="oracle.xdb.ResourceBean"
        xdb:beanClassname="oracle.xdb.ResourceBean" xdb:numCols="33" minOccurs="1"
        maxOccurs="1"/>
  <element xdb:propNumber="775" name="Locks" type="xdb:locksType" xdb:memType="258"
        xdb:system="false" xdb:mutable="true" xdb:JavaType="XMLType" xdb:global="false"
        xdb:hidden="false" nillable="false" abstract="false" xdb:SQLInline="true"
        xdb:JavaInline="false" xdb:MemInline="false" xdb:maintainDOM="false"
        xdb:defaultTableSchema="XDB" xdb:numCols="1" minOccurs="0" maxOccurs="1"/>
</schema>
```

XDBResConfig.xsd: XML Schema for Resource Configuration

This section presents the Oracle XML DB-supplied XML schema used to configure repository resources. This is accessible in Oracle XML DB Repository at path `/sys/schemas/PUBLIC/xmlns.oracle.com/xdb/XDBResConfig.xsd`.

XDBResConfig.xsd

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        xmlns:rescfg="http://xmlns.oracle.com/xdb/XDBResConfig.xsd"
        elementFormDefault="qualified" xdb:schemaOwner="XDB" version="1.0" >

  <annotation>
    <documentation>
      This XML schema declares the schema of an XDB resource configuration,
      which includes default ACL, event listeners and user configuration.
      It lists all XDB repository events that will be supported.
```

```
    Future extension can be added to support user-defined events and
    XML events.
  </documentation>
</annotation>
<simpleType name="language">
  <restriction base="string">
    <enumeration value="Java" />
    <enumeration value="C" />
    <enumeration value="PL/SQL" />
  </restriction>
</simpleType>
<complexType name = "existsNode">
   <all>
     <element name="XPath" type = "string" minOccurs="1" maxOccurs="1" />
     <element name="namespace" type = "string" minOccurs="0" maxOccurs="1" />
   </all>
</complexType>

<!-- listener pre-condition element  -->
<complexType name = "condition">
   <all>
     <element name="existsNode" type = "rescfg:existsNode" minOccurs="0" maxOccurs="1" />
   </all>
</complexType>
<complexType name = "events">
  <all>
    <element name="Render" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Create" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Create" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Delete" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Delete" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Update" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Update" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Lock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Lock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Unlock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Unlock" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-LinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-LinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-LinkTo" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-LinkTo" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UnlinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UnlinkIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UnlinkFrom" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UnlinkFrom" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-CheckIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-CheckIn" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-CheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-CheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-UncheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-UncheckOut" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-VersionControl" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-VersionControl" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-Open" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-Open" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Pre-InconsistentUpdate" type="string" minOccurs="0" maxOccurs="1"/>
    <element name="Post-InconsistentUpdate" type="string" minOccurs="0" maxOccurs="1"/>
  </all>
</complexType>
```

```
<!-- event listener element  -->
<complexType name = "event-listener">
  <all>
    <element name="description" type = "string" minOccurs="0" maxOccurs="1"/>
    <element name="schema" type = "string" minOccurs="0" maxOccurs="1"/>
    <element name="source" type = "string" minOccurs="1" maxOccurs="1"/>
    <element name="language" type = "rescfg:language" minOccurs="0" maxOccurs="1"/>
    <element name="pre-condition" type = "rescfg:condition" minOccurs="0" maxOccurs="1"/>
    <element name="events" type = "rescfg:events" minOccurs="0" maxOccurs="1"/>
  </all>
</complexType>
<complexType name="event-listeners">
  <sequence>
    <element name="listener" type = "rescfg:event-listener" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
  <attribute name = "default-schema" type = "string" xdb:baseProp="true" use="optional"/>
  <attribute name = "default-language" type = "rescfg:language" xdb:baseProp="true"
             use="optional"/>
  <attribute name = "set-invoker" type = "boolean" xdb:baseProp="true" default="false" />
</complexType>
<complexType name="defaultPath">
  <all>
    <element name="pre-condition" type = "rescfg:condition" minOccurs="0" maxOccurs="1"/>
    <element name="path" type="string" minOccurs="0" maxOccurs="1" xdb:transient="generated"/>
    <element name = "resolvedpath" type = "string" minOccurs="1" maxOccurs="1"
             xdb:baseProp="true" xdb:hidden="true"/>
    <element name = "oid" type = "hexBinary" minOccurs="1" maxOccurs="1" xdb:baseProp="true"
             xdb:hidden="true"/>
  </all>
</complexType>
<complexType name="defaultACL">
  <sequence>
    <element name="ACL" type="rescfg:defaultPath" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
</complexType>
<complexType name = "defaultConfig">
  <sequence>
    <element name="configuration" type="rescfg:defaultPath" minOccurs="1" maxOccurs="unbounded"/>
  </sequence>
</complexType>
<simpleType name="link-type">
  <restriction base="string">
    <enumeration value="None"/>
    <enumeration value="Hard"/>
    <enumeration value="Weak"/>
    <enumeration value="Symbolic"/>
  </restriction>
</simpleType>
<simpleType name="path-format">
  <restriction base="string">
    <enumeration value="OID"/>
    <enumeration value="Named"/>
  </restriction>
</simpleType>
<simpleType name="link-metadata">
  <restriction base="string">
    <enumeration value="None"/>
    <enumeration value="Attributes"/>
    <enumeration value="All"/>
```

```
  </restriction>
</simpleType>
<simpleType name="unresolved-link">
  <restriction base="string">
    <enumeration value="Error"/>
    <enumeration value="SymLink"/>
    <enumeration value="Skip"/>
  </restriction>
</simpleType>
<simpleType name="conflict-rule">
  <restriction base="string">
    <enumeration value="Error"/>
    <enumeration value="Overwrite"/>
    <enumeration value="Syspath"/>
  </restriction>
</simpleType>
 <simpleType name="section-type">
   <restriction base="string">
     <enumeration value="None"/>
     <enumeration value="Fragment"/>
     <enumeration value="Document"/>
   </restriction>
 </simpleType>

<!-- XLinkConfig complex type -->
  <complexType name="xlink-config">
   <sequence>
    <element name="LinkType" type = "rescfg:link-type"/>
    <element name="PathFormat" type = "rescfg:path-format" minOccurs="0" default="OID"/>
    <element name="LinkMetadata" type = "rescfg:link-metadata" minOccurs="0" default="None"/>
   </sequence>
   <attribute name="UnresolvedLink" type = "rescfg:unresolved-link" default="Error"/>
  </complexType>

<!-- XIncludeConfig element -->
  <complexType name="xinclude-config">
   <sequence>
    <element name="LinkType" type = "rescfg:link-type"/>
    <element name="PathFormat" type = "rescfg:path-format" minOccurs="0" default="OID"/>
    <element name="ConflictRule" type = "rescfg:conflict-rule" minOccurs="0" default="Error"/>
   </sequence>
   <attribute name="UnresolvedLink" type = "rescfg:unresolved-link" default="Error"/>
  </complexType>

<!-- SectionConfig element -->
<complexType name="section-config">
 <sequence>
  <element name="Section" maxOccurs="unbounded">
    <complexType>
      <sequence>
       <element name="sectionPath" type="string"/>
       <element name="documentPath" type="string" minOccurs="0"/>
       <element name="namespace" type="string" minOccurs="0"/>
      </sequence>
      <attribute name="type" type="rescfg:section-type" default="None"/>
    </complexType>
  </element>
 </sequence>
</complexType>
```

```
  <!-- ContentFormat element -->
  <simpleType name="content-format" >
    <restriction base="string">
      <enumeration value="text"/>
      <enumeration value="binary"/>
    </restriction>
   </simpleType>

  <!-- resource configuration element  -->
  <complexType name = "ResConfig">
    <all>
      <element name="defaultChildConfig" type="rescfg:defaultConfig" minOccurs="0"  maxOccurs="1"/>
      <element name="defaultChildACL" type="rescfg:defaultACL" minOccurs="0" maxOccurs="1"/>
      <element name="event-listeners" type = "rescfg:event-listeners" minOccurs="0" maxOccurs="1"/>
      <element name="XLinkConfig" type="rescfg:xlink-config" minOccurs="0" maxOccurs="1"/>
      <element name="XIncludeConfig" type="rescfg:xinclude-config" minOccurs="0" maxOccurs="1"/>
      <element name="SectionConfig" type="rescfg:section-config" minOccurs="0" maxOccurs="1"/>
      <element name="ContentFormat" type="rescfg:content-format" minOccurs="0" maxOccurs="1"/>

      <!-- application data -->
      <element name="applicationData" minOccurs="0" maxOccurs="1" >
         <complexType>
           <sequence>
             <any namespace="##other" maxOccurs="unbounded" processContents="lax"/>
           </sequence>
         </complexType>
     </element>
    </all>
    <attribute name = "enable" type = "boolean" xdb:baseProp="true" default="true" />
    <attribute name = "copy-on-inconsistent-update" type = "boolean" use="optional" />
  </complexType>
  <element name="ResConfig" type="rescfg:ResConfig" xdb:defaultTable = "XDB$RESCONFIG" />
</schema>
```

acl.xsd: XML Schema for Oracle XML DB ACLs

This section presents the Oracle XML DB supplied XML schema used to represent Oracle XML DB access control lists (ACLs).

