

# Oracle9i

Java Developer's Guide

Release 2 (9.2)

March 2002

Part No. A96656-01

ORACLE®

---

Oracle9i Java Developer's Guide, Release 2 (9.2)

Part No. A96656-01

Copyright © 2000, 2002 Oracle Corporation. All rights reserved.

Primary Author: Sheryl Maring

Contributors: Steve Harris, Ellen Barnes, Peter Benson, Greg Colvin, Bill Courington, Matthieu Devin, Jim Haungs, Hal Hildebrand, Mark Jungerman, Susan Kraft, Thomas Kurian, Scott Meyer, Tom Portfolio, Dave Rosenberg, Jerry Schwarz, Harlan Sexton, Tim Smith, David Unietis, Brian Wright.

The Programs (which include both the software and documentation) contain proprietary information of Oracle Corporation; they are provided under a license agreement containing restrictions on use and disclosure and are also protected by copyright, patent and other intellectual and industrial property laws. Reverse engineering, disassembly or decompilation of the Programs, except to the extent required to obtain interoperability with other independently created software or as specified by law, is prohibited.

The information contained in this document is subject to change without notice. If you find any problems in the documentation, please report them to us in writing. Oracle Corporation does not warrant that this document is error-free. Except as may be expressly permitted in your license agreement for these Programs, no part of these Programs may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, without the express written permission of Oracle Corporation.

If the Programs are delivered to the U.S. Government or anyone licensing or using the programs on behalf of the U.S. Government, the following notice is applicable:

**Restricted Rights Notice** Programs delivered subject to the DOD FAR Supplement are "commercial computer software" and use, duplication, and disclosure of the Programs, including documentation, shall be subject to the licensing restrictions set forth in the applicable Oracle license agreement. Otherwise, Programs delivered subject to the Federal Acquisition Regulations are "restricted computer software" and use, duplication, and disclosure of the Programs shall be subject to the restrictions in FAR 52.227-19, Commercial Computer Software - Restricted Rights (June, 1987). Oracle Corporation, 500 Oracle Parkway, Redwood City, CA 94065.

The Programs are not intended for use in any nuclear, aviation, mass transit, medical, or other inherently dangerous applications. It shall be the licensee's responsibility to take all appropriate fail-safe, backup, redundancy, and other measures to ensure the safe use of such applications if the Programs are used for such purposes, and Oracle Corporation disclaims liability for any damages caused by such use of the Programs.

Oracle is a registered trademark, and Oracle9i, Oracle8i, PL/SQL, and SQL\*Plus are trademarks or registered trademarks of Oracle Corporation. Other names may be trademarks of their respective owners.

---

---

# Contents

<b>Send Us Your Comments .....</b>	<b>xi</b>
<b>Preface.....</b>	<b>xiii</b>
Who Should Read This Book?.....	xiii
Java API Programming Models.....	xiv
Java Information Resources.....	xiv
Documentation Accessibility .....	xv
<b>1 Introduction to Java in Oracle9i</b>	
<b>Chapter Contents .....</b>	<b>1-2</b>
<b>What's New in this Release?.....</b>	<b>1-2</b>
Upgrading to JDK 1.3.....	1-2
Desupport of J2EE Technologies in the Oracle Database .....	1-3
Additions to the loadjava Tool .....	1-3
Replacement of the sess_sh tool with ojvmjava .....	1-4
Debugger Modifications .....	1-4
<b>Overview of Java.....</b>	<b>1-5</b>
Java and Object-Oriented Programming Terminology.....	1-5
Classes.....	1-5
Attributes.....	1-6
Methods .....	1-7
Class Hierarchy.....	1-7
Interfaces.....	1-8
Polymorphism.....	1-9

The Java Virtual Machine (JVM).....	1-10
Key Features of the Java Language .....	1-13
<b>Why Use Java in Oracle9i?</b> .....	1-14
Multithreading .....	1-14
Automated Storage Management .....	1-15
Footprint.....	1-16
Performance.....	1-17
How Native Compilers Improve Performance .....	1-17
Dynamic Class Loading.....	1-18
<b>Oracle’s Java Application Strategy</b> .....	1-19
Java Stored Procedures .....	1-19
PL/SQL Integration and Oracle RDBMS Functionality.....	1-20
JDBC Drivers .....	1-20
SQLJ – Embedded SQL in Java .....	1-21
Development Tools.....	1-22
<b>Overview of Oracle9i Java Documentation</b> .....	1-22

## 2 Writing Java Applications on Oracle9i

<b>Overview</b> .....	2-2
Terminology .....	2-2
<b>Database Sessions Imposed on Java Applications</b> .....	2-3
Java Supported APIs .....	2-5
<b>Execution Control</b> .....	2-6
<b>Java Code, Binaries, and Resources Storage</b> .....	2-6
<b>Preparing Java Class Methods for Execution</b> .....	2-8
Compiling Java Classes.....	2-8
Compiling Source Through javac.....	2-8
Compiling Source Through loadjava.....	2-8
Compiling Source at Runtime.....	2-9
Specifying Compiler Options .....	2-9
Automatic Recompilation.....	2-11
Resolving Class Dependencies .....	2-12
Allowing References to Non-Existent Classes .....	2-14
ByteCode Verifier .....	2-15
Loading Classes.....	2-16

Defining the Same Class Twice .....	2-18
Designating Database Privileges and JVM Permissions.....	2-19
Loading JAR or ZIP Files.....	2-19
How to Grant Execute Rights .....	2-19
Controlling the Current User .....	2-21
Checking Java Uploads.....	2-23
Object Name and Type .....	2-23
Status .....	2-24
Publishing .....	2-25
<b>User Interfaces on the Server</b> .....	2-25
<b>Shortened Class Names</b> .....	2-26
<b>Class.forName() in Oracle9i</b> .....	2-27
Supply the ClassLoader in Class.forName .....	2-28
Supply Class and Schema Names to classForNameAndSchema .....	2-29
Supply Class and Schema Names to lookupClass.....	2-30
Supply Class and Schema Names when Serializing .....	2-30
Class.forName Example .....	2-31
<b>Managing Your Operating System Resources</b> .....	2-32
Overview of Operating System Resources .....	2-32
Operating System Resource Access .....	2-33
Operating System Resource Lifetime .....	2-33
Referencing Files with Relative Path Names.....	2-34
Garbage Collection and Operating System Resources.....	2-34
Operating System Resources Affected Across Calls .....	2-35
Sockets.....	2-37
<b>Threading in Oracle9i</b> .....	2-38
Thread Lifecycle .....	2-39

### 3 Invoking Java in the Database

<b>Overview</b> .....	3-2
<b>Invoking Java Methods</b> .....	3-3
Utilizing Java Stored Procedures .....	3-3
Utilizing Remote Method Invocation (RMI).....	3-5
Utilizing Java Native Interface (JNI) Support .....	3-5
Utilizing SQLJ and JDBC for Querying the Database .....	3-6

JDBC .....	3-6
SQLJ .....	3-7
An Example Comparing JDBC and SQLJ.....	3-7
Complete SQLJ Example.....	3-9
SQLJ Strong Typing Paradigm .....	3-10
Translating a SQLJ Program .....	3-11
Running a SQLJ Program in the Server.....	3-11
Converting a Client Application to Run in the Server .....	3-12
Interacting with PL/SQL.....	3-12
<b>Debugging Server Applications.....</b>	<b>3-13</b>
The Debug Agent Protocol .....	3-13
1. Prepare the Code for Debugging .....	3-14
2. Start the Debug Proxy .....	3-15
3. Starting, Stopping, and Restarting the Debug Agent.....	3-16
OracleAgent Class .....	3-17
4. Connecting a Debugger .....	3-18
<b>How To Tell You Are Executing in the Server .....</b>	<b>3-20</b>
<b>Redirecting Output on the Server.....</b>	<b>3-20</b>

## 4 Java Installation and Configuration

<b>Initializing a Java-Enabled Database.....</b>	<b>4-2</b>
Oracle9i Database Template Configuration and Install.....	4-2
Modifying an Existing Oracle9i Database to Include Oracle JVM .....	4-2
<b>Configuring Oracle JVM.....</b>	<b>4-2</b>
<b>Using The DBMS_JAVA Package .....</b>	<b>4-3</b>
<b>Enabling the Java Client.....</b>	<b>4-6</b>
1. Install JDK on the Client .....	4-6
2. Set up Environment Variables .....	4-6
JAR Files Necessary for JDK 1.1 Clients.....	4-6
JAR Files Necessary for Java 2 Clients.....	4-7
JAR Files Included for Clients that use SQLJ.....	4-8
Server Application Development on the Client .....	4-8
3. Test Install with Samples .....	4-8

## 5 Security For Oracle9i Java Applications

Network Connection Security .....	5-2
Database Contents and JVM Security .....	5-2
Java 2 Security .....	5-3
Setting Permissions .....	5-5
Fine-Grain Definition for Each Permission.....	5-7
Acquiring Administrative Permission to Update Policy Table .....	5-12
Creating Permissions .....	5-14
Enabling or Disabling Permissions.....	5-18
Permission Types.....	5-19
Initial Permission Grants.....	5-21
General Permission Definition Assigned to Roles.....	5-24
Debugging Permissions.....	5-25
Permission for Loading Classes.....	5-25

## 6 Oracle9i Java Application Performance

Natively Compiled Code.....	6-2
Accelerator Overview .....	6-3
Oracle9i Core Java Class Libraries .....	6-5
Natively Compiling Java Application Class Libraries .....	6-5
Installation Requirements .....	6-5
Executing Accelerator .....	6-7
ncomp.....	6-7
Syntax.....	6-8
Argument Summary .....	6-8
Argument Details .....	6-10
Errors.....	6-11
Native Compilation Usage Scenarios .....	6-13
Natively Compiling on Test Platform—Java Classes Already Loaded in the Database .....	6-13
Natively Compiling Java Classes Not Loaded in the Database .....	6-13
Clean Compile and Generate Output for Future Deployment.....	6-14
Controlling Native Compilation Build Environment .....	6-14
Natively Compiling Specific Classes .....	6-15
Natively Compiling Packages That Are Fully or Partially Modified .....	6-15

deploync.....	6-16
Syntax.....	6-16
Argument Summary .....	6-16
statusnc.....	6-17
Syntax.....	6-18
Argument Summary .....	6-18
<b>Java Memory Usage .....</b>	<b>6-19</b>
Configuring Memory Initialization Parameters.....	6-19
Initializing Pool Sizes within Database Templates.....	6-20
Java Pool Memory.....	6-21
Displaying Used Amounts of Java Pool Memory.....	6-22
Correcting Out of Memory Errors.....	6-24
Running out of memory while compiling .....	6-24
Running out of memory while loading.....	6-24
<b>End-of-Call Migration.....</b>	<b>6-25</b>
Oracle-Specific Support for End-of-Call Optimization.....	6-26
<b>Memory Profiling Utility.....</b>	<b>6-30</b>
How MemStat Works.....	6-31
Using MemStat.....	6-31
MemStat Permissions.....	6-33
The MemStat Report Format.....	6-34

## 7 Schema Object Tools

<b>Schema Object Tool Overview .....</b>	<b>7-2</b>
<b>What and When to Load .....</b>	<b>7-2</b>
<b>Resolution.....</b>	<b>7-3</b>
<b>Digest Table.....</b>	<b>7-4</b>
<b>Compilation .....</b>	<b>7-5</b>
loadjava.....	7-7
dropjava .....	7-23
ojvmjava.....	7-27

## Glossary

## Index



---

---

# Send Us Your Comments

**Oracle9i Java Developer's Guide, Release 2 (9.2)**

**Part No. A96656-01**

Oracle Corporation welcomes your comments and suggestions on the quality and usefulness of this document. Your input is an important part of the information used for revision.

- Did you find any errors?
- Is the information clearly presented?
- Do you need more information? If so, where?
- Are the examples correct? Do you need more examples?
- What features did you like most?