ACL Representation XML Schema, acl.xsd

XML schema, `acl.xsd`, represents Oracle XML DB access control lists (ACLs).

acl.xsd

```
<schema xmlns="http://www.w3.org/2001/XMLSchema"
        targetNamespace="http://xmlns.oracle.com/xdb/acl.xsd" version="1.0"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        xmlns:xdbacl="http://xmlns.oracle.com/xdb/acl.xsd"
        elementFormDefault="qualified">

   <annotation>
     <documentation>
        This XML schema describes the structure of XDB ACL documents.

        Note : The "systemPrivileges" element below lists all supported
          system privileges and their aggregations.
          See dav.xsd for description of DAV privileges
        Note : The elements and attributes marked "hidden" are for
```

```
        internal use only.
    </documentation>
    <appinfo>
      <xdb:systemPrivileges>
       <xdbacl:all>
         <xdbacl:read-properties/>
         <xdbacl:read-contents/>
         <xdbacl:read-acl/>
         <xdbacl:update/>
         <xdbacl:link/>
         <xdbacl:unlink/>
         <xdbacl:unlink-from/>
         <xdbacl:write-acl-ref/>
         <xdbacl:update-acl/>
         <xdbacl:link-to/>
         <xdbacl:resolve/>
         <xdbacl:write-config/>
       </xdbacl:all>
      </xdb:systemPrivileges>
    </appinfo>
  </annotation>

<!-- privilegeNameType (this is an emptycontent type) -->
<complexType name = "privilegeNameType"/>

<!-- privilegeName element
     All system and user privileges are in the substitutionGroup
     of this element.
  -->
<element name = "privilegeName" type="xdbacl:privilegeNameType"
         xdb:defaultTable=""/>

<!-- all system privileges in the XDB ACL namespace -->
<element name = "read-properties" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "read-contents" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "read-acl" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "update" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "link" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "unlink" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "unlink-from" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "write-acl-ref" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "update-acl" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "link-to" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "resolve" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
<element name = "all" type="xdbacl:privilegeNameType"
         substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>

<!-- privilege element -->
<element name = "privilege" xdb:defaultTable="">
```

```
  <complexType>
    <sequence>
      <any maxOccurs="unbounded" processContents="lax"/>
    </sequence>
  </complexType>
</element>

<!-- ace element -->
<element name = "ace" xdb:defaultTable="">
  <complexType>
    <sequence>
      <element name = "grant" type = "boolean"/>
      <choice>
        <element name="invert" xdb:transient="generated">
          <complexType>
            <sequence>
              <element name="principal" type="string"
                       xdb:transient="generated" />
            </sequence>
          </complexType>
        </element>
        <element name="principal" type="string" xdb:transient="generated"/>
      </choice>
      <element ref="xdbacl:privilege" minOccurs="1"/>
      <!-- "any" contain all app info for an ACE e.g.reason for creation -->
      <any minOccurs="0" maxOccurs="unbounded" namespace="##other"/>
      <!-- HIDDEN ELEMENTS -->
      <choice minOccurs="0">
        <element name = "principalID" type = "hexBinary"
                 xdb:baseProp="true" xdb:hidden="true"/>
        <element name = "principalString" type = "string"
                 xdb:baseProp="true" xdb:hidden="true"/>
      </choice>
      <element name = "flags" type = "unsignedInt" minOccurs="0"
               xdb:baseProp="true" xdb:hidden="true"/>
    </sequence>
    <attribute name = "collection" type = "boolean"
               xdb:transient="generated" use="optional"/>
    <attribute name = "principalFormat"
               xdb:transient="generated" use="optional">
      <simpleType>
        <restriction base="string">
          <enumeration value="ShortName"/>
          <enumeration value="DistinguishedName"/>
          <enumeration value="GUID"/>
          <enumeration value="XSName"/>
        </restriction>
      </simpleType>
    </attribute>
    <attribute name = "start_date" type = "dateTime" use = "optional"/>
    <attribute name = "end_date" type = "dateTime" use = "optional"/>
  </complexType>
</element>

<!-- acl element -->
<complexType name="inheritanceType">
  <attribute name="type" type="string" use="required"/>
  <attribute name="href" type="string" use="required"/>
</complexType>
```

```
<complexType name="aclType">
 <sequence>
  <element name = "schemaURL" type = "string" minOccurs="0"
           xdb:transient="generated"/>
  <element name = "elementName" type = "string" minOccurs="0"
           xdb:transient="generated"/>
  <element name = "security-class" type = "QName" minOccurs="0"/>
  <choice minOccurs="0">
    <element name="extends-from" type="xdbacl:inheritanceType"/>
    <element name="constrained-with" type="xdbacl:inheritanceType"/>
  </choice>
  <element ref = "xdbacl:ace" minOccurs="1" maxOccurs = "unbounded"/>
  <!-- this "any" contains all application specific info for an ACL,
       e.g., reason for creation  -->
  <any minOccurs="0" maxOccurs="unbounded" namespace="##other" />
  <!-- HIDDEN ELEMENTS -->
  <element name = "schemaOID" type = "hexBinary" minOccurs="0"
           xdb:baseProp="true" xdb:hidden="true"/>
  <element name = "elementNum" type = "unsignedInt" minOccurs="0"
           xdb:baseProp="true" xdb:hidden="true"/>
 </sequence>
 <attribute name = "shared" type = "boolean" default="true"/>
 <attribute name = "description" type = "string"/>
</complexType>
<complexType name="rule-based-acl">
  <complexContent>
    <extension base="xdbacl:aclType">
      <sequence>
        <element name = "param" minOccurs="0" maxOccurs="unbounded">
          <complexType>
            <simpleContent>
              <extension base="string">
                <attribute name = "name" type = "string" use = "required"/>
              </extension>
            </simpleContent>
          </complexType>
        </element>
      </sequence>
    </extension>
  </complexContent>
 </complexType>
 <element name = "acl" type="xdbacl:aclType" xdb:defaultTable = "XDB$ACL"/>
 <element name = "write-config" type="xdbacl:privilegeNameType"
          substitutionGroup="xdbacl:privilegeName" xdb:defaultTable=""/>
</schema>
```

xdbconfig.xsd: XML Schema for Configuring Oracle XML DB

File `xdbconfig.xsd` contains the Oracle XML DB supplied XML schema used to configure Oracle XML DB.