If you find any errors or have any other suggestions for improvement, please indicate the document title and part number, and the chapter, section, and page number (if available). You can send comments to us in the following ways:

- Electronic mail: [jpgcomment\\_us@oracle.com](mailto:jpgcomment_us@oracle.com)
- FAX: (650) 506-7225 Attn: Java Platform Group, Information Development Manager
- Postal service:  
Oracle Corporation  
Java Platform Group, Information Development Manager  
500 Oracle Parkway, Mailstop 4op9  
Redwood Shores, CA 94065  
USA

If you would like a reply, please give your name, address, telephone number, and (optionally) electronic mail address.

If you have problems with the software, please contact your local Oracle Support Services.



---

---

# Preface

## Who Should Read This Book?

This book has been written for the following audiences:

- **Management**—You may have purchased Oracle9i for reasons other than Java development within the database. However, if you want to know more about Oracle9i Java features, see "[Overview of Oracle9i Java Documentation](#)" on page 1-22 for a management perspective.
- **Non-Java Developers**—Oracle database programming consists of PL/SQL and other non-Java programming. For experienced PL/SQL developers who are not familiar with Java, a brief overview of Java and object-oriented concepts is discussed in the first part of [Chapter 1, "Introduction to Java in Oracle9i"](#). For more detailed information on Java, see "[Java Information Resources](#)" at the end of this Preface.
- **Java Developers**—Pure Java developers are used to a Java environment that follows the Sun Microsystems specification. However, when Java is combined in the database, both Java and database concepts merge. Thus, the Java environment within Oracle9i is expanded to include database concerns. The bulk of this book discusses how to execute Java in the database. The following outlines the two viewpoints that arise from this merge:
  - \* **Java environment**—Note that Oracle9i delivers a compliant Java implementation—any 100% pure Java code will work. Oracle9i JVM affects your Java development in the way you manage your classes, and the environment in which your classes exist. For example, the classes must be loaded into the database. In addition, there is a clearer separation of client and server in the Oracle9i model.

- \* Database environment—You need to be aware of database concepts for managing your Java objects. This book gives you a comprehensive view of how the two well-defined realms—the Oracle9i database and the Java environment—fit together. For example, when deciding on your security policies, you must consider both database security and Java security for a comprehensive security policy.

## Java API Programming Models

The building blocks that Java developers use in Oracle9i are as follows:

- Java stored procedures—You can develop Java applications that are stored in the database. Once loaded, these procedures can be invoked from SQL, PL/SQL, or as triggers. See the *Oracle9i Java Stored Procedures Developer's Guide* for more information.
- JDBC and SQLJ—You can write a Java application that accesses SQL data from the client, or directly on the server.

Each of these models is briefly discussed in [Chapter 1, "Introduction to Java in Oracle9i"](#) and examples are given in [Chapter 3, "Invoking Java in the Database"](#). Both of these chapters should help you decide which model to use for your particular application. Once you decide on the appropriate model, examine the appropriate developer's guide for in-depth information on each model. For example, if you decide to use Java stored procedures, examine *Oracle9i Java Stored Procedures Developer's Guide*.

## Java Information Resources

The following table lists the sources of current information discussed in the Java programming documentation suite:

Location	Description
<a href="http://java.sun.com/">http://java.sun.com/</a>	The Sun Microsystems Web site that is the central source for Java. This site contains Java products and information, such as tutorials, book recommendations, and the Java Developer's Kit (JDK). The JDK is located at <a href="http://java.sun.com/products">http://java.sun.com/products</a>
<a href="http://java.sun.com/docs/books/jls">http://java.sun.com/docs/books/jls</a>	The Oracle9i Java Server is based on the Java Language Specification (JLS) and the Java virtual machine (JVM) specification.
<a href="http://java.sun.com/docs/books/vmspec">http://java.sun.com/docs/books/vmspec</a>	

---

Location	Description
comp.lang.java.programmer comp.lang.java.databases	Internet newsgroups can be a valuable source of information on Java from other Java developers. We recommend that you monitor these two newsgroups. Note: Oracle monitors activity on some of these newsgroups and posts responses to Oracle-specific issues.

---

## 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. Standards will continue to evolve over time, and Oracle Corporation 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 additional information, visit the Oracle Accessibility Program Web site at

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

**Accessibility of Code Examples in Documentation** JAWS, a Windows screen reader, 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, JAWS 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 Corporation does not own or control. Oracle Corporation neither evaluates nor makes any representations regarding the accessibility of these Web sites.



---

---

# Introduction to Java in Oracle9i

This book provides a general overview on how to develop, load, and execute your Java applications in the database.

This chapter contains the following information:

- [Chapter Contents](#)
- [What's New in this Release?](#)
- [Overview of Java](#)
- [Why Use Java in Oracle9i?](#)
- [Oracle's Java Application Strategy](#)
- [Overview of Oracle9i Java Documentation](#)

## Chapter Contents

This chapter covers the following three missions:

- Introduces the Java language for Oracle database programmers. Oracle PL/SQL developers are accustomed to developing server-side applications that have tight integration with SQL data. You can develop Java server-side applications that take advantage of the scalability and performance of the Oracle database. If you are not familiar with Java, see "[Overview of Java](#)" on page 1-5.
- Examines why you should consider using Java within an Oracle9i database. See "[Why Use Java in Oracle9i?](#)" on page 1-14. In addition, a brief description is given for each of the Java APIs supported within Oracle9i. The list of APIs include SQLJ, JDBC, and Java stored procedures. See "[Oracle's Java Application Strategy](#)" on page 1-19.
- Provides a roadmap to the Oracle9i Java documentation. Several Java APIs are supported within Oracle9i. Each API is described generally in this book, and more intimately in their own books. "[Overview of Oracle9i Java Documentation](#)" on page 1-22 shows you which books cover each Java application type in detail.

## What's New in this Release?

The following sections describe the additions to this release:

- [Upgrading to JDK 1.3](#)
- [Desupport of J2EE Technologies in the Oracle Database](#)
- [Additions to the loadjava Tool](#)
- [Replacement of the sess\\_sh tool with ojvmjava](#)
- [Debugger Modifications](#)

## Upgrading to JDK 1.3

In this release, the system classes are upgraded from JDK 1.2 to JDK 1.3. The JDK 1.3 is compatible with JDK 1.2. Sun Microsystems publishes the list of incompatibilities between the two versions at the following Web site:

<http://java.sun.com/products/jdk/1.2/compatibility.html>



## Desupport of J2EE Technologies in the Oracle Database

With the introduction of Oracle9i Application Server Containers for J2EE (OC4J)--a new, lighter-weight, easier-to-use, faster, and certified J2EE container--Oracle will desupport the Java 2 Enterprise Edition (J2EE) and CORBA stacks from the database, starting with Oracle9i database release 2. However, the database-embedded Java VM (Oracle JVM) will still be present and will continue to be enhanced to offer Java 2 Standard Edition (J2SE) features, Java stored procedures, JDBC, and SQLJ in the database.

As of Oracle9i database release 2 (9.2.0), Oracle will no longer support the following technologies in the database:

- the J2EE stack, consisting of:
  - Enterprise Beans (EJB) container
  - JavaServer Pages (JSP) container
  - Oracle9i Servlet Engine (OSE)
- the embedded Common Object Request Broker Architecture (CORBA) framework, based on Visibroker for Java

Customers will no longer be able to deploy servlets, JSP pages, EJBs, and CORBA objects in Oracle databases. Oracle9i database release 1 (9.0.1) will be the last database release to support the J2EE and CORBA stack. Oracle is encouraging customers to migrate existing J2EE applications running in the database to OC4J now.

## Additions to the `loadjava` Tool

New options have been added to the `loadjava` tool. Specifically, the `-genmissing` option enables you to do the following:

Determines what classes and methods are referred to by the classes that `loadjava` is asked to process. Any classes not found in the database or file arguments are called "missing" classes. This option generates dummy definitions for missing classes containing all referred to methods. It then loads the generated classes into the database. This processing happens before the class resolution.

Because detecting references from source is more difficult than detecting references from classfiles, and because source is not generally used for distributing libraries, `loadjava` will not attempt to do this processing for source files.

The schema in which the missing classes are loaded will be the one specified by the `-user` command-line option, even when referring classes are created in some other schema. The created classes will be flagged as such so that tools can recognize them. In particular, this is needed, so that the verifier can recognize generated classes.

See "[loadjava](#)" on page 1-2 for more information.

## Replacement of the `sess_sh` tool with `ojmjava`

With the removal of the EJB, JSP, and servlet APIs, there is no longer a need for most of the functionality of the `sess_sh` tool. Instead, a scaled-down version of this tool is made available in the `ojmjava` tool. See "[ojmjava](#)" on page 1-2 for more information.

## Debugger Modifications

Oracle9i furnishes a debugging capability that is useful for developers who use the JDK's `jdb` debugger. Two interfaces are supported.

- The debug Agent protocol that was introduced in Oracle8i, and is supported by JDK 1.2 and later versions of JDB. The class `DebugProxy` makes remote Java programs appear to be local. It lets any debugger that supports the `sun.tools.debug.Agent` protocol connect to a program as if the program were local. The proxy forwards requests to the server and returns results to the debugger.

For detailed instructions, see the *Oracle9i Java Developer's Guide*.

- The Java Debug Wire Protocol supported by JDK 1.3 and later versions of the Sun Microsystems JDB debugger (<http://java.sun.com/j2se/1.3/docs/guide/jpda/>, <http://java.sun.com/j2se/1.4/docs/guide/jpda/>.) The use of this interface is documented on OTN. The JDWP protocol supports many new features, including the ability to listen for connections (no more `DebugProxy`), change the values of variables while debugging, and evaluate arbitrary Java expressions, including method evaluation.

Oracle's JDeveloper provides a user-friendly integration with these debugging features. See the JDeveloper documentation for more information on how to debug your Java application through JDeveloper. Other independent IDE vendors will be able to integrate their own debuggers with Oracle9i.

## Overview of Java

Java has emerged as the object-oriented programming language of choice. It includes the following concepts:

- a Java virtual machine (JVM), which provides the fundamental basis for platform independence
- automated storage management techniques, the most visible of which is garbage collection
- language syntax that borrows from C and enforces strong typing

The result is a language that is object-oriented and efficient for application-level programs.

## Java and Object-Oriented Programming Terminology

This section covers some basic terminology of Java application development in the Oracle9i environment. The terms should be familiar to experienced Java programmers. A detailed discussion of object-oriented programming or of the Java language is beyond the scope of this book. Many texts, in addition to the complete language specification, are available at your bookstore and on the Internet. See "[Java Information Resources](#)" in the [Preface](#), and "Suggested Reading" in the *Oracle9i Java Stored Procedures Developer's Guide* for pointers to reference materials and for places to find Java-related information on the Internet.

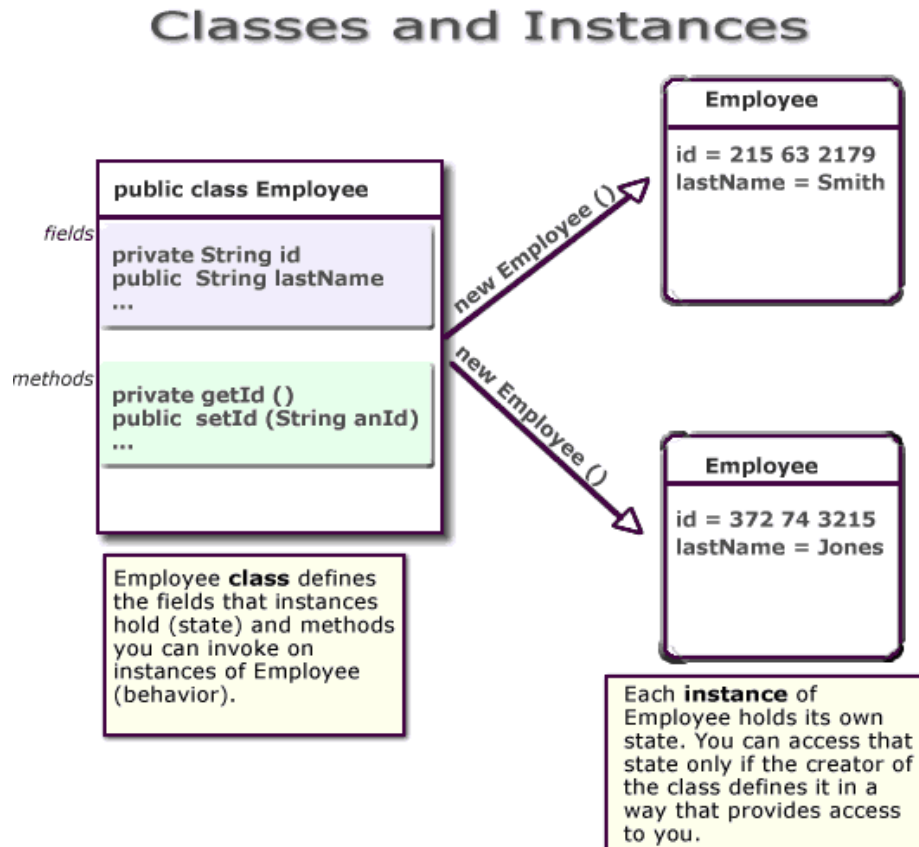
### Classes

All object-oriented programming languages support the concept of a class. As with a table definition, a class provides a template for objects that share common characteristics. Each class can contain the following:

- **Attributes**—static or instance variables that each object of a particular class possesses.
- **Methods**—you can invoke methods defined by the class or inherited by any classes extended from the class.

When you create an object from a class, you are creating an instance of that class. The instance contains the fields of an object, which are known as its data, or state. [Figure 1-1](#) shows an example of an `Employee` class defined with two attributes: last name (`lastName`) and employee identifier (`ID`).

Figure 1–1 Classes and Instances



When you create an instance, the attributes store individual and private information relevant only to the employee. That is, the information contained within an employee instance is known only for that single employee. The example in [Figure 1–1](#) shows two instances of employee—Smith and Jones. Each instance contains information relevant to the individual employee.

### Attributes

Attributes within an instance are known as fields. Instance fields are analogous to the fields of a relational table row. The class defines the fields, as well as the type of each field. You can declare fields in Java to be static, public, private, protected, or default access.

- Public, private, protected, or default access fields are created within each instance.
- Static fields are like global variables in that the information is available to all instances of the employee class.

The language specification defines the rules of visibility of data for all fields. Rules of visibility define under what circumstances you can access the data in these fields.

## Methods

The class also defines the methods you can invoke on an instance of that class. Methods are written in Java and define the behavior of an object. This bundling of state and behavior is the essence of encapsulation, which is a feature of all object-oriented programming languages. If you define an `Employee` class, declaring that each employee's `id` is a private field, other objects can access that private field only if a method returns the field. In this example, an object could retrieve the employee's identifier by invoking the `Employee.getId()` method.

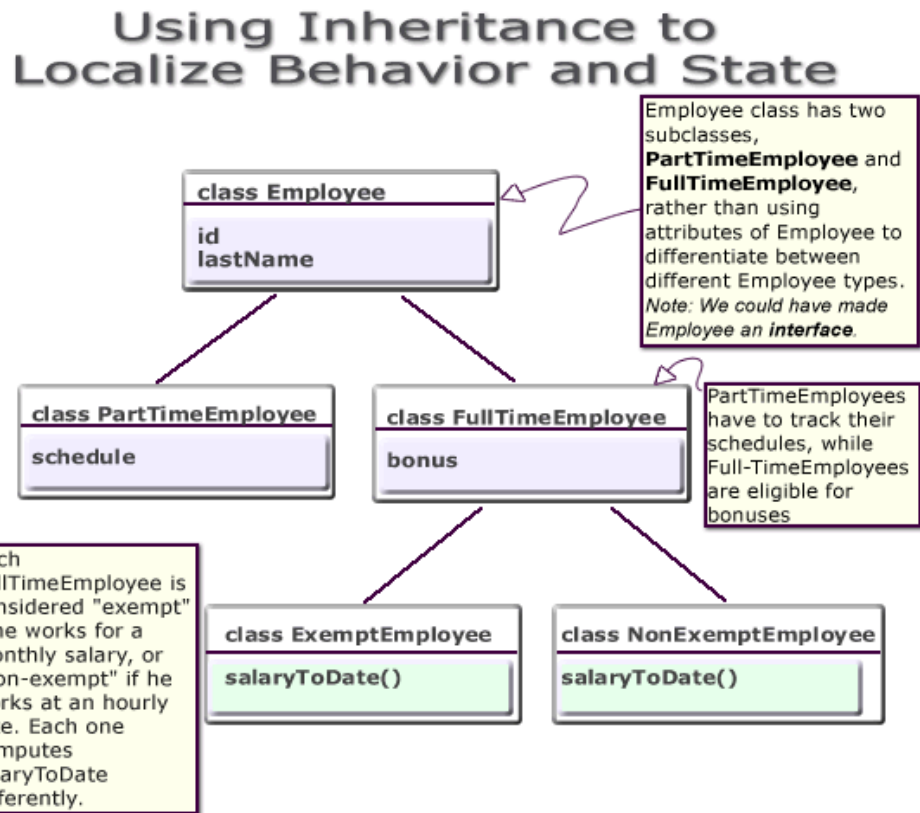
In addition, with encapsulation, you can declare that the `Employee.getId()` method is private, or you can decide not to write an `Employee.getId()` method. Encapsulation helps you write programs that are reusable and not misused. Encapsulation makes public only those features of an object that are declared public; all other fields and methods are private. Private fields and methods can be used for internal object processing.

## Class Hierarchy

Java defines classes within a large hierarchy of classes. At the top of the hierarchy is the `Object` class. All classes in Java inherit from the `Object` class at some level, as you walk up through the inheritance chain of superclasses. When we say Class B inherits from Class A, each instance of Class B contains all the fields defined in class B, as well as all the fields defined in Class A. For example, in [Figure 1-2](#), the `FullTimeEmployee` class contains the `id` and `lastName` fields defined in the `Employee` class, because it inherits from the `Employee` class. In addition, the `FullTimeEmployee` class adds another field, `bonus`, which is contained only within `FullTimeEmployee`.

You can invoke any method on an instance of Class B that was defined in either Class A or B. In our employee example, the `FullTimeEmployee` instance can invoke methods defined only within its own class, or methods defined within the `Employee` class.

Figure 1–2 Class Hierarchy



Instances of Class B are substitutable for instances of Class A, which makes inheritance another powerful construct of object-oriented languages for improving code reuse. You can create new classes that define behavior and state where it makes sense in the hierarchy, yet make use of pre-existing functionality in class libraries.

## Interfaces

Java supports only single inheritance; that is, each class has one and only one class from which it inherits. If you must inherit from more than one source, Java provides the equivalent of multiple inheritance, without the complications and confusion that usually accompany it, through interfaces. Interfaces are similar to classes; however, interfaces define method signatures, not implementations. The methods

are implemented in classes declared to implement an interface. Multiple inheritance occurs when a single class simultaneously supports many interfaces.

## Polymorphism

Assume in our `Employee` example that the different types of employees must be able to respond with their compensation to date. Compensation is computed differently for different kinds of employees.

- `FullTimeEmployees` are eligible for a bonus
- `NonExemptEmployees` get overtime pay

In traditional procedural languages, you would write a long switch statement, with the different possible cases defined.

```
switch: (employee.type) {
    case: Employee
        return employee.salaryToDate;
    case: FullTimeEmployee
        return employee.salaryToDate + employee.bonusToDate
    ...
}
```

If you add a new kind of `Employee`, you must update your switch statement. If you modify your data structure, you must modify all switch statements that use it. In an object-oriented language such as Java, you implement a method, `compensationToDate()`, for each subclass of `Employee` class that requires any special treatment beyond what is already defined in `Employee` class. For example, you could implement the `compensationToDate()` method of `NonExemptEmployee`, as follows:

```
private float compensationToDate() {
    return super.compensationToDate() + this.overtimeToDate();
}
```

You implement `FullTimeEmployee`'s method, as follows:

```
private float compensationToDate() {
    return super.compensationToDate() + this.bonusToDate();
}
```

The common usage of the method name `compensationToDate()` allows you to invoke the identical method on different classes and receive different results, without knowing the type of employee you are using. You do not have to write a special method to handle `FullTimeEmployees` and `PartTimeEmployees`. This

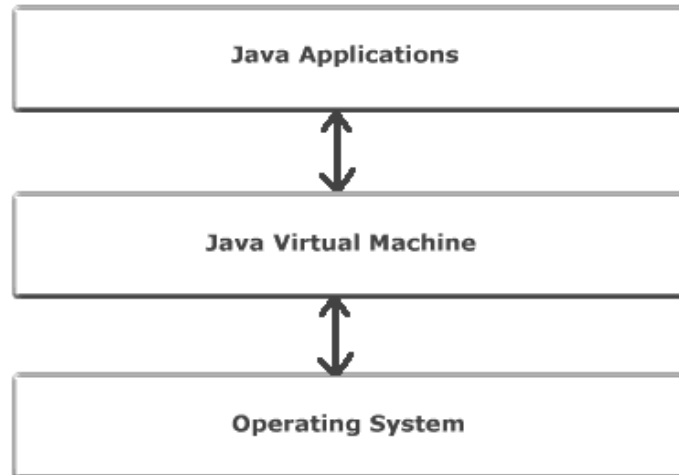
ability for the different objects to respond to the identical message in different ways is known as polymorphism.

In addition, you could create an entirely new class that does not inherit from `Employee` at all—`Contractor`—and implement a `compensationToDate()` method in it. A program that calculates total payroll to date would iterate over all people on payroll, regardless of whether they were full-time, part-time, or contractors, and add up the values returned from invoking the `compensationToDate()` method on each. You can safely make changes to the individual `compensationToDate()` methods with the knowledge that callers of the methods will work correctly. For example, you can safely add new fields to existing classes.

## The Java Virtual Machine (JVM)

As with other high-level computer languages, your Java source compiles to low-level machine instructions. In Java, these instructions are known as bytecodes (because their size is uniformly one byte of storage). Most other languages—such as C—compile to machine-specific instructions—such as instructions specific to an Intel or HP processor. Your Java source compiles to a standard, platform-independent set of bytecodes, which interacts with a Java virtual machine (JVM). The JVM is a separate program that is optimized for the specific platform on which you execute your Java code. [Figure 1-3](#) illustrates how Java can maintain platform independence. Your Java source is compiled into bytecodes, which are platform independent. Each platform has installed a JVM that is specific to its operating system. The Java bytecodes from your source get interpreted through the JVM into appropriate platform dependent actions.