xdbconfig.xsd

```
<schema targetNamespace="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:xdbc="http://xmlns.oracle.com/xdb/xdbconfig.xsd"
        xmlns:xdb="http://xmlns.oracle.com/xdb"
        version="1.0" elementFormDefault="qualified">
  <element name="xdbconfig" xdb:defaultTable="XDB$CONFIG">
```

```
<complexType><sequence>

  <!-- predefined XDB properties - these should NOT be changed -->
  <element name="sysconfig">
  <complexType><sequence>
      <!-- generic XDB properties -->
      <element name="acl-max-age" type="unsignedInt" default="15"/>
      <element name="acl-cache-size" type="unsignedInt" default="32"/>
      <element name="invalid-pathname-chars" type="string" default=""/>
      <element name="case-sensitive" type="boolean" default="true"/>
      <element name="call-timeout"   type="unsignedInt" default="300"/>
      <element name="max-link-queue" type="unsignedInt" default="65536"/>
      <element name="max-session-use" type="unsignedInt" default="100"/>
      <element name="persistent-sessions" type="boolean" default="false"/>
      <element name="default-lock-timeout" type="unsignedInt" default="3600"/>
      <element name="xdbcore-logfile-path" type="string" default="/sys/log/xdblog.xml"/>
      <element name="xdbcore-log-level" type="unsignedInt" default="0"/>
      <element name="resource-view-cache-size" type="unsignedInt" default="1048576"/>
      <element name="case-sensitive-index-clause" type="string" minOccurs="0"/>

      <!-- protocol specific properties -->
      <element name="protocolconfig">
      <complexType><sequence>

          <!-- these apply to all protocols -->
          <element name="common">
          <complexType><sequence>
              <element name="extension-mappings">
              <complexType><sequence>
                <element name="mime-mappings" type="xdbc:mime-mapping-type"/>
                <element name="lang-mappings" type="xdbc:lang-mapping-type"/>
                <element name="charset-mappings" type="xdbc:charset-mapping-type"/>
                <element name="encoding-mappings" type="xdbc:encoding-mapping-type"/>
                <element name="xml-extensions" type="xdbc:xml-extension-type"
                         minOccurs="0"/>
              </sequence></complexType>
              </element>
              <element name="session-pool-size" type="unsignedInt" default="50"/>
              <element name="session-timeout" type="unsignedInt" default="6000"/>
          </sequence></complexType>
          </element>

          <!-- FTP specific -->
          <element name="ftpconfig">
          <complexType><sequence>
            <element name="ftp-port" type="unsignedShort" default="2100"/>
            <element name="ftp-listener" type="string"/>
            <element name="ftp-protocol" type="string"/>
            <element name="logfile-path" type="string" default="/sys/log/ftplog.xml"/>
            <element name="log-level" type="unsignedInt" default="0"/>
            <element name="session-timeout"  type="unsignedInt" default="6000"/>
            <element name="buffer-size" default="8192">
              <simpleType>
                <restriction base="unsignedInt">
                  <minInclusive value="1024"/>       <!-- 1KB -->
                  <maxInclusive value="1048496"/>    <!-- 1MB -->
                </restriction>
              </simpleType>
            </element>
            <element name="ftp-welcome-message" type="string" minOccurs="0"
```

```
          maxOccurs="1"/>
</sequence></complexType>
</element>

<!-- HTTP specific -->
<element name="httpconfig">
<complexType><sequence>
    <element name="http-port" type="unsignedShort" default="8080"/>
    <element name="http-listener" type="string"/>
    <element name="http-protocol" type="string"/>
    <element name="max-http-headers" type="unsignedInt" default="64"/>
    <element name="max-header-size" type="unsignedInt" default="4096"/>
    <element name="max-request-body" type="unsignedInt" default="2000000000"
             minOccurs="1"/>
    <element name="session-timeout"  type="unsignedInt" default="6000"/>
    <element name="server-name" type="string"/>
    <element name="logfile-path" type="string"
             default="/sys/log/httplog.xml"/>
    <element name="log-level" type="unsignedInt" default="0"/>
    <element name="servlet-realm" type="string" minOccurs="0"/>

    <element name="webappconfig">
    <complexType><sequence>
      <element name="welcome-file-list" type="xdbc:welcome-file-type"/>
      <element name="error-pages" type="xdbc:error-page-type"/>
      <element name="servletconfig" type="xdbc:servlet-config-type"/>
    </sequence></complexType>
    </element>
    <element name="default-url-charset" type="string" minOccurs="0"/>
    <element name="http2-port" type="unsignedShort" minOccurs="0"/>
    <element name="http2-protocol" type="string" default="tcp" minOccurs="0"/>
    <element name="plsql" minOccurs="0">
    <complexType><sequence>
      <element name="log-level" type="unsignedInt" minOccurs="0"/>
      <element name="max-parameters" type="unsignedInt" minOccurs="0"/>
    </sequence></complexType>
    </element>
    <element name="allow-repository-anonymous-access"
             minOccurs="0" default="false" type="boolean"/>
    <element name="authentication" minOccurs="0" maxOccurs="1">
    <complexType><sequence>
      <element name="allow-mechanism" minOccurs="1" maxOccurs="unbounded">
        <simpleType>
        <restriction base="string">
          <enumeration value="digest"/>
          <enumeration value="basic" />
        </restriction>
        </simpleType>
      </element>
      <element name="digest-auth" minOccurs="0" maxOccurs="1">
        <complexType><sequence>
          <element name="nonce-timeout" type="unsignedInt" minOccurs="1"
                   maxOccurs="1" default="300"/>
        </sequence></complexType>
      </element>
    </sequence></complexType>
    </element>
    <element name="http-host" type="string" minOccurs="0"/>
    <element name="http2-host" type="string" minOccurs="0"/>
</sequence></complexType>
```

```
          </element>
          <element name="nfsconfig" minOccurs="0">
          <complexType><sequence>
            <element name="nfs-port" type="unsignedShort" default="2049"/>
            <element name="nfs-listener" type="string"/>
            <element name="nfs-protocol" type="string"/>
            <element name="logfile-path" type="string" default="/sys/log/nfslog.xml"/>
            <element name="log-level" type="unsignedInt" default="0"/>
            <element name="nfs-exports" type="xdbc:nfs-exports-type"/>
          </sequence></complexType>
          </element>
      </sequence></complexType>
      </element>
      <element name="schemaLocation-mappings" type="xdbc:schemaLocation-mapping-type"
               minOccurs="0"/>
      <element name="xdbcore-xobmem-bound" type="unsignedInt" default="1024"
               minOccurs="0"/>
      <element name="xdbcore-loadableunit-size" type="unsignedInt" default="16"
               minOccurs="0"/>
      <element name="folder-hard-links" type="boolean" default="false" minOccurs="0"/>
      <element name="non-folder-hard-links" type="boolean" default="true"
               minOccurs="0"/>
      <element name="copy-on-inconsistent-update" type="boolean" default="false"
               minOccurs="0"/>
      <element name="rollback-on-sync-error" type="boolean" default="false"
               minOccurs="0"/>
      <element name="acl-evaluation-method" default="deny-trumps-grant" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="deny-trumps-grant"/>
            <enumeration value="ace-order"/>
          </restriction>
        </simpleType>
      </element>
      <element name="default-workspace" type="string" minOccurs="0"/>
      <element name="num_job_queue_processes" type="unsignedInt" minOccurs="0"/>
  </sequence></complexType>
  </element>

 <!-- users can add any properties they want here -->
 <element name="userconfig" minOccurs="0">
      <complexType><sequence>
         <any maxOccurs="unbounded" namespace="##other"/>
      </sequence></complexType>
 </element>
</sequence></complexType>
</element>
<complexType name="welcome-file-type">
   <sequence>
       <element name="welcome-file" minOccurs="0" maxOccurs="unbounded">
        <simpleType>
        <restriction base="string">
          <pattern value="[^/]*"/>
        </restriction>
        </simpleType>
       </element>
   </sequence>
</complexType>

<!-- customized error pages -->
```

```
<complexType name="error-page-type">
<sequence>
      <element name="error-page" minOccurs="0" maxOccurs="unbounded">
      <complexType><sequence>
            <choice>
              <element name="error-code">
                <simpleType>
                  <restriction base="positiveInteger">
                    <minInclusive value="100"/>
                    <maxInclusive value="999"/>
                  </restriction>
                </simpleType>
              </element>

              <!-- Fully qualified classname of a Java exception type -->
              <element name="exception-type" type="string"/>
              <element name="OracleError">
               <complexType><sequence>
                  <element name="facility" type="string" default="ORA"/>
                  <element name="errnum" type="unsignedInt"/>
               </sequence></complexType>
              </element>
            </choice>
            <element name="location" type="anyURI"/>

       </sequence></complexType>
       </element>
</sequence>
</complexType>

<!-- parameter for a servlet: name, value pair and a description  -->
<complexType name="param">
  <sequence>
    <element name="param-name" type="string"/>
    <element name="param-value" type="string"/>
    <element name="description" type="string"/>
  </sequence>
</complexType>
<complexType name="servlet-config-type">
  <sequence>
       <element name="servlet-mappings">
         <complexType><sequence>
            <element name="servlet-mapping" minOccurs="0" maxOccurs="unbounded">
            <complexType><sequence>
                <element name="servlet-pattern" type="string"/>
                <element name="servlet-name" type="string"/>
            </sequence></complexType>
            </element>
         </sequence></complexType>
        </element>
    <element name="servlet-list">
      <complexType><sequence>
            <element name="servlet" minOccurs="0" maxOccurs="unbounded">
              <complexType><sequence>
                <element name="servlet-name" type="string"/>
                <element name="servlet-language">
                  <simpleType>
                    <restriction base="string">
                      <enumeration value="C"/>
                      <enumeration value="Java"/>
```

```
                    <enumeration value="PL/SQL"/>
                  </restriction>
                </simpleType>
              </element>
              <element name="icon" type="string" minOccurs="0"/>
              <element name="display-name" type="string"/>
              <element name="description" type="string" minOccurs="0"/>
              <choice>
                <element name="servlet-class" type="string" minOccurs="0"/>
                <element name="jsp-file" type="string" minOccurs="0"/>
                <element name="plsql" type="xdbc:plsql-servlet-config" minOccurs="0"/>
              </choice>
              <element name="servlet-schema" type="string" minOccurs="0"/>
              <element name="init-param" minOccurs="0"
                       maxOccurs="unbounded" type="xdbc:param"/>
              <element name="load-on-startup" type="string" minOccurs="0"/>
              <element name="security-role-ref" minOccurs="0"
                    maxOccurs="unbounded">
              <complexType><sequence>
                  <element name="description" type="string" minOccurs="0"/>
                  <element name="role-name" type="string"/>
                  <element name="role-link" type="string"/>
              </sequence></complexType>
              </element>
            </sequence></complexType>
          </element>
    </sequence></complexType>
  </element>
</sequence>
</complexType>
<complexType name="lang-mapping-type"><sequence>
    <element name="lang-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType><sequence>
      <element name="extension" type="xdbc:exttype"/>
      <element name="lang" type="string"/>
      </sequence></complexType>
    </element></sequence>
</complexType>
<complexType name="charset-mapping-type"><sequence>
    <element name="charset-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType><sequence>
      <element name="extension" type="xdbc:exttype"/>
      <element name="charset" type="string"/>
      </sequence></complexType>
    </element></sequence>
</complexType>
<complexType name="encoding-mapping-type"><sequence>
    <element name="encoding-mapping" minOccurs="0" maxOccurs="unbounded">
      <complexType><sequence>
      <element name="extension" type="xdbc:exttype"/>
      <element name="encoding" type="string"/>
      </sequence></complexType>
    </element></sequence>
</complexType>
<complexType name="mime-mapping-type"><sequence>
    <element name="mime-mapping" minOccurs="0" maxOccurs="unbounded">
    <complexType><sequence>
      <element name="extension" type="xdbc:exttype"/>
      <element name="mime-type" type="string"/>
    </sequence></complexType>
```

```
     </element></sequence>
  </complexType>
 <complexType name="xml-extension-type"><sequence>
     <element name="extension" type="xdbc:exttype"
              minOccurs="0" maxOccurs="unbounded">
     </element></sequence>
  </complexType>
 <complexType name="schemaLocation-mapping-type"><sequence>
     <element name="schemaLocation-mapping"
              minOccurs="0" maxOccurs="unbounded">
     <complexType><sequence>
       <element name="namespace" type="string"/>
       <element name="element" type="string"/>
       <element name="schemaURL" type="string"/>
     </sequence></complexType>
     </element></sequence>
  </complexType>
  <complexType name="plsql-servlet-config">
    <sequence>
      <element name="database-username" type="string" minOccurs="0"/>
      <element name="authentication-mode" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="Basic"/>
            <enumeration value="SingleSignOn"/>
            <enumeration value="GlobalOwa"/>
            <enumeration value="CustomOwa"/>
            <enumeration value="PerPackageOwa"/>
          </restriction>
        </simpleType>
      </element>
      <element name="session-cookie-name" type="string" minOccurs="0"/>
      <element name="session-state-management" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="StatelessWithResetPackageState"/>
            <enumeration value="StatelessWithFastResetPackageState"/>
            <enumeration value="StatelessWithPreservePackageState"/>
          </restriction>
        </simpleType>
      </element>
      <element name="max-requests-per-session" type="unsignedInt" minOccurs="0"/>
      <element name="default-page" type="string" minOccurs="0"/>
      <element name="document-table-name" type="string" minOccurs="0"/>
      <element name="document-path" type="string" minOccurs="0"/>
      <element name="document-procedure" type="string" minOccurs="0"/>
      <element name="upload-as-long-raw" type="string" minOccurs="0"
               maxOccurs="unbounded"/>
      <element name="path-alias" type="string" minOccurs="0"/>
      <element name="path-alias-procedure" type="string" minOccurs="0"/>
      <element name="exclusion-list" type="string" minOccurs="0" maxOccurs="unbounded"/>
      <element name="cgi-environment-list" type="string" minOccurs="0"
               maxOccurs="unbounded"/>
      <element name="compatibility-mode" type="unsignedInt" minOccurs="0"/>
      <element name="nls-language" type="string" minOccurs="0"/>
      <element name="fetch-buffer-size" type="unsignedInt" minOccurs="0"/>
      <element name="error-style" minOccurs="0">
        <simpleType>
          <restriction base="string">
            <enumeration value="ApacheStyle"/>
```

```
          <enumeration value="ModplsqlStyle"/>
          <enumeration value="DebugStyle"/>
        </restriction>
      </simpleType>
    </element>
    <element name="transfer-mode" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="Char"/>
          <enumeration value="Raw"/>
        </restriction>
      </simpleType>
    </element>
    <element name="before-procedure" type="string" minOccurs="0"/>
    <element name="after-procedure" type="string" minOccurs="0"/>
    <element name="bind-bucket-lengths" type="unsignedInt" minOccurs="0"
             maxOccurs="unbounded"/>
    <element name="bind-bucket-widths" type="unsignedInt" minOccurs="0"
             maxOccurs="unbounded"/>
    <element name="always-describe-procedure" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="On"/>
          <enumeration value="Off"/>
        </restriction>
      </simpleType>
    </element>
    <element name="info-logging" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="InfoDebug"/>
        </restriction>
      </simpleType>
    </element>
    <element name="owa-debug-enable" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="On"/>
          <enumeration value="Off"/>
        </restriction>
      </simpleType>
    </element>
    <element name="request-validation-function" type="string" minOccurs="0"/>
    <element name="input-filter-enable" minOccurs="0">
      <simpleType>
        <restriction base="string">
          <enumeration value="On"/>
          <enumeration value="Off"/>
        </restriction>
      </simpleType>
    </element>
  </sequence>
</complexType>
<simpleType name="exttype">
    <restriction base="string">
      <pattern value="[^\*\./]*"/>
    </restriction>
</simpleType>
<simpleType name="ipaddress">
    <restriction base="string">
```

```
        <pattern value="(\d{1,3}\.){3}\d{1,3}" />
      </restriction>
  </simpleType>
  <complexType name="nfs-exports-type"><sequence>
    <element name="nfs-export" minOccurs="1" maxOccurs="unbounded">
      <complexType><sequence>
         <element name="nfs-clientgroup">
           <complexType><sequence>
             <element name="nfs-client" minOccurs="1" maxOccurs="unbounded">
               <complexType><sequence>
                 <choice>
                   <element name="nfs-client-subnet" type="xdbc:ipaddress"/>
                   <element name="nfs-client-dnsname" type="string"/>
                   <element name="nfs-client-address" type="xdbc:ipaddress"/>
                 </choice>
                 <element name="nfs-client-netmask" type="xdbc:ipaddress"/>
               </sequence></complexType>
             </element>
           </sequence></complexType>
         </element>
         <element name="nfs-export-paths">
           <complexType><sequence>
             <element name="nfs-export-path" minOccurs="1" maxOccurs="unbounded">
               <complexType><sequence>
                 <element name="path" type="string"/>
                 <element name="mode">
                   <simpleType>
                     <restriction base="string">
                       <enumeration value="read-write"/>
                       <enumeration value="read-only"/>
                     </restriction>
                   </simpleType>
                 </element>
               </sequence></complexType>
             </element>
           </sequence></complexType>
         </element>
       </sequence></complexType>
     </element>
   </sequence></complexType>
</schema>
```