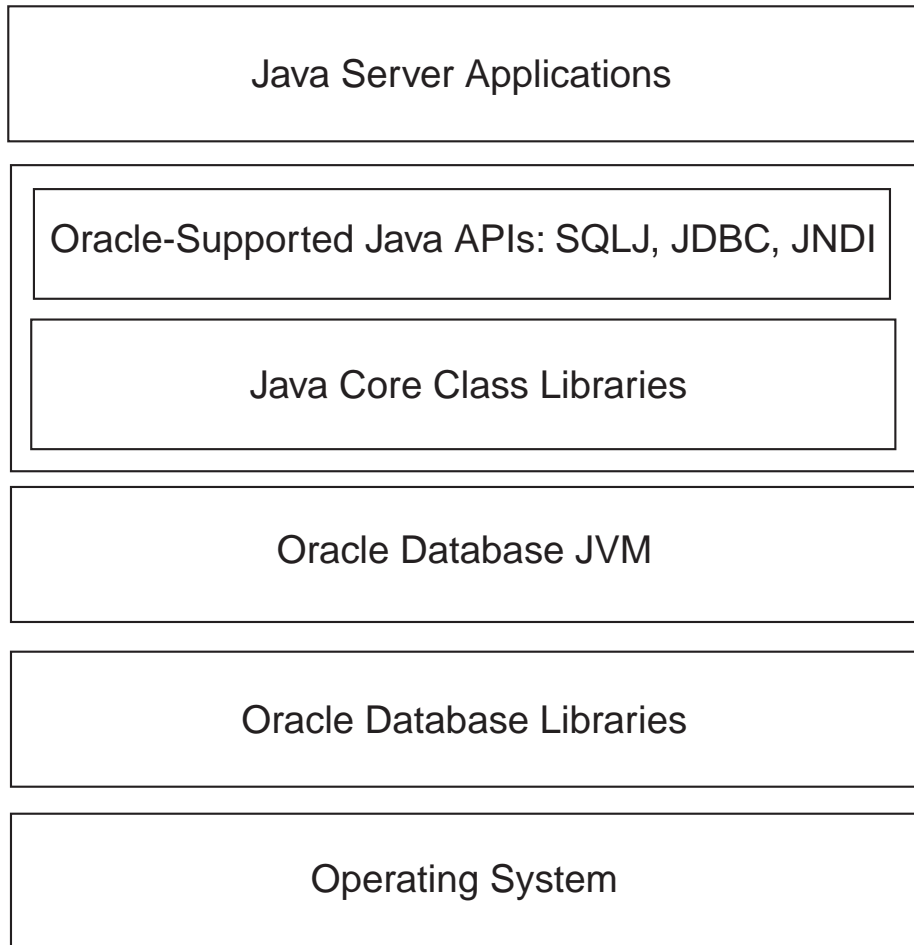


**Figure 1–3 Java Component Structure**

When you develop a Java program, you use predefined core class libraries written in the Java language. The Java core class libraries are logically divided into packages that provide commonly-used functionality, such as basic language support (`java.lang`), input/output (`java.io`), and network access (`java.net`). Together, the JVM and core class libraries provide a platform on which Java programmers can develop with the confidence that any hardware and operating system that supports Java will execute their program. This concept is what drives the “write once, run anywhere” idea of Java.

[Figure 1–4](#) illustrates how Oracle’s Java applications sit on top of the Java core class libraries, which in turn sit on top of the JVM. Because Oracle’s Java support system is located within the database, the JVM interacts with the Oracle database libraries, instead of directly with the operating system.

**Figure 1–4 Oracle9i Java Component Structure**



Sun Microsystems furnishes publicly available specifications for both the Java language and the JVM. The Java Language Specification (JLS) defines things such as syntax and semantics; the JVM specification defines the necessary low-level behavior for the “machine” that executes the bytecodes. In addition, Sun Microsystems provides a compatibility test suite for JVM implementors to determine if they have complied with the specifications. This test suite is known as the Java Compatibility Kit (JCK). Oracle’s JVM implementation complies fully with JCK. Part of the overall Java strategy is that an openly specified standard, together

with a simple way to verify compliance with that standard, allows vendors to offer uniform support for Java across all platforms.

## Key Features of the Java Language

The Java language has key features that make it ideal for developing server applications. These features include:

- **Simplicity**—Java is a simpler language than most others used in server applications because of its consistent enforcement of the object model. The large, standard set of class libraries brings powerful tools to Java developers on all platforms.
- **Portability**—Java is portable across platforms. It is possible to write platform-dependent code in Java, but it is also simple to write programs that move seamlessly across machines. Oracle server applications, which do not support graphical user interfaces directly on the platform that hosts them, also tend to avoid the few platform portability issues that Java has.
- **Automatic Storage Management**—The Java virtual machine automatically performs all memory allocation and deallocation during program execution. Java programmers can neither allocate nor free memory explicitly. Instead, they depend on the JVM to perform these bookkeeping operations, allocating memory as they create new objects and deallocating memory when the objects are no longer referenced. The latter operation is known as garbage collection.
- **Strong Typing**—Before you use a Java variable, you must declare the class of the object it will hold. Java's strong typing makes it possible to provide a reasonable and safe solution to inter-language calls between Java and PL/SQL applications, and to integrate Java and SQL calls within the same application.
- **No Pointers**—Although Java retains much of the flavor of C in its syntax, it does not support direct pointers or pointer manipulation. You pass all parameters, except primitive types, by reference (that is, object identity is preserved), not by value. Java does not provide C's low level, direct access to pointers, which eliminates memory corruption and leaks.
- **Exception Handling**—Java exceptions are objects. Java requires developers to declare which exceptions can be thrown by methods in any particular class.
- **Flexible Namespace**—Java defines classes and holds them within a hierarchical structure that mirrors the Internet's domain namespace. You can distribute Java applications and avoid name collisions. Java extensions such as the Java Naming and Directory Interface (JNDI) provide a framework for multiple name services to be federated. Java's namespace approach is flexible enough for

Oracle to incorporate the concept of a schema for resolving class names, while fully complying with the language specification.

- **Security**—The design of Java bytecodes and the JVM allow for built-in mechanisms to verify that the Java binary code was not tampered with. Oracle9i is installed with an instance of `SecurityManager`, which, when combined with Oracle database security, determines who can invoke any Java methods.
- **Standards for Connectivity to Relational Databases**—JDBC and SQLJ enable Java code to access and manipulate data resident in relational databases. Oracle provides drivers that allow vendor-independent, portable Java code to access the relational database.

## Why Use Java in Oracle9i?

The only reason that you are allowed to write and load Java applications within the database is because it is a safe language. Java has been developed to prevent anyone from tampering with the operating system that the Java code resides in. Some languages, such as C, can introduce security problems within the database; Java, because of its design, is a safe language to allow within the database.

Although the Java language presents many advantages to developers, providing an implementation of a JVM that supports Java server applications in a scalable manner is a challenge. This section discusses some of these challenges.

- [Multithreading](#)
- [Automated Storage Management](#)
- [Footprint](#)
- [Performance](#)
- [Dynamic Class Loading](#)

## Multithreading

Multithreading support is often cited as one of the key scalability features of the Java language. Certainly, the Java language and class libraries make it simpler to write multithreaded applications in Java than many other languages, but it is still a daunting task in any language to write reliable, scalable multithreaded code.

As a database server, Oracle9i efficiently schedules work for thousands of users. The Oracle9i JVM uses the facilities of the RDBMS server to concurrently schedule Java execution for thousands of users. Although Oracle9i supports Java language

level threads required by the JLS and JCK, using threads within the scope of the database will not increase your scalability. Using the embedded scalability of the database eliminates the need for writing multithreaded Java servers. You should use the database's facilities for scheduling users by writing single-threaded Java applications. The database will take care of the scheduling between each application; thus, you achieve scalability without having to manage threads. You can still write multithreaded Java applications, but multiple Java threads will not increase your server's performance.

One difficulty multithreading imposes on Java is the interaction of threads and automated storage management, or garbage collection. The garbage collector executing in a generic JVM has no knowledge of which Java language threads are executing or how the underlying operating system schedules them.

- **Non-Oracle9i model**—A single user maps to a single Java language level thread; the same single garbage collector manages all garbage from all users. Different techniques typically deal with allocation and collection of objects of varying lifetimes and sizes. The result in a heavily multithreaded application is, at best, dependent upon operating system support for native threads, which can be unreliable and limited in scalability. High levels of scalability for such implementations have not been convincingly demonstrated.
- **Oracle9i JVM model**—Even when thousands of users connect to the server and execute the same Java code, each user experiences it as if he is executing his own Java code on his own Java virtual machine. The responsibility of the Oracle9i JVM is to make use of operating system processes and threads, using the scalable approach of the Oracle RDBMS. As a result of this approach, the JVM's garbage collector is more reliable and efficient because it never collects garbage from more than one user at any time. Refer to "[Threading in Oracle9i](#)" on page 2-38 for more information on the thread model implementation in Oracle9i JVM.

## Automated Storage Management

Garbage collection is a major feature of Java's automated storage management, eliminating the need for Java developers to allocate and free memory explicitly. Consequently, this eliminates a large source of memory leaks that commonly plague C and C++ programs. There is a price for such a benefit: garbage collection contributes to the overhead of program execution speed and footprint. Although many papers have been written qualifying and quantifying the trade-off, the overall cost is reasonable, considering the alternatives.

Garbage collection imposes a challenge to the JVM developer seeking to supply a highly scalable and fast Java platform. The Oracle9i JVM meets these challenges in the following ways:

- The Oracle9i JVM uses the Oracle9i scheduling facilities, which can manage multiple users efficiently.
- Garbage collection is performed consistently for multiple users because garbage collection is focused on a single user within a single session. The Oracle9i JVM enjoys a huge advantage because the burden and complexity of the memory manager's job does not increase as the number of users increases. The memory manager performs the allocation and collection of objects within a single session—which typically translates to the activity of a single user.
- The Oracle9i JVM uses different garbage collection techniques depending on the type of memory used. These techniques provide high efficiency and low overhead.

## Footprint

The footprint of an executing Java program is affected by many factors:

- Size of the program itself—how many classes and methods and how much code they contain.
- Complexity of the program—the amount of core class libraries that the Oracle9i JVM uses as the program executes, as opposed to the program itself.
- Amount of state the JVM uses—how many objects the JVM allocates, how large they are, and how many must be retained across calls.
- Ability of the garbage collector and memory manager to deal with the demands of the executing program, which is often non-deterministic. The speed with which objects are allocated and the way they are held on to by other objects influences the importance of this factor.

From a scalability perspective, the key to supporting many concurrent clients is a minimum per-user session footprint. The Oracle9i JVM keeps the per-user session footprint to a minimum by placing all read-only data for users, such as Java bytecodes, in shared memory. Appropriate garbage collection algorithms are applied against call and session memories to maintain a small footprint for the user's session. The Oracle9i JVM uses three types of garbage collection algorithms to maintain the user's session memory:

- generational scavenging for short-lived objects

- mark and lazy sweep collection for objects that exist for the life of a single call
- copying collector for long-lived objects—objects that live across calls within a session

## Performance

Oracle9i JVM performance is enhanced by implementing a native compiler.

### How Native Compilers Improve Performance

Java executes platform-independent bytecodes on top of a JVM, which in turn interacts with the specific hardware platform. Any time you add levels within software, your performance is degraded. Because Java requires going through an intermediary to interpret platform-independent bytecodes, a degree of inefficiency exists for Java applications that does not exist within a platform-dependent language, such as C. To address this issue, several JVM suppliers create native compilers. Native compilers translate Java bytecodes into platform-dependent native code, which eliminates the interpreter step and improves performance.

The following describes two methods for native compilation:

Compiler	Description
Just-In-Time (JIT) Compilation	JIT compilers quickly compile Java bytecodes to native (platform-specific) machine code during runtime. This does not produce an executable to be executed on the platform; instead, it provides platform-dependent code from Java bytecodes that is executed directly after it is translated. This should be used for Java code that is run frequently, which will be executed at speeds closer to languages such as C.
Ahead-of-Time Compilation	Compilation translates Java bytecodes to platform-independent C code before runtime. Then a standard C compiler compiles the C code into an executable for the target platform. This approach is more suitable for Java applications that are modified infrequently. This approach takes advantage of the mature and efficient platform-specific compilation technology found in modern C compilers.

Oracle9i uses Ahead-of-Time compilation to deliver its core Java class libraries: JDBC code in natively compiled form. It is applicable across all the platforms Oracle supports, whereas a JIT approach requires low-level, processor-dependent code to be written and maintained for each platform. You can use this native compilation

technology with your own Java code. Refer to "[Natively Compiled Code](#)" on page 6-2 for more information.