xdiff.xsd: XML Schema for Comparing Schemas for In-Place Evolution

`xdiff.xsd`, is the Oracle XML DB-supplied XML schema to which the document specified as the `diffXML` parameter to procedure `DBMS_XMLSCHEMA.inPlaceEvolve` must conform.

xdiff.xsd

```
<schema targetNamespace="http://xmlns.oracle.com/xdb/xdiff.xsd"
    xmlns="http://www.w3.org/2001/XMLSchema"
    xmlns:xd="http://xmlns.oracle.com/xdb/xdiff.xsd"
    version="1.0" elementFormDefault="qualified"
    attributeFormDefault="qualified">
    <annotation>
        <documentation xml:lang="en">
         Defines the structure of XML documents that capture the difference
         between two XML documents. Changes that are not supported by Oracle
```

```
     XmlDiff may not be expressible in this schema.

    'oracle-xmldiff' PI:

    We use 'oracle-xmldiff' PI to describe certain aspects of the diff.
    This should be the first element of top level xdiff element.

    operations-in-docorder:
    Can be either 'true' or 'false'.
    If true, the operations in the diff document refer to the
    elements of the input doc in the same order as document order. Output of
    global algorithm meets this requirement while local does not.

    output-model: output models for representing the diff. Can be either
    'Snapshot' or 'Current'.

    Snapshot model:
    Each operation uses Xpaths as if no operations
    have been applied to the input document. (like UNIX diff)
    Default and works for both Xmldiff and XmlPatch.
    For XmlPatch to handle this model, "operations-in-docorder" must be
    true and the Xpaths must be simple. (see XmlDif C API documentation).

    Current model :
    Each operation uses Xpaths as if all operations till the previous one
    have been applied to the input document. Not implemented for Xmldiff.
    Works with XmlPatch.

    <!-- Example:
        <?oracle-xmldiff operations-in-docorder="true" output-model=
        "snapshot" diff-algorithm="global"?>
    -->
    </documentation>
</annotation>
<!-- Enumerate the supported node types -->
<simpleType name="xdiff-nodetype">
    <restriction base="string">
        <enumeration value="element"/>
        <enumeration value="attribute"/>
        <enumeration value="text"/>
        <enumeration value="cdata"/>
        <enumeration value="entity-reference"/>
        <enumeration value="entity"/>
        <enumeration value="processing-instruction"/>
        <enumeration value="notation"/>
        <enumeration value="comment"/>
     </restriction>
</simpleType>

<element name="xdiff">
    <complexType>
        <choice minOccurs="0" maxOccurs="unbounded">
            <element name="append-node">
                <complexType>
                    <sequence>
                        <element name="content" type="anyType"/>
                    </sequence>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>
                    <attribute name="xpath" type="string"/>
                    <attribute name="parent-xpath" type="string"/>
```

```
                    <attribute name="attr-local" type="string"/>
                    <attribute name="attr-uri" type="string"/>
                </complexType>
            </element>

            <element name="insert-node-before">
                <complexType>
                    <sequence>
                        <element name="content" type="anyType"/>
                    </sequence>
                    <attribute name="xpath" type="string"/>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>

                </complexType>
            </element>

            <element name="delete-node">
                <complexType>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>
                    <attribute name="xpath" type="string"/>
                    <attribute name="parent-xpath" type="string"/>
                    <attribute name="attr-local" type="string"/>
                    <attribute name="attr-uri" type="string"/>
                </complexType>
            </element>
             <element name="update-node">
                <complexType>
                    <sequence>
                        <element name="content" type="anyType"/>
                    </sequence>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>
                    <attribute name="parent-xpath" type="string"/>
                    <attribute name="xpath" type="string"/>
                    <attribute name="attr-local" type="string"/>
                    <attribute name="attr-uri" type="string"/>
                </complexType>
            </element>
            <element name="rename-node">
                <complexType>
                    <sequence>
                        <element name="content" type="anyType"/>
                    </sequence>
                    <attribute name="xpath" type="string"/>
                    <attribute name="node-type" type="xd:xdiff-nodetype"/>
                </complexType>
            </element>
        </choice>
        <attribute name="xdiff-version" type="string"/>
      </complexType>
    </element>
</schema>
```

Purchase-Order XML Schemas

This section contains the complete listings of the annotated purchase-order XML schemas used in various examples, particularly in Chapter 3. Example A–2 represents a modified version of Example A–1; the modification is used in Chapter 9 to illustrate XML schema evolution.

Example A–1 Annotated Purchase-Order XML Schema, purchaseOrder.xsd

This is the complete listing of the annotated XML schema presented in Example 3–8 on page 3-20.

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0"
           xdb:storeVarrayAsTable="true">
  <xs:element name="PurchaseOrder" type="PurchaseOrderType" xdb:defaultTable="PURCHASEORDER"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Reference" type="ReferenceType" minOccurs="1" xdb:SQLName="REFERENCE"/>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" minOccurs="1" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
      <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
    <xs:sequence>
      <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded"
                  xdb:SQLName="LINEITEM" xdb:SQLCollType="LINEITEM_V"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
    <xs:sequence>
      <xs:element name="Description" type="DescriptionType"
                  xdb:SQLName="DESCRIPTION"/>
      <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
    </xs:sequence>
    <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                  xdb:SQLType="NUMBER"/>
  </xs:complexType>
  <xs:complexType name="PartType" xdb:SQLType="PART_T">
    <xs:attribute name="Id" xdb:SQLName="PART_NUMBER" xdb:SQLType="VARCHAR2">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:minLength value="10"/>
          <xs:maxLength value="14"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
    <xs:attribute name="Quantity" type="moneyType" xdb:SQLName="QUANTITY"/>
    <xs:attribute name="UnitPrice" type="quantityType" xdb:SQLName="UNITPRICE"/>
  </xs:complexType>
  <xs:simpleType name="ReferenceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="18"/>
      <xs:maxLength value="30"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
    <xs:sequence>
      <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
        <xs:complexType xdb:SQLType="actioN_t">
          <xs:sequence>
            <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
            <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
          </xs:sequence>
        </xs:complexType>
```

```
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
    <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
    <xs:element name="address" type="AddressType" minOccurs="0" xdb:SQLName="SHIP_TO_ADDRESS"/>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="4"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="VendorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PurchaseOrderNumberType">
  <xs:restriction base="xs:integer"/>
</xs:simpleType>
<xs:simpleType name="SpecialInstructionsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="NameType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="20"/>
```

```
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="AddressType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="TelephoneType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="24"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DateType">
    <xs:restriction base="xs:date"/>
  </xs:simpleType>
  <xs:simpleType name="CommentsType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="2048"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="DescriptionType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="256"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

Example A–2 Revised Purchase-Order XML Schema

This is the complete listing of the revised annotated XML schema presented in Example 9–1 on page 9-2. Text that is in **bold face** is additional or significantly different from that in the schema of Example A–1.

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           xmlns:xdb="http://xmlns.oracle.com/xdb"
           version="1.0">
  <xs:element
    name="PurchaseOrder" type="PurchaseOrderType"
    xdb:defaultTable="PURCHASEORDER"
    xdb:columnProps=
      "CONSTRAINT purchaseorder_pkey PRIMARY KEY (XMLDATA.reference),
       CONSTRAINT valid_email_address FOREIGN KEY (XMLDATA.userid)
         REFERENCES hr.employees (EMAIL)"
    xdb:tableProps=
      "VARRAY XMLDATA.ACTIONS.ACTION STORE AS TABLE ACTION_TABLE
        ((CONSTRAINT action_pkey PRIMARY KEY (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       VARRAY XMLDATA.LINEITEMS.LINEITEM STORE AS TABLE LINEITEM_TABLE
        ((constraint LINEITEM_PKEY primary key (NESTED_TABLE_ID, SYS_NC_ARRAY_INDEX$)))
       lob (XMLDATA.NOTES) STORE AS (ENABLE STORAGE IN ROW STORAGE(INITIAL 4K NEXT 32K))"/>
  <xs:complexType name="PurchaseOrderType" xdb:SQLType="PURCHASEORDER_T">
    <xs:sequence>
      <xs:element name="Actions" type="ActionsType" xdb:SQLName="ACTIONS"/>
      <xs:element name="Reject" type="RejectionType" minOccurs="0" xdb:SQLName="REJECTION"/>
      <xs:element name="Requestor" type="RequestorType" xdb:SQLName="REQUESTOR"/>
      <xs:element name="User" type="UserType" xdb:SQLName="USERID"/>
      <xs:element name="CostCenter" type="CostCenterType" xdb:SQLName="COST_CENTER"/>
      <xs:element name="BillingAddress" type="AddressType" minOccurs="0"
                  xdb:SQLName="BILLING_ADDRESS"/>
      <xs:element name="ShippingInstructions" type="ShippingInstructionsType"
                  xdb:SQLName="SHIPPING_INSTRUCTIONS"/>
      <xs:element name="SpecialInstructions" type="SpecialInstructionsType"
                  xdb:SQLName="SPECIAL_INSTRUCTIONS"/>
```

```
    <xs:element name="LineItems" type="LineItemsType" xdb:SQLName="LINEITEMS"/>
    <xs:element name="Notes" type="NotesType" minOccurs="0" xdb:SQLType="CLOB"
                xdb:SQLName="NOTES"/>
  </xs:sequence>
  <xs:attribute name="Reference" type="ReferenceType" use="required" xdb:SQLName="REFERENCE"/>
  <xs:attribute name="DateCreated" type="xs:dateTime" use="required"
                xdb:SQLType="TIMESTAMP WITH TIME ZONE"/>
</xs:complexType>
<xs:complexType name="LineItemsType" xdb:SQLType="LINEITEMS_T">
  <xs:sequence>
    <xs:element name="LineItem" type="LineItemType" maxOccurs="unbounded" xdb:SQLName="LINEITEM"
                xdb:SQLCollType="LINEITEM_V"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LineItemType" xdb:SQLType="LINEITEM_T">
  <xs:sequence>
    <xs:element name="Part" type="PartType" xdb:SQLName="PART"/>
    <xs:element name="Quantity" type="quantityType"/>
  </xs:sequence>
  <xs:attribute name="ItemNumber" type="xs:integer" xdb:SQLName="ITEMNUMBER"
                xdb:SQLType="NUMBER"/>
</xs:complexType>
<xs:complexType name="PartType" xdb:SQLType="PART_T">
  <xs:simpleContent>
    <xs:extension base="UPCCodeType">
      <xs:attribute name="Description" type="DescriptionType" use="required"
                    xdb:SQLName="DESCRIPTION"/>
      <xs:attribute name="UnitCost" type="moneyType" use="required"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:simpleType name="ReferenceType">
  <xs:restriction base="xs:string">
    <xs:minLength value="18"/>
    <xs:maxLength value="30"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="ActionsType" xdb:SQLType="ACTIONS_T">
  <xs:sequence>
    <xs:element name="Action" maxOccurs="4" xdb:SQLName="ACTION" xdb:SQLCollType="ACTION_V">
      <xs:complexType xdb:SQLType="ACTION_T">
        <xs:sequence>
          <xs:element name="User" type="UserType" xdb:SQLName="ACTIONED_BY"/>
          <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_ACTIONED"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="RejectionType" xdb:SQLType="REJECTION_T">
  <xs:all>
    <xs:element name="User" type="UserType" minOccurs="0" xdb:SQLName="REJECTED_BY"/>
    <xs:element name="Date" type="DateType" minOccurs="0" xdb:SQLName="DATE_REJECTED"/>
    <xs:element name="Comments" type="CommentsType" minOccurs="0" xdb:SQLName="REASON_REJECTED"/>
  </xs:all>
</xs:complexType>
<xs:complexType name="ShippingInstructionsType" xdb:SQLType="SHIPPING_INSTRUCTIONS_T">
  <xs:sequence>
    <xs:element name="name" type="NameType" minOccurs="0" xdb:SQLName="SHIP_TO_NAME"/>
    <xs:choice>
      <xs:element name="address" type="AddressType" minOccurs="0"/>
      <xs:element name="fullAddress" type="FullAddressType" minOccurs="0"
                  xdb:SQLName="SHIP_TO_ADDRESS"/>
    </xs:choice>
    <xs:element name="telephone" type="TelephoneType" minOccurs="0" xdb:SQLName="SHIP_TO_PHONE"/>
  </xs:sequence>
```

```
</xs:complexType>
<xs:simpleType name="moneyType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="2"/>
    <xs:totalDigits value="12"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="quantityType">
  <xs:restriction base="xs:decimal">
    <xs:fractionDigits value="4"/>
    <xs:totalDigits value="8"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="UserType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="10"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="RequestorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CostCenterType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="4"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="VendorType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PurchaseOrderNumberType">
  <xs:restriction base="xs:integer"/>
</xs:simpleType>
<xs:simpleType name="SpecialInstructionsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="0"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="NameType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="20"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="FullAddressType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="256"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="TelephoneType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="24"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="DateType">
        <xs:restriction base="xs:date"/>
```

```
</xs:simpleType>
<xs:simpleType name="CommentsType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="2048"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="DescriptionType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="256"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="AddressType" xdb:SQLType="ADDRESS_T">
  <xs:sequence>
    <xs:element name="StreetLine1" type="StreetType"/>
    <xs:element name="StreetLine2" type="StreetType" minOccurs="0"/>
    <xs:element name="City" type="CityType"/>
    <xs:choice>
      <xs:sequence>
        <xs:element name="State" type="StateType"/>
        <xs:element name="ZipCode" type="ZipCodeType"/>
      </xs:sequence>
      <xs:sequence>
        <xs:element name="Province" type="ProvinceType"/>
        <xs:element name="PostCode" type="PostCodeType"/>
      </xs:sequence>
      <xs:sequence>
        <xs:element name="County" type="CountyType"/>
        <xs:element name="Postcode" type="PostCodeType"/>
      </xs:sequence>
    </xs:choice>
    <xs:element name="Country" type="CountryType"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="StreetType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="128"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="CityType">
  <xs:restriction base="xs:string">
    <xs:minLength value="1"/>
    <xs:maxLength value="64"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="StateType">
  <xs:restriction base="xs:string">
    <xs:minLength value="2"/>
    <xs:maxLength value="2"/>
    <xs:enumeration value="AK"/>
    <xs:enumeration value="AL"/>
    <xs:enumeration value="AR"/>
    <xs:enumeration value="AS"/>
    <xs:enumeration value="AZ"/>
    <xs:enumeration value="CA"/>
    <xs:enumeration value="CO"/>
    <xs:enumeration value="CT"/>
    <xs:enumeration value="DC"/>
    <xs:enumeration value="DE"/>
    <xs:enumeration value="FL"/>
    <xs:enumeration value="FM"/>
    <xs:enumeration value="GA"/>
    <xs:enumeration value="GU"/>
    <xs:enumeration value="HI"/>
```

```
      <xs:enumeration value="IA"/>
      <xs:enumeration value="ID"/>
      <xs:enumeration value="IL"/>
      <xs:enumeration value="IN"/>
      <xs:enumeration value="KS"/>
      <xs:enumeration value="KY"/>
      <xs:enumeration value="LA"/>
      <xs:enumeration value="MA"/>
      <xs:enumeration value="MD"/>
      <xs:enumeration value="ME"/>
      <xs:enumeration value="MH"/>
      <xs:enumeration value="MI"/>
      <xs:enumeration value="MN"/>
      <xs:enumeration value="MO"/>
      <xs:enumeration value="MP"/>
      <xs:enumeration value="MQ"/>
      <xs:enumeration value="MS"/>
      <xs:enumeration value="MT"/>
      <xs:enumeration value="NC"/>
      <xs:enumeration value="ND"/>
      <xs:enumeration value="NE"/>
      <xs:enumeration value="NH"/>
      <xs:enumeration value="NJ"/>
      <xs:enumeration value="NM"/>
      <xs:enumeration value="NV"/>
      <xs:enumeration value="NY"/>
      <xs:enumeration value="OH"/>
      <xs:enumeration value="OK"/>
      <xs:enumeration value="OR"/>
      <xs:enumeration value="PA"/>
      <xs:enumeration value="PR"/>
      <xs:enumeration value="PW"/>
      <xs:enumeration value="RI"/>
      <xs:enumeration value="SC"/>
      <xs:enumeration value="SD"/>
      <xs:enumeration value="TN"/>
      <xs:enumeration value="TX"/>
      <xs:enumeration value="UM"/>
      <xs:enumeration value="UT"/>
      <xs:enumeration value="VA"/>
      <xs:enumeration value="VI"/>
      <xs:enumeration value="VT"/>
      <xs:enumeration value="WA"/>
      <xs:enumeration value="WI"/>
      <xs:enumeration value="WV"/>
      <xs:enumeration value="WY"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ZipCodeType">
    <xs:restriction base="xs:string">
      <xs:pattern value="\d{5}"/>
      <xs:pattern value="\d{5}-\d{4}"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountryType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="64"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="CountyType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="32"/>
    </xs:restriction>
  </xs:simpleType>
```

```
  <xs:simpleType name="PostCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="1"/>
      <xs:maxLength value="12"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ProvinceType">
    <xs:restriction base="xs:string">
      <xs:minLength value="2"/>
      <xs:maxLength value="2"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="NotesType">
    <xs:restriction base="xs:string">
      <xs:maxLength value="32767"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="UPCCodeType">
    <xs:restriction base="xs:string">
      <xs:minLength value="11"/>
      <xs:maxLength value="14"/>
      <xs:pattern value="\d{11}"/>
      <xs:pattern value="\d{12}"/>
      <xs:pattern value="\d{13}"/>
      <xs:pattern value="\d{14}"/>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```

XSL Style Sheet Example, PurchaseOrder.xsl

The following example, `PurchaseOrder.xsl`, is an example of an XSLT style sheet. The example style sheet is used in examples in Chapter 3, "Using Oracle XML DB".