## Dynamic Class Loading

Another strong feature of Java is dynamic class loading. The class loader loads classes from the disk (and places them in the JVM-specific memory structures necessary for interpretation) only as they are used during program execution. The class loader locates the classes in the `CLASSPATH` and loads them during program execution. This approach, which works well for applets, poses the following problems in a server environment:

Problem	Description	Solution
Predictability	The class loading operation places a severe penalty on first-time execution. A simple program can cause the Oracle9i JVM to load many core classes to support its needs. A programmer cannot easily predict or determine the number of classes loaded.	The Oracle9i JVM loads classes dynamically, just as with any other Java virtual machine. The same one-time class loading speed hit is encountered. However, because the classes are loaded into shared memory, no other users of those classes will cause the classes to load again—they will simply use the same pre-loaded classes.
Reliability	A benefit of dynamic class loading is that it supports program updating. For example, you would update classes on a server, and clients who download the program and load it dynamically see the update whenever they next use the program. Server programs tend to emphasize reliability. As a developer, you must know that every client executes a specific program configuration. You do not want clients to inadvertently load some classes that you did not intend them to load.	Oracle9i separates the upload and resolve operation from the class loading operation at runtime. You upload Java code you developed to the server using the <code>loadjava</code> utility. Instead of using <code>CLASSPATH</code> , you specify a resolver at installation time. The resolver is analogous to <code>CLASSPATH</code> , but allows you to specify the schemas in which the classes reside. This separation of resolution from class loading means you always know what program users execute. Refer to <a href="#">Chapter 7, "Schema Object Tools"</a> for details on <code>loadjava</code> and resolvers.



## Oracle's Java Application Strategy

One appeal of Java is its ubiquity and the growing number of programmers capable of developing applications using it. Oracle furnishes enterprise application developers with an end-to-end Java solution for creating, deploying, and managing Java applications. The total solution consists of client-side and server-side programmatic interfaces, tools to support Java development, and a Java virtual machine integrated with the Oracle9i database server. All these products are 100 percent compatible with Java standards.

In addition to the Oracle9i JVM, the Java programming environment consists of:

- Java stored procedures as the Java equivalent and companion for PL/SQL. Java stored procedures are tightly integrated with PL/SQL. You can call a Java stored procedure from a PL/SQL package; you can call PL/SQL procedures from a Java stored procedure.
- SQL data can be accessed through JDBC and SQLJ programming interfaces.
- Tools and scripts used in assisting in development, class loading, and class management.

To help you decide which Java APIs to use, examine the following table:

Type of functionality you need	Java API to use
To have a Java procedure invoked from SQL, such as a trigger.	Java Stored Procedures
To invoke a static, simple SQL statement from a known table with known column names from a Java object.	SQLJ
To invoke dynamic, complex SQL statements from a Java object.	JDBC

### Java Stored Procedures

If you are a PL/SQL programmer exploring Java, you will be interested in Java stored procedures. A Java stored procedure is a program you write in Java to execute in the server, exactly as a PL/SQL stored procedure. You invoke it directly with products like SQL\*Plus, or indirectly with a trigger. You can access it from any Oracle Net client—OCI, PRO\*, JDBC or SQLJ. The *Oracle9i Java Stored Procedures Developer's Guide* explains how to write stored procedures in Java, how to access them from PL/SQL, and how to access PL/SQL functionality from Java.

In addition, you can use Java to develop powerful programs independently of PL/SQL. Oracle9i provides a fully-compliant implementation of the Java programming language and JVM.

## PL/SQL Integration and Oracle RDBMS Functionality

You can invoke existing PL/SQL programs from Java and invoke Java programs from PL/SQL. This solution protects and leverages your existing investment while opening up the advantages and opportunities of Java-based Internet computing.

Oracle offers two different application programming interfaces (APIs) for Java developers to access SQL data—JDBC and SQLJ. Both APIs are available on client and server, so you can deploy the same code in either place.

- **JDBC Drivers**—Used to build client/server 2-tier applications.
- **SQLJ - Embedded SQL in Java**—Used to access static SQL. You must know the name of the columns.

### JDBC Drivers

JDBC is a database access protocol that enables you to connect to a database and then prepare and execute SQL statements against the database. Core Java class libraries provide only one JDBC API. JDBC is designed, however, to allow vendors to supply drivers that offer the necessary specialization for a particular database. Oracle delivers the following three distinct JDBC drivers.

Driver	Description
JDBC Thin Driver	You can use the JDBC Thin driver to write 100% pure Java applications and applets that access Oracle SQL data. The JDBC Thin driver is especially well-suited to Web browser-based applications and applets, because you can dynamically download it from a Web page just like any other Java applet.
JDBC Oracle Call Interface Driver	The JDBC Oracle Call Interface (OCI) driver accesses Oracle-specific native code (that is, non-Java) libraries on the client or middle tier, providing a richer set of functionality and some performance boost compared to the JDBC Thin driver, at the cost of significantly larger size and client-side installation.

Driver	Description
JDBC Server-side Internal Driver	Oracle9i uses the server-side internal driver when Java code executes on the server. It allows Java applications executing in the server's Java virtual machine to access locally defined data (that is, on the same machine and in the same process) with JDBC. It provides a further performance boost because of its ability to use underlying Oracle RDBMS libraries directly, without the overhead of an intervening network connection between your Java code and SQL data. By supporting the same Java-SQL interface on the server, Oracle9i does not require you to rework code when deploying it.

For more information on JDBC, see ["Utilizing SQLJ and JDBC for Querying the Database"](#) on page 3-6. Or for a complete detailed description, see the *Oracle9i JDBC Developer's Guide and Reference*.

### SQLJ – Embedded SQL in Java

Oracle has worked with other vendors, including IBM, Tandem, Sybase, and Sun Microsystems, to develop a standard way to embed SQL statements in Java programs—SQLJ. This work has resulted in a new standard (ANSI x.3.135.10-1998) for a simpler and more highly productive programming API than JDBC. A user writes applications to this higher-level API and then employs a preprocessor to translate the program to standard Java source with JDBC calls. At runtime, the program can communicate with multi-vendor databases using standard JDBC drivers.

SQLJ provides a simple, but powerful, way to develop both client-side and middle-tier applications that access databases from Java. You can use it in stored procedures, triggers, and methods within the Oracle9i environment. In addition, you can combine SQLJ programs with JDBC.

The SQLJ translator is a Java program that translates embedded SQL in Java source code to pure JDBC-based Java code. Because Oracle9i provides a complete Java environment, you cannot only compile SQLJ programs on a client for execution on the server, but you can compile them directly on the server. The adherence of Oracle9i to Internet standards allows you to choose the development style that fits your needs.

For more information on SQLJ, see ["Utilizing SQLJ and JDBC for Querying the Database"](#) on page 3-6 or for a complete description, see the *Oracle9i SQLJ Developer's Guide and Reference*.

## Development Tools

The introduction of Java to the Oracle9i server allows you to use several Java Integrated Development Environments. The adherence of Oracle9i to Java compatibility and open Internet standards and protocols ensures that your 100% pure Java programs work when you deploy them on Oracle9i. Oracle delivers many tools or utilities, all written in Java, that make development and deployment of Java server applications easier. Oracle's JDeveloper has many features designed specifically to make deployment of Java stored procedures and Enterprise JavaBeans easier.

## Overview of Oracle9i Java Documentation

This guide is the starting point for Oracle9i Java developers. It outlines some of the unique features of Java programming with Oracle9i, including aspects of the Oracle9i JVM, explaining how to take advantage of these features in your Java programs.

Once you have mastered the basics of Java development within the Oracle9i database, you may need more information for the specific protocol you will use in implementing your Java application. The following list includes other books within the documentation set that will help you in your application development:

<b>Protocol</b>	<b>Description</b>	<b>Book Title</b>
JDBC	Oracle9i Java developers should become familiar with Oracle's Java Database Connectivity (JDBC) product because it provides the basis for accessing SQL data from Java programs, as well as Oracle-specific extensions to this Java standard. JDBC is an industry standard.	<i>Oracle9i JDBC Developer's Guide and Reference</i>
SQLJ	You may find it easier to develop Java programs that access SQL data using embedded SQL in Java (SQLJ). SQLJ uses a preprocessor, written in Java, to translate embedded SQL statements to standard JDBC-style programs. SQLJ is an industry standard.	<i>Oracle9i SQLJ Developer's Guide and Reference</i>
JPublisher	JPublisher provides a simple and convenient tool to create Java programs that access existing Oracle relational database tables.	<i>Oracle9i JPublisher User's Guide</i>

---

<b>Protocol</b>	<b>Description (Cont.)</b>	<b>Book Title</b>
Java Stored Procedures	<p>If you are a PL/SQL programmer exploring Java, you will be interested in Java stored procedures. A Java stored procedure is a program you write in Java to execute in the server, exactly as a PL/SQL stored procedure. You invoke it directly with products like SQL*Plus or indirectly with a trigger and can access it from any Oracle Net client—OCI, PRO*, JDBC or SQLJ. The <i>Oracle9i Java Stored Procedures Developer's Guide</i> explains how to write stored procedures in Java, how to access them from PL/SQL, and how to access PL/SQL functionality from Java.</p> <p>In addition, you can use Java to develop powerful programs independently of PL/SQL. Oracle9i provides a fully compliant implementation of the Java programming language and JVM.</p>	<p><i>Oracle9i Java Stored Procedures Developer's Guide</i></p>

---



---

# Writing Java Applications on Oracle9i

Oracle9i executes standard Java applications. However, by integrating Java classes within the database server, your environment is different from a typical Java development environment. This chapter describes the basic differences for writing, installing, and deploying Java applications within Oracle9i.

- [Overview](#)
- [Database Sessions Imposed on Java Applications](#)
- [Execution Control](#)
- [Java Code, Binaries, and Resources Storage](#)
- [Preparing Java Class Methods for Execution](#)
- [User Interfaces on the Server](#)
- [Shortened Class Names](#)
- [Class.forName\(\) in Oracle9i](#)
- [Managing Your Operating System Resources](#)
- [Threading in Oracle9i](#)

---

**Note:** To fully explore the usage for each API, refer to the documentation for each API. The intent of this chapter is to place the Java APIs in an overall context, with enough detail for you to see how they fit together and how you use them in the Oracle9i environment.

---

## Overview

As discussed in Chapter 1, the Oracle9i JVM platform is a standard, compatible Java environment, which will execute any 100% pure Java application. It has been implemented by Oracle to be compatible with the Java Language Specification and the Java virtual machine specification. It supports the standard Java binary format and the standard Java APIs. In addition, Oracle9i adheres to standard Java language semantics, including dynamic class loading at runtime. However, unlike other Java environments, the JVM is embedded within the Oracle9i RDBMS and, therefore, introduces a number of new concepts. This section gives an overview of the differences between the Sun Microsystems JDK environment and the environment that occurs when you combine Java with the Oracle9i database.

### Terminology

Term	Definition
Oracle9i JVM	Java-enabled Oracle9i database server with JVM.
Session	As a user who executes Java code, you must establish a session in the server. The word <i>session</i> as we employ it here is identical to the standard Oracle (or any other database server) usage. A session is typically, although not necessarily, bounded by the time a single user connects to the server.
Call	When a user causes Java code to execute within a session, we refer to it as a <i>call</i> . You can initiate a call in different ways. <ul style="list-style-type: none"><li>■ A SQL client program executes a Java stored procedure.</li><li>■ A trigger can execute a Java stored procedure.</li><li>■ A PL/SQL program calls some Java code.</li></ul> In all cases, a call begins, some combination of Java, SQL, or PL/SQL code is executed to completion, and the call ends.

In your standard Java environment, you run a Java application through the interpreter by executing `java <classname>`. This causes the application to execute within a process on your operating system.

With the Oracle9i JVM, you must load the application into the database, publish the interface, and then run the application within a database session. This book discusses how to run your Java applications within the database. Specifically, see the following sections for instructions on executing Java in the database:



- Load and publish your Java applications before execution—See "[Java Code, Binaries, and Resources Storage](#)" and "[Preparing Java Class Methods for Execution](#)", starting on page 2-6.
- Running within a database session—See "[Database Sessions Imposed on Java Applications](#)" on page 2-3.