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0"
                xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
                xmlns:xdb="http://xmlns.oracle.com/xdb"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <xsl:template match="/">
    <html>
      <head/>
      <body bgcolor="#003333" text="#FFFFCC" link="#FFCC00"
            vlink="#66CC99" alink="#669999">
        <FONT FACE="Arial, Helvetica, sans-serif">
          <xsl:for-each select="PurchaseOrder"/>
          <xsl:for-each select="PurchaseOrder">
            <center>
              <span style="font-family:Arial; font-weight:bold">
                <FONT COLOR="#FF0000">
                  <B>Purchase Order </B>
                </FONT>
              </span>
            </center>
            <br/>
            <center>
              <xsl:for-each select="Reference">
                <span style="font-family:Arial; font-weight:bold">
                  <xsl:apply-templates/>
                </span>
              </xsl:for-each>
            </center>
```

```
</xsl:for-each>
<P>
  <xsl:for-each select="PurchaseOrder">
    <br/>
  </xsl:for-each>
  <P/>
  <P>
    <xsl:for-each select="PurchaseOrder">
      <br/>
    </xsl:for-each>
  </P>
</P>
<xsl:for-each select="PurchaseOrder"/>
<xsl:for-each select="PurchaseOrder">
  <table border="0" width="100%" BGCOLOR="#000000">
    <tbody>
      <tr>
        <td WIDTH="296">
          <P>
            <B>
              <FONT SIZE="+1" COLOR="#FF0000"
               FACE="Arial, Helvetica, sans-serif">Internal
              </FONT>
            </B>
          </P>
          <table border="0" width="98%" BGCOLOR="#000099">
            <tbody>
              <tr>
                <td WIDTH="49%">
                  <B>
                    <FONT COLOR="#FFFF00">Actions</FONT>
                  </B>
                </td>
                <td WIDTH="51%">
                  <xsl:for-each select="Actions">
                    <xsl:for-each select="Action">
                      <table border="1" WIDTH="143">
                        <xsl:if test="position()=1">
                          <thead>
                            <tr>
                              <td HEIGHT="21">
                                <FONT
                                 COLOR="#FFFF00">User</FONT>
                              </td>
                              <td HEIGHT="21">
                                <FONT
                                 COLOR="#FFFF00">Date</FONT>
                              </td>
                            </tr>
                          </thead>
                        </xsl:if>
                        <tbody>
                          <tr>
                            <td>
                              <xsl:for-each select="User">
                                <xsl:apply-templates/>
                              </xsl:for-each>
                            </td>
                            <td>
                              <xsl:for-each select="Date">
```

```
                                <xsl:apply-templates/>
                              </xsl:for-each>
                            </td>
                          </tr>
                        </tbody>
                      </table>
                    </xsl:for-each>
                  </xsl:for-each>
                </td>
              </tr>
              <tr>
                <td WIDTH="49%">
                  <B>
                    <FONT COLOR="#FFFF00">Requestor</FONT>
                  </B>
                </td>
                <td WIDTH="51%">
                  <xsl:for-each select="Requestor">
                    <xsl:apply-templates/>
                  </xsl:for-each>
                </td>
              </tr>
              <tr>
                <td WIDTH="49%">
                  <B>
                    <FONT COLOR="#FFFF00">User</FONT>
                  </B>
                </td>
                <td WIDTH="51%">
                  <xsl:for-each select="User">
                    <xsl:apply-templates/>
                  </xsl:for-each>
                </td>
              </tr>
              <tr>
                <td WIDTH="49%">
                  <B>
                    <FONT COLOR="#FFFF00">Cost Center</FONT>
                  </B>
                </td>
                <td WIDTH="51%">
                  <xsl:for-each select="CostCenter">
                    <xsl:apply-templates/>
                  </xsl:for-each>
                </td>
              </tr>
            </tbody>
          </table>
        </td>
        <td width="93"/>
        <td valign="top" WIDTH="340">
          <B>
            <FONT COLOR="#FF0000">
              <FONT SIZE="+1">Ship To</FONT>
            </FONT>
          </B>
          <xsl:for-each select="ShippingInstructions">
            <xsl:if test="position()=1"/>
          </xsl:for-each>
          <xsl:for-each select="ShippingInstructions">
```

```
          <xsl:if test="position()=1">
            <table border="0" BGCOLOR="#999900">
              <tbody>
                <tr>
                  <td WIDTH="126" HEIGHT="24">
                    <B>Name</B>
                  </td>
                  <xsl:for-each
                       select="../ShippingInstructions">
                    <td WIDTH="218" HEIGHT="24">
                      <xsl:for-each select="name">
                        <xsl:apply-templates/>
                      </xsl:for-each>
                    </td>
                  </xsl:for-each>
                </tr>
                <tr>
                  <td WIDTH="126" HEIGHT="34">
                    <B>Address</B>
                  </td>
                  <xsl:for-each
                       select="../ShippingInstructions">
                    <td WIDTH="218" HEIGHT="34">
                      <xsl:for-each select="address">
                        <span style="white-space:pre">
                          <xsl:apply-templates/>
                        </span>
                      </xsl:for-each>
                    </td>
                  </xsl:for-each>
                </tr>
                <tr>
                  <td WIDTH="126" HEIGHT="32">
                    <B>Telephone</B>
                  </td>
                  <xsl:for-each
                       select="../ShippingInstructions">
                    <td WIDTH="218" HEIGHT="32">
                      <xsl:for-each select="telephone">
                        <xsl:apply-templates/>
                      </xsl:for-each>
                    </td>
                  </xsl:for-each>
                </tr>
              </tbody>
            </table>
          </xsl:if>
        </xsl:for-each>
      </td>
    </tr>
  </tbody>
</table>
<br/>
<B>
  <FONT COLOR="#FF0000" SIZE="+1">Items:</FONT>
</B>
<br/>
<br/>
<table border="0">
  <xsl:for-each select="LineItems">
```

```
<xsl:for-each select="LineItem">
  <xsl:if test="position()=1">
    <thead>
      <tr bgcolor="#C0C0C0">
        <td>
          <FONT COLOR="#FF0000">
            <B>ItemNumber</B>
          </FONT>
        </td>
        <td>
          <FONT COLOR="#FF0000">
            <B>Description</B>
          </FONT>
        </td>
        <td>
          <FONT COLOR="#FF0000">
            <B>PartId</B>
          </FONT>
        </td>
        <td>
          <FONT COLOR="#FF0000">
            <B>Quantity</B>
          </FONT>
        </td>
        <td>
          <FONT COLOR="#FF0000">
            <B>Unit Price</B>
          </FONT>
        </td>
        <td>
          <FONT COLOR="#FF0000">
            <B>Total Price</B>
          </FONT>
        </td>
      </tr>
    </thead>
  </xsl:if>
  <tbody>
    <tr bgcolor="#DADADA">
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="@ItemNumber">
            <xsl:value-of select="."/>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Description">
            <xsl:apply-templates/>
          </xsl:for-each>
        </FONT>
      </td>
      <td>
        <FONT COLOR="#000000">
          <xsl:for-each select="Part">
            <xsl:for-each select="@Id">
              <xsl:value-of select="."/>
            </xsl:for-each>
          </xsl:for-each>
```

```
                    </FONT>
                  </td>
                  <td>
                    <FONT COLOR="#000000">
                      <xsl:for-each select="Part">
                        <xsl:for-each select="@Quantity">
                          <xsl:value-of select="."/>
                        </xsl:for-each>
                      </xsl:for-each>
                    </FONT>
                  </td>
                  <td>
                    <FONT COLOR="#000000">
                      <xsl:for-each select="Part">
                        <xsl:for-each select="@UnitPrice">
                          <xsl:value-of select="."/>
                        </xsl:for-each>
                      </xsl:for-each>
                    </FONT>
                  </td>
                  <td>
                    <FONT FACE="Arial, Helvetica, sans-serif"
                          COLOR="#000000">
                      <xsl:for-each select="Part">
                        <xsl:value-of select="@Quantity*@UnitPrice"/>
                      </xsl:for-each>
                    </FONT>
                  </td>
                </tr>
              </tbody>
            </xsl:for-each>
          </xsl:for-each>
        </table>
      </xsl:for-each>
    </FONT>
  </body>
 </html>
</xsl:template>
</xsl:stylesheet>
```

Loading XML Using C (OCI)

Example A–3 Inserting XML Content into an XMLType Table Using C

This example is partially listed in Chapter 3, "Using Oracle XML DB", "Loading XML Content Using C" on page 3-6.

```
#include "stdio.h"
#include <xml.h>
#include <stdlib.h>
#include <string.h>
#include <ocixmldb.h>
OCIEnv *envhp;
OCIError *errhp;
OCISvcCtx *svchp;
OCIStmt *stmthp;
OCIServer *srvhp;
OCIDuration dur;
OCISession *sesshp;
```

```
oratext *username = "QUINE";
oratext *password = "CURRY";
oratext *filename = "AMCEWEN-20021009123336171PDT.xml";
oratext *schemaloc = "http://localhost:8080/source/schemas/poSource/xsd/purchaseOrder.xsd";

/* Execute a SQL statement that binds XML data            */
sword exec_bind_xml(OCISvcCtx *svchp, OCIError *errhp, OCIStmt *stmthp,
                    void *xml,        OCIType *xmltdo, OraText *sqlstmt)
{
  OCIBind *bndhp1 = (OCIBind *) 0;
  sword  status = 0;
  OCIInd ind = OCI_IND_NOTNULL;
  OCIInd *indp = &ind;
  if(status = OCIStmtPrepare(stmthp, errhp, (OraText *)sqlstmt,
                             (ub4)strlen((const char *)sqlstmt),
                             (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindByPos(stmthp, &bndhp1, errhp, (ub4) 1, (dvoid *) 0,
                           (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                           (ub2 *)0, (ub4) 0, (ub4 *) 0, (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  if(status = OCIBindObject(bndhp1, errhp, (CONST OCIType *) xmltdo,
                            (dvoid **) &xml, (ub4 *) 0,
                            (dvoid **) &indp, (ub4 *) 0))
    return OCI_ERROR;
  if(status = OCIStmtExecute(svchp, stmthp, errhp, (ub4) 1, (ub4) 0,
                             (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                             (ub4) OCI_DEFAULT))
    return OCI_ERROR;
  return OCI_SUCCESS;
}

/* Initialize OCI handles, and connect                    */
sword init_oci_connect()
{
  sword status;
  if (OCIEnvCreate((OCIEnv **) &(envhp), (ub4) OCI_OBJECT,
                   (dvoid *) 0, (dvoid * (*)(dvoid *,size_t)) 0,
                   (dvoid * (*)(dvoid *, dvoid *, size_t)) 0,
                   (void (*)(dvoid *, dvoid *)) 0, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIEnvCreate()\n");
      return OCI_ERROR;
    }
  /* Allocate error handle */
  if (OCIHandleAlloc((dvoid *) envhp, (dvoid **) &(errhp),
                     (ub4) OCI_HTYPE_ERROR, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on errhp\n");
      return OCI_ERROR;
    }
  /* Allocate server handle */
  if (status = OCIHandleAlloc((dvoid *) envhp, (dvoid **) &srvhp,
                              (ub4) OCI_HTYPE_SERVER, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on srvhp\n");
      return OCI_ERROR;
    }
  /* Allocate service context handle */
  if (status = OCIHandleAlloc((dvoid *) envhp,
                              (dvoid **) &(svchp), (ub4) OCI_HTYPE_SVCCTX,
                              (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on svchp\n");
      return OCI_ERROR;
    }
```

```
  /* Allocate session handle */
  if (status = OCIHandleAlloc((dvoid *) envhp, (dvoid **) &sesshp ,
                              (ub4) OCI_HTYPE_SESSION, (size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on sesshp\n");
      return OCI_ERROR;
    }
  /* Allocate statement handle */
  if (OCIHandleAlloc((dvoid *)envhp, (dvoid **) &stmthp,
                     (ub4)OCI_HTYPE_STMT, (CONST size_t) 0, (dvoid **) 0))
    {
      printf("FAILED: OCIHandleAlloc() on stmthp\n");
      return status;
    }
  if (status = OCIServerAttach((OCIServer *) srvhp, (OCIError *) errhp,
                               (CONST oratext *)"", 0, (ub4) OCI_DEFAULT))
    {
      printf("FAILED: OCIServerAttach() on srvhp\n");
      return OCI_ERROR;
    }
  /* Set server attribute to service context */
  if (status = OCIAttrSet((dvoid *) svchp, (ub4) OCI_HTYPE_SVCCTX,
                          (dvoid *) srvhp, (ub4) 0, (ub4) OCI_ATTR_SERVER,
                          (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on svchp\n");
      return OCI_ERROR;
    }
  /* Set user attribute to session */
  if (status = OCIAttrSet((dvoid *)sesshp, (ub4) OCI_HTYPE_SESSION,
                          (dvoid *)username,
                          (ub4) strlen((const char *)username),
                          (ub4) OCI_ATTR_USERNAME, (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on authp for user\n");
      return OCI_ERROR;
    }
  /* Set password attribute to session */
  if (status = OCIAttrSet((dvoid *) sesshp, (ub4) OCI_HTYPE_SESSION,
                          (dvoid *)password,
                          (ub4) strlen((const char *)password),
                          (ub4) OCI_ATTR_PASSWORD, (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on authp for password\n");
      return OCI_ERROR;
    }
  /* Begin a session  */
  if (status = OCISessionBegin((OCISvcCtx *) svchp,
                               (OCIError *) errhp,
                               (OCISession *) sesshp, (ub4) OCI_CRED_RDBMS,
                               (ub4) OCI_STMT_CACHE))
    {
      printf("FAILED: OCISessionBegin(). Make sure database is up and the username/password is valid. \n");
      return OCI_ERROR;
    }
  /* Set session attribute to service context */
  if (status = OCIAttrSet((dvoid *) svchp, (ub4) OCI_HTYPE_SVCCTX,
                          (dvoid *)sesshp, (ub4) 0, (ub4) OCI_ATTR_SESSION,
                          (OCIError *) errhp))
    {
      printf("FAILED: OCIAttrSet() on svchp\n");
      return OCI_ERROR;
    }
}

/* Free OCI handles, and disconnect                        */
```

```
void free_oci()
{
  sword  status = 0;

  /* End the session */
  if (status = OCISessionEnd((OCISvcCtx *)svchp, (OCIError *)errhp,
                             (OCISession *)sesshp, (ub4) OCI_DEFAULT))
    {
      if (envhp)
        OCIHandleFree((dvoid *)envhp, OCI_HTYPE_ENV);
      return;
    }
  /* Detach from the server */
  if (status = OCIServerDetach((OCIServer *)srvhp, (OCIError *)errhp,
                               (ub4)OCI_DEFAULT))
    {
      if (envhp)
        OCIHandleFree((dvoid *)envhp, OCI_HTYPE_ENV);
      return;
    }
  /* Free the handles */
  if (stmthp) OCIHandleFree((dvoid *)stmthp, (ub4) OCI_HTYPE_STMT);
  if (sesshp) OCIHandleFree((dvoid *)sesshp, (ub4) OCI_HTYPE_SESSION);
  if (svchp) OCIHandleFree((dvoid *)svchp, (ub4) OCI_HTYPE_SVCCTX);
  if (srvhp) OCIHandleFree((dvoid *)srvhp, (ub4) OCI_HTYPE_SERVER);
  if (errhp) OCIHandleFree((dvoid *)errhp, (ub4) OCI_HTYPE_ERROR);
  if (envhp) OCIHandleFree((dvoid *)envhp, (ub4) OCI_HTYPE_ENV);
  return;
}

void main()
{
  OCIType *xmltdo;
  xmldocnode  *doc;
  ocixmldbparam params[1];
  xmlerr       err;
  xmlctx  *xctx;
  oratext *ins_stmt;
  sword    status;
  xmlnode *root;
  oratext buf[10000];

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_connect();

  /* Get an XML context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &dur;
  xctx = OCIXmlDbInitXmlCtx(envhp, svchp, errhp, params, 1);
  if (!(doc = XmlLoadDom(xctx, &err, "file", filename,
                         "schema_location", schemaloc, NULL)))
    {
      printf("Parse failed.\n");
      return;
    }
  else
    printf("Parse succeeded.\n");
  root = XmlDomGetDocElem(xctx, doc);
  printf("The xml document is :\n");
  XmlSaveDom(xctx, &err, (xmlnode *)doc, "buffer", buf, "buffer_length", 10000, NULL);
  printf("%s\n", buf);

  /* Insert the document into my_table */
  ins_stmt = (oratext *)"insert into purchaseorder values (:1)";
  status = OCITypeByName(envhp, errhp, svchp, (const text *) "SYS",
                         (ub4) strlen((const char *)"SYS"), (const text *) "XMLTYPE",
```

```
                        (ub4) strlen((const char *)"XMLTYPE"), (CONST text *) 0,
                        (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                        (OCIType **) &xmltdo);
  if (status == OCI_SUCCESS)
    {
      status = exec_bind_xml(svchp, errhp, stmthp, (void *)doc,
                             xmltdo, ins_stmt);
    }
  if (status == OCI_SUCCESS)
    printf ("Insert successful\n");
  else
    printf ("Insert failed\n");

  /* Free XML instances */
  if (doc) XmlFreeDocument((xmlctx *)xctx, (xmldocnode *)doc);

  /* Free XML CTX */
  OCIXmlDbFreeXmlCtx(xctx);
  free_oci();
}
```

Initializing and Terminating an XML Context (OCI)

Example A–4 shows how to use OCI functions `OCIXmlDbInitXmlCtx()` and `OCIXmlDbFreeXmlCtx()` to initialize and terminate the XML context. It constructs an XML document using the C DOM API and saves it to the database.

Example A–4 is partially listed in Chapter 15, "Using the C API for XML", "Initializing and Terminating an XML Context" on page 15-3. It assumes that the following SQL code has first been executed to create table `my_table` in database schema `CAPIUSER`:

```
CONNECT CAPIUSER/CAPIUSER
CREATE TABLE my_table OF XMLType;
```

Example A–4 Using OCIXmlDbInitXmlCtx() and OCIXmlDbFreeXmlCtx()

```
#ifndef S_ORACLE
#include <s.h>
#endif
#ifndef ORATYPES_ORACLE
#include <oratypes.h>
#endif
#ifndef XML_ORACLE
#include <xml.h>
#endif
#ifndef OCIXML_ORACLE
#include <ocixml.h>
#endif
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#include <string.h>

typedef struct test_ctx {
        OCIEnv *envhp;
        OCIError *errhp;
        OCISvcCtx *svchp;
        OCIStmt *stmthp;
        OCIServer *srvhp;
        OCIDuration dur;
        OCISession *sesshp;
        oratext *username;
```

```
        oratext *password;
} test_ctx;

/* Helper function 1: execute a sql statement which binds xml data */
STATICF sword exec_bind_xml(OCISvcCtx *svchp,
                    OCIError *errhp,
                    OCIStmt *stmthp,
                    void *xml,
                    OCIType *xmltdo,
                    OraText *sqlstmt);

/* Helper function 2: Initialize OCI handles and connect */
STATICF sword init_oci_handles(test_ctx *ctx);

/* Helper function 3: Free OCI handles and disconnect */
STATICF sword free_oci_handles(test_ctx *ctx);

void main()
{
  test_ctx temp_ctx;
  test_ctx *ctx = &temp_ctx;
  OCIType *xmltdo = (OCIType *) 0;
  xmldocnode *doc = (xmldocnode *)0;
  ocixmldbparam params[1];
  xmlnode *quux, *foo, *foo_data, *top;
  xmlerr err;
  sword status = 0;
  xmlctx *xctx;

  oratext ins_stmt[] = "insert into my_table values (:1)";
  oratext tlpxml_test_sch[] = "<TOP/>";
  ctx->username = (oratext *)"CAPIUSER";
  ctx->password = (oratext *)"CAPIUSER";

  /* Initialize envhp, svchp, errhp, dur, stmthp */
  init_oci_handles(ctx);

  /* Get an xml context */
  params[0].name_ocixmldbparam = XCTXINIT_OCIDUR;
  params[0].value_ocixmldbparam = &ctx->dur;
  xctx = OCIXmlDbInitXmlCtx(ctx->envhp, ctx->svchp, ctx->errhp, params, 1);

  /* Start processing - first, check that this DOM supports XML 1.0 */
  printf("\n\nSupports XML 1.0? : %s\n",
         XmlHasFeature(xctx, (oratext *) "xml", (oratext *) "1.0") ?
         "YES" : "NO");

  /* Parse a document */
  if (!(doc = XmlLoadDom(xctx, &err, "buffer", tlpxml_test_sch,
                         "buffer_length", sizeof(tlpxml_test_sch)-1,
                         "validate", TRUE, NULL)))
  {
    printf("Parse failed, code %d\n", err);
  }
  else
  {
    /* Get the document element */
    top = (xmlnode *)XmlDomGetDocElem(xctx, doc);

    /* Print out the top element */
```

```
    printf("\n\nOriginal top element is :\n");
    XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

    /* Print out the document-note that the changes are reflected here */
    printf("\n\nOriginal document is :\n");
    XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

    /* Create some elements and add them to the document */
    quux = (xmlnode *) XmlDomCreateElem(xctx ,doc, (oratext *) "QUUX");
    foo = (xmlnode *) XmlDomCreateElem(xctx, doc, (oratext *) "FOO");
    foo_data = (xmlnode *) XmlDomCreateText(xctx, doc, (oratext *) "data");
    foo_data = XmlDomAppendChild(xctx, (xmlnode *) foo, (xmlnode *) foo_data);
    foo = XmlDomAppendChild(xctx, quux, foo);
    quux = XmlDomAppendChild(xctx, top, quux);

    /* Print out the top element */
    printf("\n\nNow the top element is :\n");
    XmlSaveDom(xctx, &err, top, "stdio", stdout, NULL);

    /* Print out the document. Note that the changes are reflected here */
    printf("\n\nNow the document is :\n");
    XmlSaveDom(xctx, &err, (xmlnode *)doc, "stdio", stdout, NULL);