In addition, certain features, included within standard Java, change when you run your application within a database session. These are covered in the following sections:

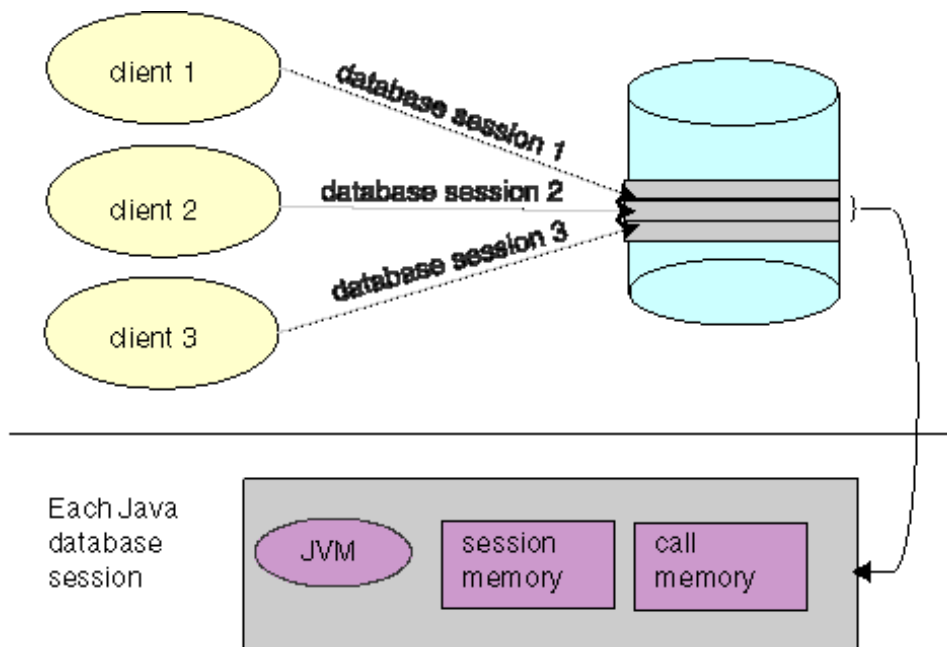
- [Execution Control](#)
- [User Interfaces on the Server](#)
- [Shortened Class Names](#)
- [Class.forName\(\) in Oracle9i](#)
- [Managing Your Operating System Resources](#)
- [Threading in Oracle9i](#)

Once you are familiar with this chapter, see [Chapter 3, "Invoking Java in the Database"](#) for directions on how to set up your client, and examples for invoking different types of Java applications.

## Database Sessions Imposed on Java Applications

In incorporating Java within the Oracle9i database, your Java application exists within the context of a database session. Oracle9i JVM sessions are entirely analogous to traditional Oracle sessions. Each Oracle9i JVM session maintains the client's Java state across calls within the session.

[Figure 2-1](#) demonstrates how each Java client starts up a database session as the environment for executing Java within the database. Garbage collection, session memory, and call memory exist solely for each client within its session.

**Figure 2–1 Java Environment Within Each Database Session**

Within the context of a session, the client performs the following:

1. Connects to the database and opens a session.
2. Executes Java within the database. This is referred to as a call.
3. Continues to work within the session, performing as many calls as necessary.
4. Ends the session.

Within a single session, the client has its own Java environment, which is separate from every other client's environment. It appears to the client as if a separate, individual JVM was invoked for each session, although the implementation is vastly more efficient than this seems to imply. Within a session, the Oracle9i JVM manages the scalability for you within the database. Every call executed from a single client is managed within its own session—separately from other clients. The Oracle9i JVM maximizes sharing read-only data between clients and emphasizes a minimum amount of per-session incremental footprint to maximize performance for multiple clients.

The underlying server environment hides the details associated with session, network, state, and other shared resource management issues from Java server code. Static variables are all local to the client. No client can access another client's static variables, because the memory is not available across session boundaries. Because each client executes its calls within its own session, each client's activities are separate from any other client. During a call, you can store objects in static fields of different classes, and you can expect this state to be available for your next call. The entire state of your Java program is private to you and exists for your entire session.

The Oracle9i JVM manages the following within the session:

- all the objects referenced by Java static variables, all the objects referred to by these objects, and so on (their transitive closure)
- garbage collection for the single client
- session memory for static variables and across call memory needs
- call memory for variables that exist within a single call

## Java Supported APIs

For the current Oracle9i release, we offer the following Java APIs—Java stored procedures, JNDI, JDBC, and SQLJ.

- JNDI—Store objects in a JNDI namespace.
- JDBC and SQLJ—You can access SQL data through SQLJ or JDBC. See [Chapter 3, "Invoking Java in the Database"](#), for examples of each Java API.
- Java stored procedures—The lifetime of a Java stored procedure session is identical to the SQL session in which it is embedded. This concept is familiar to PL/SQL users. Any state represented in Java transparently persists for the lifetime of the RDBMS session, simplifying the process of writing stored procedures, triggers, and methods for Oracle Abstract Data Types. Individual invocations of Java code within a session are known as calls. For example, a call may be initiated by a SQL call.

---

---

**Note:** The concepts of call and session apply across all uses of Oracle9i.

---

---

## Execution Control

In the Sun Microsystems JDK environment, you develop Java applications with a `main()` method, which is called by the interpreter when the class is run. The `main()` method is invoked when you execute `java <classname>` on the command-line. This command starts the Java interpreter and passes the desired classname to be executed to the interpreter. The interpreter loads the class and starts the execution by invoking `main()`. However, Java applications within the database do not start their execution from a `main()` method.

After loading your Java application within the database (see "[Loading Classes](#)" on page 2-16), you can execute your Java code by invoking any static method within the loaded class. The class or methods must be published for you to execute them (see "[Publishing](#)" on page 2-25). Your only entry point is no longer always assumed to be `main()`. Instead, when you execute your Java application, you specify a method name within the loaded class as your entry point.

For example, in a normal Java environment, you would start up the Java object on the server by executing the following:

```
java myprogram
```

where `myprogram` is the name of a class that contains a `main()` method. In `myprogram`, `main()` immediately calls `mymethod` for processing incoming information.

In Oracle9i, you load the `myprogram.class` file into the database and publish `mymethod` as an entry-point. Then, the client or trigger can invoke `mymethod` explicitly.

## Java Code, Binaries, and Resources Storage

In the Sun Microsystems Java development environment, Java source code, binaries, and resources are stored as files in a file system.

- Source code files are known as `.java` files.
- Compiled Java binary files are known as `.class` files.
- Resources are any data files, such as `.properties` or `.ser` files that are held within the file system hierarchy, which are loaded or used at runtime.

In addition, when you execute Java, you specify a `CLASSPATH`, which is a set of a file system tree roots containing your files. Java also provides a way to group these files into a single archive form—a ZIP or JAR file.

Both of these concepts are different within the database. The following describes how Oracle9i handles Java classes and locates dependent classes:

Java code, binaries, and resources	In the Oracle9i JVM environment, source, classes, and resources reside within the Oracle9i database. Because they reside in the database, they are known as Java schema objects, where a schema corresponds to a database user. There are three types of Java objects: source, class, and resource. There are no .java, .class, .sqlj, .properties, or .ser files on the server; instead, these files map to source, class, and resource Java schema objects.
Locating Java classes	Instead of a CLASSPATH, you use a resolver to specify one or more schemas to search for source, class, and resource Java schema objects.

The call and session terms, used during our discussions, are not Java terms; but are server terms that apply to the Oracle9i JVM platform. The Oracle9i memory manager preserves Java program state throughout your session (that is, between calls). The JVM uses the Oracle database to hold Java source, classes, and resources within a schema—Java schema objects. You can use a resolver to specify how Java, when executed in the server, locates source code, classes, and resources.

## Preparing Java Class Methods for Execution

For your Java methods to be executed, you must do the following:

1. Decide when your source is going to be compiled.
2. Decide if you are going to use the default resolver or another resolver for locating supporting Java classes within the database.
3. Load the classes into the database. If you do not wish to use the default resolver for your classes, you should specify a separate resolver on the load command.
4. Publish your class or method.

## Compiling Java Classes

Compilation of your source can be performed in one of the following ways:

- You can compile the source explicitly on your client machine, before loading it into the database, through a Java compiler, such as `javac`.
- You can ask the database to compile the source during the loading process managed within the `loadjava` tool.
- You can force the compilation to occur dynamically at runtime.

---

---

**Note:** If you decide to compile through `loadjava`, you can specify compiler options. See "[Specifying Compiler Options](#)" on page 2-9 for more information.

---

---

### Compiling Source Through `javac`

You can compile your Java with a conventional Java compiler, such as `javac`. After compilation, you load the compiled binary into the database, rather than the source itself. This is a better option, because it is normally easier to debug your Java code on your own system, rather than debugging it on the database.

### Compiling Source Through `loadjava`

When you specify the `-resolve` option on `loadjava` for a source file, the following occurs:

1. The source file is loaded as a source schema object.
2. The source file is compiled.

3. Class schema objects are created for each class defined in the compiled `.java` file.
4. The compiled code is stored in the class schema objects.

Oracle9i logs all compilation errors both to `loadjava`'s logfile and the `USER_ERRORS` view.

### Compiling Source at Runtime

When you load the Java source into the database without the `-resolve` option, Oracle9i compiles the source automatically when the class is needed during runtime. The source file is loaded into a source schema object.

Oracle9i logs all compilation errors both to `loadjava`'s logfile and the `USER_ERRORS` view.

### Specifying Compiler Options

There are two ways to specify options to the compiler.

- Specify compiler options on the `loadjava` command line. You can specify the encoding option on the `loadjava` command line.
- Specify persistent compiler options in a per-schema database table called `JAVA$OPTIONS`. Every time you compile, the compiler uses these options. However, any specified compiler options on the `loadjava` command override the options defined in this table.

You must create this table yourself if you wish to specify compiler options this way. See "[Compiler Options Specified in a Database Table](#)" on page 2-10 for instructions on how to create the `JAVA$OPTIONS` table.

The following sections describe your compiler options:

- [Default Compiler Options](#)
- [Compiler Options on the Command Line](#)
- [Compiler Options Specified in a Database Table](#)

**Default Compiler Options** When compiling a source schema object for which there is neither a `JAVA$OPTIONS` entry nor a command line value for an option, the compiler assumes a default value as follows:

- `encoding = System.getProperty("file.encoding");`

- `online = true`: See the *Oracle9i SQLJ Developer's Guide and Reference* for a description of this option, which applies only to Java sources that contain SQLJ constructs.
- `debug = true`: This option is equivalent to `javac -g`.

**Compiler Options on the Command Line** The `loadjava` compiler option, `encoding`, identifies the encoding of the `.java` file. This option overrides any matching value in the `JAVA$OPTIONS` table. The values are identical to the `javac -encoding` option. This option is relevant only when loading a source file.

**Compiler Options Specified in a Database Table** Each `JAVA$OPTIONS` row contains the names of source schema objects to which an option setting applies; you can use multiple rows to set the options differently for different source schema objects.

You can set `JAVA$OPTIONS` entries by means of the following functions and procedures, which are defined in the database package `DBMS_JAVA`:

- `PROCEDURE set_compiler_option(name VARCHAR2, option VARCHAR2, value VARCHAR2);`
- `FUNCTION get_compiler_option(name VARCHAR2, option VARCHAR2) RETURNS VARCHAR2;`
- `PROCEDURE reset_compiler_option(name VARCHAR2, option VARCHAR2);`

The parameters for these methods are described below:

Parameter	Description
<code>name</code>	The <code>name</code> parameter is a Java package name, a fully qualified class name, or the empty string. When the compiler searches the <code>JAVA\$OPTIONS</code> table for the options to use for compiling a Java source schema object, it uses the row whose <code>name</code> most closely matches the schema object's fully qualified class name. A name whose value is the empty string matches any schema object name.
<code>option</code>	The <code>option</code> parameter is either 'online', 'encoding' or 'debug'. For the values you can specify for these options, see the <i>Oracle9i SQLJ Developer's Guide and Reference</i> .

A schema does not initially have a `JAVA$OPTIONS` table. To create a `JAVA$OPTIONS` table, use the `DBMS_JAVA` package's `java.set_compiler_option` procedure to set a value. The procedure will create the table if it does not exist. Specify parameters in single quotes. For example:



```
SQL> execute dbms_java.set_compiler_option('x.y', 'online', 'false');
```

**Table 2–1** represents a hypothetical `JAVA$OPTIONS` database table. The pattern match rule is to match as much of the schema name against the table entry as possible. The schema name with a higher resolution for the pattern match is the entry that applies. Because the table has no entry for the `encoding` option, the compiler uses the default or the value specified on the command line. The `online` option shown in the table matches schema object names as follows:

- The name `a.b.c.d` matches class and package names beginning with `a.b.c.d`; the packages and classes are compiled with `online = true`.
- The name `a.b` matches class and package names beginning with `a.b`. The name `a.b` does not match `a.b.c.d`; therefore, the packages and classes are compiled with `online = false`.
- All other packages and classes match the empty string entry and are compiled with `online = true`.

**Table 2–1 Example JAVA\$OPTIONS Table**

Name	Option	Value	Match Examples
<code>a.b.c.d</code>	<code>online</code>	<code>true</code>	<ul style="list-style-type: none"> <li>■ <code>a.b.c.d</code>—matches the pattern exactly.</li> <li>■ <code>a.b.c.d.e</code>—first part matches the pattern exactly; no other rule matches full name.</li> </ul>
<code>a.b</code>	<code>online</code>	<code>false</code>	<ul style="list-style-type: none"> <li>■ <code>a.b</code>—matches the pattern exactly</li> <li>■ <code>a.b.c.x</code>—first part matches the pattern exactly; no other rule matches beyond specified rule name.</li> </ul>
(empty string)	<code>online</code>	<code>true</code>	<ul style="list-style-type: none"> <li>■ <code>a.c</code>—no pattern match with any defined name; defaults to (empty string) rule</li> <li>■ <code>x.y</code>—no pattern match with any defined name; defaults to (empty string) rule</li> </ul>

## Automatic Recompilation

Oracle9i provides a dependency management and automatic build facility that will transparently recompile source programs when you make changes to the source or binary programs upon which they depend. Consider the following cases:

```
public class A
```

```
{
    B b;
    public void assignB () {b = new B()}
}
public class B
{
    C c;
    public void assignC () {c = new C()}
}
public class C
{
    A a;
    public void assignA () {a = new A()}
}
```

The system tracks dependencies at a class level of granularity. In the preceding example, you can see that classes A, B, and C depend on one another, because A holds an instance of B, B holds an instance of C, and C holds an instance of A. If you change the definition of class A by adding a new field to it, the dependency mechanism in Oracle9i flags classes B and C as invalid. Before you use any of these classes again, Oracle9i attempts to resolve them again and recompile, if necessary. Note that classes can be recompiled only if source is present on the server.

The dependency system enables you to rely on Oracle9i to manage dependencies between classes, to recompile, and to resolve automatically. You must force compilation and resolution yourself only if you are developing and you want to find problems early. The `loadjava` utility also provides the facilities for forcing compilation and resolution if you do not want to allow the dependency management facilities to perform this for you.

## Resolving Class Dependencies

Many Java classes contain references to other classes, which is the essence of reusing code. A conventional Java virtual machine searches for classes, ZIP, and JAR files within the directories specified in the `CLASSPATH`. In contrast, the Oracle9i Java virtual machine searches database schemas for class objects. With Oracle9i, you load all Java classes within the database, so you might need to specify where to find the dependent classes for your Java class within the database.

All classes loaded within the database are referred to as class schema objects and are loaded within certain schemas. All JVM classes, such as `java.lang.*`, are loaded within `PUBLIC`. If your classes depend upon other classes you have defined, you will probably load them all within your own schema. For example, if your

schema is `SCOTT`, the database resolver (the database replacement for `CLASSPATH`) searches the `SCOTT` schema before `PUBLIC`. The listing of schemas to search is known as a resolver spec. Resolver specs are per-class, whereas in a classic Java virtual machine, `CLASSPATH` is global to all classes.

When locating and resolving the interclass dependencies for classes, the resolver marks each class as valid or invalid, depending on whether all interdependent classes are located. If the class that you load contains a reference to a class that is not found within the appropriate schemas, the class is listed as invalid. Unsuccessful resolution at runtime produces a “class not found” exception. Furthermore, runtime resolution can fail for lack of database resources if the tree of classes is very large.

---

---

**Note:** As with the Java compiler, `loadjava` resolves references to classes, but not to resources. Be sure to correctly load the resource files that your classes need.

---

---

For each interclass reference in a class, the resolver searches the schemas specified by the resolver spec for a valid class schema object that satisfies the reference. If all references are resolved, the resolver marks the class valid. A class that has never been resolved, or has been resolved unsuccessfully, is marked invalid. A class that depends on a schema object that becomes invalid is also marked invalid.

To make searching for dependent classes easier, Oracle9i provides a default resolver and resolver spec that searches first the definer’s schema and then `PUBLIC`. This covers most of the classes loaded within the database. However, if you are accessing classes within a schema other than your own or `PUBLIC`, you must define your own resolver spec.

- loading using Oracle’s default resolver, which searches the definer’s schema and `PUBLIC`:

```
loadjava -resolve
```

- loading using your own resolver spec definition containing the `SCOTT` schema, `OTHER` schema, and `PUBLIC`:

```
loadjava -resolve -resolver "((* SCOTT)(* OTHER)(* PUBLIC))"
```

The `-resolver` option specifies the objects to search within the schemas defined. In the example above, all class schema objects are searched within `SCOTT`, `OTHER`, and `PUBLIC`. However, if you wanted to search for only a certain class or group of classes within the schema, you could narrow the scope for the search. For example,

to search only for the classes "my/gui/\*" within the OTHER schema, you would define the resolver spec as follows:

```
loadjava -resolve -resolver '(( * SCOTT) ("my/gui/*" OTHER) (* PUBLIC))'
```

The first parameter within the resolver spec is for the class schema object; the second parameter defines the schema within which to search for these class schema objects.

### Allowing References to Non-Existent Classes

You can specify a special option within a resolver spec that allows an unresolved reference to a non-existent class. Sometimes, internal classes are never used within a product. For example, some ISVs do not remove all references to internal test classes from the JAR file before shipping. In a normal Java environment, this is not a problem, because as long as the methods are not called, the Sun Microsystems JVM ignores them. However, the Oracle9i resolver tries to resolve all classes referenced within the JAR file—even unused classes. If the reference cannot be validated, the classes within the JAR file are marked as invalid.

To ignore references, you can specify the "-" wildcard within the resolver spec. The following example specifies that any references to classes within "my/gui" are to be allowed, even if it is not present within the resolver spec schema list.

```
loadjava -resolve -resolver '(( * SCOTT) (* PUBLIC) ("my/gui/*" -))'
```

In addition, you can define that all classes not found are to be ignored. Without the wildcard, if a dependent class is not found within one of the schemas, your class is listed as invalid and cannot be run. However, this is also dangerous, because if there is a dependent class on a used class, you mark a class as valid that can never run without the dependent class. In this case, you will receive an exception at runtime.

To ignore all classes not found within SCOTT or PUBLIC, specify the following resolver spec:

```
loadjava -resolve -resolver "(( * SCOTT) (* PUBLIC) (* -))"
```

---

**Note:** An alternative mechanism for dealing with non-existent classes is with the `-gemissing` option of `loadjava`. This option causes `loadjava` to create and load definitions of classes that are referenced, but not defined. For more details, see ["loadjava"](#) on page 2-2.

---

## ByteCode Verifier

According to the JVM specification, `.class` files are subject to verification before the class they define is available in a JVM. In Oracle9i JVM, the verification process occurs at class resolution. The resolver might find one of the following problems and issue the appropriate Oracle error code:

- ORA-29545 If the resolver determines that the class is malformed, the resolver does not mark it valid. When the resolver rejects a class, it issues an ORA-29545 error (badly formed class). The `loadjava` tool reports the error. For example, this error is thrown if the contents of a `.class` file are not the result of a Java compilation or if the file has been corrupted.
- ORA-29552 In some situations, the resolver allows a class to be marked valid, but will replace bytecodes in the class to throw an exception at runtime. In these cases, the resolver issues an ORA-29552 (verification warning), which `loadjava` will report. The `loadjava` tool issues this warning when the Java Language Specification would require an `IncompatibleClassChangeError` be thrown. Oracle9i JVM relies on the resolver to detect these situations, supporting the proper runtime behavior that the JLS requires.

The resolver also issues warnings, as defined below:

- Resolvers containing “-”

This type of resolver marks your class valid regardless of whether classes it references are present. Because of inheritance and interfaces, you may want to write valid Java methods that use an instance of a class as if it were an instance of a superclass or of a specific interface. When the method being verified uses a reference to class A as if it were a reference to class B, the resolver must check that A either extends or implements B. For example, consider the potentially valid method below, whose signature implies a return of an instance of B, but whose body returns an instance of A:

```
B myMethod(A a) { return a; }
```

The method is valid only if A extends B, or A implements the interface B. If A or B have been resolved using a “-” term, the resolver does not know that this method is safe. It will replace the bytecodes of `myMethod` with bytecodes that throw an `Exception` if `myMethod` is ever called.

- Use of other resolvers

The resolver ensures that the class definitions of A and B are found and resolved properly if they are present in the schemas they specifically identify. The only time you might consider using the alternative resolver is if you must load an existing JAR file containing classes that reference other non-system classes that are not included in the JAR file.

For more information on class resolution and loading your classes within the database, see [Chapter 7, "Schema Object Tools"](#).

## Loading Classes

This section gives an overview of loading your classes into the database using the `loadjava` tool. You can also execute `loadjava` within your SQL. See [Chapter 7, "Schema Object Tools"](#) for complete information on `loadjava`.

Unlike a conventional Java virtual machine, which compiles and loads from files, the Oracle9i Java virtual machine compiles and loads from database schema objects.

<code>.java</code> source files or <code>.sqlj</code> source files	correspond to Java source schema objects
<code>.class</code> compiled Java files	correspond to Java class schema objects
<code>.properties</code> Java resource files, <code>.ser</code> SQLJ profile files, or data files	correspond to Java resource schema objects

You must load all classes or resources into the database to be used by other classes within the database. In addition, at loadtime, you define who can execute your classes within the database.

The `loadjava` tool performs the following for each type of file:

**Table 2–2** *loadjava* Operations on Schema Objects

Schema Object	loadjava Operations on Objects
<code>.java</code> source files	<ol style="list-style-type: none"> <li>1. It creates a source schema object within the definer's schema unless another schema is specified.</li> <li>2. It loads the contents of the source file into a schema object.</li> <li>3. It creates a class schema object for all classes defined in the source file.</li> <li>4. If <code>-resolve</code> is requested, it does the following: <ol style="list-style-type: none"> <li>a. It compiles the source schema object.</li> <li>b. It resolves the class and its dependencies.</li> <li>c. It stores the compiled class into a class schema object.</li> </ol> </li> </ol>
<code>.sqlj</code> source files	<ol style="list-style-type: none"> <li>1. It creates a source schema object within the definer's schema unless another schema is specified.</li> <li>2. It loads contents of the source file into the schema object.</li> <li>3. It creates a class schema object for all classes and resources defined in the source file.</li> <li>4. If <code>-resolve</code> is requested, it does the following: <ol style="list-style-type: none"> <li>a. It translates and compiles the source schema object.</li> <li>b. It stores the compiled class into a class schema object.</li> <li>c. It stores the profile into a <code>.ser</code> resource schema object and customizes it.</li> </ol> </li> </ol>
<code>.class</code> compiled Java files	<ol style="list-style-type: none"> <li>1. It creates a class schema object within the definer's schema unless another schema is specified.</li> <li>2. It loads the class file into the schema object.</li> <li>3. It resolves and verifies the class and its dependencies if <code>-resolve</code> is specified.</li> </ol>
<code>.properties</code> Java resource files	<ol style="list-style-type: none"> <li>1. It creates a resource schema object within the definer's schema unless another schema is specified.</li> <li>2. It loads a resource file into a schema object.</li> </ol>
<code>.ser</code> SQLJ profile	<ol style="list-style-type: none"> <li>1. It creates a resource schema object within the definer's schema unless another schema is specified.</li> <li>2. It loads the <code>.ser</code> resource file into a schema object and customizes it.</li> </ol>

The `dropjava` tool performs the reverse of the `loadjava` tool: it deletes schema objects that correspond to Java files. Always use `dropjava` to delete a Java schema object created with `loadjava`. Dropping with SQL DDL commands will not update auxiliary data maintained by `loadjava` and `dropjava`. You can also execute `dropjava` from within SQL commands.