    /* Insert the document into my_table */
    status = OCITypeByName(ctx->envhp, ctx->errhp, ctx->svchp,
                           (const text *) "SYS", (ub4) strlen((char *)"SYS"),
                           (const text *) "XMLTYPE",
                           (ub4) strlen((char *)"XMLTYPE"), (CONST text *) 0,
                           (ub4) 0, OCI_DURATION_SESSION, OCI_TYPEGET_HEADER,
                           (OCIType **) &xmltdo);
    if (status == OCI_SUCCESS)
    {
      exec_bind_xml(ctx->svchp, ctx->errhp, ctx->stmthp, (void *)doc, xmltdo,
                    ins_stmt);
    }
  }
  /* Free xml ctx */
  OCIXmlDbFreeXmlCtx(xctx);

  /* Free envhp, svchp, errhp, stmthp */
  free_oci_handles(ctx);
}

/* Helper function 1: execute a SQL statement that binds xml data */
STATICF sword exec_bind_xml(OCISvcCtx *svchp,
                    OCIError *errhp,
                    OCIStmt *stmthp,
                    void *xml,
                    OCIType *xmltdo,
                    OraText *sqlstmt)
{
  OCIBind *bndhp1 = (OCIBind *) 0;
  sword status = 0;
  OCIInd ind = OCI_IND_NOTNULL;
  OCIInd *indp = &ind;
  if(status = OCIStmtPrepare(stmthp, errhp, (OraText *)sqlstmt,
                             (ub4)strlen((char *)sqlstmt),
                             (ub4) OCI_NTV_SYNTAX, (ub4) OCI_DEFAULT)) {
    printf("Failed OCIStmtPrepare\n");
    return OCI_ERROR;
```

```
  }
  if(status = OCIBindByPos(stmthp, &bndhp1, errhp, (ub4) 1, (dvoid *) 0,
                           (sb4) 0, SQLT_NTY, (dvoid *) 0, (ub2 *)0,
                           (ub2 *)0, (ub4) 0, (ub4 *) 0, (ub4) OCI_DEFAULT)) {
    printf("Failed OCIBindByPos\n");
    return OCI_ERROR;
  }
  if(status = OCIBindObject(bndhp1, errhp, (CONST OCIType *) xmltdo, (dvoid **)
                            &xml,
                            (ub4 *) 0, (dvoid **) &indp, (ub4 *) 0)) {
    printf("Failed OCIBindObject\n");
    return OCI_ERROR;
  }
  if(status = OCIStmtExecute(svchp, stmthp, errhp, (ub4) 1, (ub4) 0,
                             (CONST OCISnapshot*) 0, (OCISnapshot*) 0,
                             (ub4) OCI_DEFAULT)) {
    printf("Failed OCIStmtExecute\n");
    return OCI_ERROR;
  }
  return OCI_SUCCESS;
}

/* Helper function 2: Initialize OCI handles and connect */
STATICF sword init_oci_handles(test_ctx *ctx)
{
  sword status;
  ctx->dur = OCI_DURATION_SESSION;
  if (OCIEnvCreate((OCIEnv **) &(ctx->envhp), (ub4) OCI_OBJECT,
                   (dvoid *) 0, (dvoid * (*)(dvoid *,size_t)) 0,
                   (dvoid * (*)(dvoid *, dvoid *, size_t)) 0,
                   (void (*)(dvoid *, dvoid *)) 0, (size_t) 0, (dvoid **) 0))
  {
    printf("FAILED: OCIEnvCreate()\n");
    return OCI_ERROR;
  }
  /* Allocate error handle */
  if (OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &(ctx->errhp),
                     (ub4) OCI_HTYPE_ERROR, (size_t) 0, (dvoid **) 0))
  {
    printf("FAILED: OCIHandleAlloc() on errhp\n");
    return OCI_ERROR;
  }
  /* Allocate server handle */
  if (status = OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &ctx->srvhp,
                           (ub4) OCI_HTYPE_SERVER, (size_t) 0, (dvoid **) 0))
  {
    printf("FAILED: OCIHandleAlloc() on srvhp\n");
    return OCI_ERROR;
  }
  /* Allocate service context handle */
  if (status = OCIHandleAlloc((dvoid *) ctx->envhp,
                              (dvoid **) &(ctx->svchp), (ub4) OCI_HTYPE_SVCCTX,
                              (size_t) 0, (dvoid **) 0))
  {
    printf("FAILED: OCIHandleAlloc() on svchp\n");
    return OCI_ERROR;
  }
  /* Allocate session handle */
  if (status = OCIHandleAlloc((dvoid *) ctx->envhp, (dvoid **) &ctx->sesshp ,
                           (ub4) OCI_HTYPE_SESSION, (size_t) 0, (dvoid **) 0))
```

```
{
  printf("FAILED: OCIHandleAlloc() on sesshp\n");
  return OCI_ERROR;
}
/* Allocate statement handle */
if (OCIHandleAlloc((dvoid *)ctx->envhp, (dvoid **) &ctx->stmthp,
                   (ub4)OCI_HTYPE_STMT, (CONST size_t) 0, (dvoid **) 0))
{
  printf("FAILED: OCIHandleAlloc() on stmthp\n");
  return status;
}
if (status = OCIServerAttach((OCIServer *) ctx->srvhp, (OCIError *) ctx->errhp,
                             (CONST oratext *)"", 0, (ub4) OCI_DEFAULT))
{
  printf("FAILED: OCIServerAttach() on srvhp\n");
  return OCI_ERROR;
}
/* Set server attribute to service context */
if (status = OCIAttrSet((dvoid *) ctx->svchp, (ub4) OCI_HTYPE_SVCCTX,
                        (dvoid *) ctx->srvhp, (ub4) 0, (ub4) OCI_ATTR_SERVER,
                        (OCIError *) ctx->errhp))
{
  printf("FAILED: OCIAttrSet() on svchp\n");
  return OCI_ERROR;
}
/* Set user attribute to session */
if (status = OCIAttrSet((dvoid *)ctx->sesshp, (ub4) OCI_HTYPE_SESSION,
                        (dvoid *)ctx->username,
                        (ub4) strlen((char *)ctx->username),
                        (ub4) OCI_ATTR_USERNAME, (OCIError *) ctx->errhp))
{
  printf("FAILED: OCIAttrSet() on authp for user\n");
  return OCI_ERROR;
}
/* Set password attribute to session */
if (status = OCIAttrSet((dvoid *) ctx->sesshp, (ub4) OCI_HTYPE_SESSION,
                        (dvoid *)ctx->password,
                        (ub4) strlen((char *)ctx->password),
                        (ub4) OCI_ATTR_PASSWORD, (OCIError *) ctx->errhp))
{
  printf("FAILED: OCIAttrSet() on authp for password\n");
  return OCI_ERROR;
}
/* Begin a session  */
if (status = OCISessionBegin((OCISvcCtx *) ctx->svchp,
                             (OCIError *) ctx->errhp,
                             (OCISession *) ctx->sesshp, (ub4) OCI_CRED_RDBMS,
                             (ub4) OCI_STMT_CACHE))
{
  printf("FAILED: OCISessionBegin(). Make sure database is up and the \
          username/password is valid. \n");
  return OCI_ERROR;
}
/* Set session attribute to service context */
if (status = OCIAttrSet((dvoid *) ctx->svchp, (ub4) OCI_HTYPE_SVCCTX,
                        (dvoid *)ctx->sesshp, (ub4) 0, (ub4) OCI_ATTR_SESSION,
                        (OCIError *) ctx->errhp))
{
  printf("FAILED: OCIAttrSet() on svchp\n");
  return OCI_ERROR;
```

```
  }
  return status;
}

/* Helper function 3: Free OCI handles and disconnect */
STATICF sword free_oci_handles(test_ctx *ctx)
{
  sword  status = 0;
  /* End the session */
  if (status = OCISessionEnd((OCISvcCtx *)ctx->svchp, (OCIError *)ctx->errhp,
                             (OCISession *)ctx->sesshp, (ub4) OCI_DEFAULT))
  {
    if (ctx->envhp)
      OCIHandleFree((dvoid *)ctx->envhp, OCI_HTYPE_ENV);
    return status;
  }
  /* Detach from the server */
  if (status = OCIServerDetach((OCIServer *)ctx->srvhp, (OCIError *)ctx->errhp,
      (ub4)OCI_DEFAULT))
  {
    if (ctx->envhp)
      OCIHandleFree((dvoid *)ctx->envhp, OCI_HTYPE_ENV);
    return status;
  }
  /* Free the handles */
  if (ctx->stmthp) OCIHandleFree((dvoid *)ctx->stmthp, (ub4) OCI_HTYPE_STMT);
  if (ctx->sesshp) OCIHandleFree((dvoid *)ctx->sesshp, (ub4) OCI_HTYPE_SESSION);
  if (ctx->svchp)  OCIHandleFree((dvoid *)ctx->svchp,  (ub4) OCI_HTYPE_SVCCTX);
  if (ctx->srvhp)  OCIHandleFree((dvoid *)ctx->srvhp,  (ub4) OCI_HTYPE_SERVER);
  if (ctx->errhp)  OCIHandleFree((dvoid *)ctx->errhp,  (ub4) OCI_HTYPE_ERROR);
  if (ctx->envhp)  OCIHandleFree((dvoid *)ctx->envhp,  (ub4) OCI_HTYPE_ENV);
  return status;
}
```

B

Oracle XML DB Restrictions

This appendix describes the restrictions associated with Oracle XML DB.

- *Extending Resource Metadata Properties* – You cannot extend the resource schema. However, you can set and access custom properties belonging to other namespaces, other than `XDBResource.xsd`, using DOM operations on the `<Resource>` document.
- *References Within Scalars* – Oracle does not support references within a scalar, `XMLType`, or LOB data column.
- *Thin JDBC Driver Not Supported by Some XMLType Functions* – Methods `extract()`, `transform()`, and `existsNode()` work with the *thick* JDBC driver only. Not all `oracle.xdb.XMLType` functions are supported by the thin JDBC driver. If you do not use `oracle.xdb.XMLType` classes and the OCI driver, you could lose performance benefits.
- *NCHAR, NVARCHAR and NCLOB Not Supported for SQLType* – Oracle XML DB does not support `NCHAR`, `NVARCHAR`, and `NCLOB` as `SQLType`. You cannot specify that an element is to be of type `NCHAR`, `NVARCHAR`, or `NCLOB`. Also, if you provide your own type, do not use any of these data types.
- *Identifier Length Limited to 4000 Characters* – Oracle XML DB supports only XML identifiers that are 4000 characters long, or shorter.

> **See Also:** "Oracle XML DB Support for XQuery" on page 18-36 for information about Oracle XML DB support for XQuery

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