---

---

**Note:** More options for `loadjava` are available. However, this section discusses only the major options. See [Chapter 7, "Schema Object Tools"](#) for complete information on `loadjava` and `dropjava`.

---

---

You must abide by certain rules, which are detailed in the following sections, when loading classes into the database:

- [Defining the Same Class Twice](#)
- [Designating Database Privileges and JVM Permissions](#)
- [Loading JAR or ZIP Files](#)

After loading, you can access the `USER_OBJECTS` view in your database schema to verify that your classes and resources loaded properly. For more information, see ["Checking Java Uploads"](#) on page 2-23.

### Defining the Same Class Twice

You cannot have two different definitions for the same class. This rule affects you in two ways:

- You can load either a particular Java `.class` file or its `.java` file, but not both. Oracle9i tracks whether you loaded a class file or a source file. If you wish to update the class, you must load the same type of file that you originally loaded. If you wish to update the other type, you must drop the first before loading the second. For example, if you loaded `x.java` as the source for class `y`, to load `x.class`, you must first drop `x.java`.
- You cannot define the same class within two different schema objects within the same schema. For example, suppose `x.java` defines class `y` and you want to move the definition of `y` to `z.java`. If `x.java` has already been loaded, `loadjava` rejects any attempt to load `z.java` (which also defines `y`). Instead, do either of the following:



- Drop `x.java`, load `z.java` (which defines `y`), then load the new `x.java` (which does not define `y`).
- Load the new `x.java` (which does not define `y`), then load `z.java` (which defines `y`).

### Designating Database Privileges and JVM Permissions

You must have the following SQL database privileges to load classes:

- `CREATE PROCEDURE` and `CREATE TABLE` privileges to load into your schema.
- `CREATE ANY PROCEDURE` and `CREATE ANY TABLE` privileges to load into another schema.
- `oracle.aurora.security.JServerPermission.loadLibraryInClass.<classname>`. See "[Permission for Loading Classes](#)" on page 5-25 for more information.

### Loading JAR or ZIP Files

The `loadjava` tool accepts `.class`, `.java`, `.properties`, `.sqlj`, `.ser`, `.jar`, or `.zip` files. The JAR or ZIP files can contain source, class, and data files. When you pass `loadjava` a JAR or ZIP file, `loadjava` opens the archive and loads its members individually. There is no JAR or ZIP schema object. If the JAR or ZIP content has not changed since the last time it was loaded, it is not reloaded; therefore, there is little performance penalty for loading JAR or ZIP files. In fact, loading JAR or ZIP files is the simplest way to use `loadjava`.

---

---

**Note:** Oracle9i does not reload a class if it has not changed since the last load. However, you can force a class to be reloaded through the `loadjava -force` option.

---

---

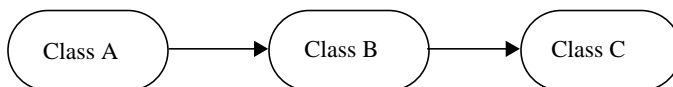
## How to Grant Execute Rights

If you load all classes within your own schema and do not reference any class outside of your schema, you already have execution rights. You have the privileges necessary for your objects to invoke other objects loaded in the same schema. That is, the ability for class A to invoke class B. Class A must be given the right to invoke class B.

The classes that define a Java application are stored within the Oracle9i RDBMS under the SQL schema of their owner. By default, classes that reside in one user's schema are not executable by other users, because of security concerns. You can

allow other users (schemas) the right to execute your class through the `loadjava -grant` option. You can grant execution rights to a certain user or schema. You cannot grant execution rights to a role, which includes the super-user DBA role. The setting of execution rights is the same as used to grant or revoke privileges in SQL DDL statements.

**Figure 2-2 Execution Rights**



Method invocation: Class A invokes class B; class B invokes class C.

Execution rights for classes:

- \* Class A needs execution rights for B.
- \* Class A does not need execution rights for C.
- \* Class B needs execution rights for C.

For information on JVM security permissions, see [Chapter 6, "Oracle9i Java Application Performance"](#).

## Controlling the Current User

During execution of Java or PL/SQL, there is always a current user. Initially, this is the user who creates the session.

Invoker's and definer's rights is a SQL concept that is used dynamically when executing SQL, PL/SQL, or JDBC. The current user controls the interpretation of SQL and determines privileges. For example, if a table is referenced by a simple name, it is assumed that the table belongs in the user's schema. In addition, the privileges that are checked when resources are requested are based on the privileges granted to the current user.

In addition, for Java stored procedures, the call specifications use a PL/SQL wrapper. So, you could specify definer's rights on either the call specification or on the Java class itself. If either is redefined to definer's rights, then the called method executes under the user that deployed the Java class.

By default, Java stored procedures execute without changing the current user—that is, with the privileges of their invoker, not their definer. Invoker-rights procedures are not bound to a particular schema. Their unqualified references to schema objects (such as database tables) are resolved in the schema of the current user, not the definer.

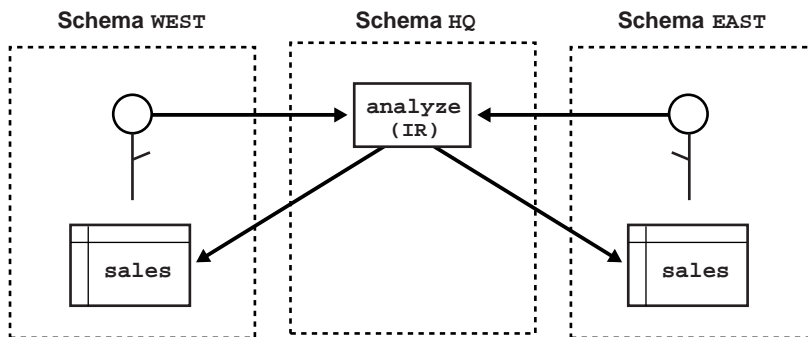
On the other hand, definer-rights procedures are bound to the schema in which they reside. They execute with the privileges of their definer, and their unqualified references to schema objects are resolved in the schema of the definer.

Invoker-rights procedures let you reuse code and centralize application logic. They are especially useful in applications that store data in different schemas. In such cases, multiple users can manage their own data using a single code base.

Consider a company that uses a definer-rights procedure to analyze sales. To provide local sales statistics, the procedure `analyze` must access `sales` tables that reside at each regional site. To do so, the procedure must also reside at each regional site. This causes a maintenance problem.

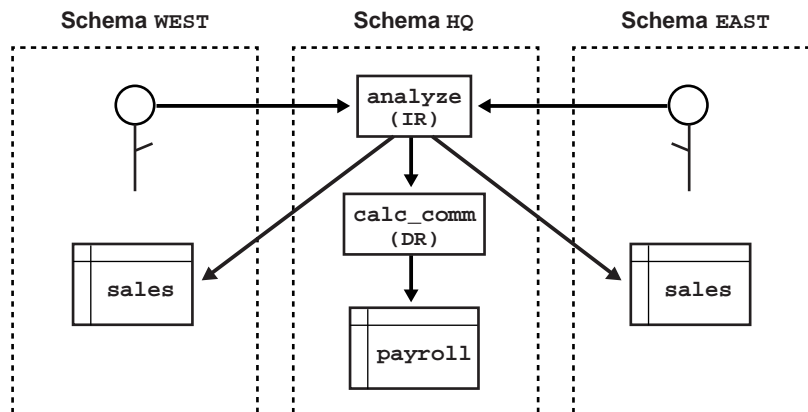
To solve the problem, the company installs an invoker-rights (IR) version of the procedure `analyze` at headquarters. Now, as [Figure 2-3](#) shows, all regional sites can use the same procedure to query their own `sales` tables.

**Figure 2-3 Invoker-Rights Solution**



Occasionally, you might want to override the default invoker-rights behavior. Suppose headquarters would like the procedure `analyze` to calculate sales commissions and update a central `payroll` table. That presents a problem because invokers of `analyze` should not have direct access to the `payroll` table, which stores employee salaries and other sensitive data. As [Figure 2-4](#) shows, the solution is to have procedure `analyze` call the definer-rights (DR) procedure `calcComm`, which, in turn, updates the `payroll` table.

**Figure 2-4 Indirect Access**



To override the default invoker-rights behavior, specify the `loadjava` option `-definer`, which is similar to the UNIX facility `setuid`, except that `-definer`

applies to individual classes, not whole programs. Alternatively, you can execute the SQL DDL that changes the AUTHID of the current user.

Different definers can have different privileges, and applications can consist of many classes. So, use the option `-definer` carefully, making sure that classes have only the privileges they need.

## Checking Java Uploads

You can query the database view `USER_OBJECTS` to obtain information about schema objects—including Java sources, classes, and resources—that you own. This allows you, for example, to verify that sources, classes, or resources that you load are properly stored into schema objects.

Columns in `USER_OBJECTS` include those contained in [Table 2-3](#) below.

**Table 2-3 Key USER\_OBJECT Columns**

Name	Description
OBJECT_NAME	name of the object
OBJECT_TYPE	type of the object (such as <code>JAVA SOURCE</code> , <code>JAVA CLASS</code> , or <code>JAVA RESOURCE</code> )
STATUS	status of the object ( <code>VALID</code> or <code>INVALID</code> ) (always <code>VALID</code> for <code>JAVA RESOURCE</code> )

### Object Name and Type

An `OBJECT_NAME` in `USER_OBJECTS` is the short name. The full name is stored as a short name if it exceeds 31 characters. See "[Shortened Class Names](#)" on page 2-26 for more information on full and short names.

If the server uses a short name for a schema object, you can use the `LONGNAME ( )` routine of the server `DBMS_JAVA` package to receive it from a query in full name format, without having to know the short name format or the conversion rules.

```
SQL*Plus> SELECT dbms_java.longname(object_name) FROM user_objects
           WHERE object_type='JAVA SOURCE';
```

This routine shows you the Java source schema objects in full name format. Where no short name is used, no conversion occurs, because the short name and full name are identical.

You can use the `SHORTNAME()` routine of the `DBMS_JAVA` package to use a full name as a query criterion, without having to know whether it was converted to a short name in the database.

```
SQL*Plus> SELECT object_type FROM user_objects
           WHERE object_name=dbms_java.shortname('known_fullname');
```

This routine shows you the `OBJECT_TYPE` of the schema object of the specified full name. This presumes that the full name is representable in the database character set.

```
SVRMGR> select * from javasnm;
SHORT                                LONGNAME
-----
/78e6d350_BinaryExceptionHandler  sun/tools/java/BinaryExceptionHandler
/b6c774bb_ClassDeclaration         sun/tools/java/ClassDeclaration
/af5a8ef3_JarVerifierStream1       sun/tools/jar/JarVerifierStream1
```

## Status

`STATUS` is a character string that indicates the validity of a Java schema object. A source schema object is `VALID` if it compiled successfully; a class schema object is `VALID` if it was resolved successfully. A resource schema object is always `VALID`, because resources are not resolved.

**Example: Accessing USER\_OBJECTS** The following `SQL*Plus` script accesses the `USER_OBJECTS` view to display information about uploaded Java sources, classes, and resources.

```
COL object_name format a30
COL object_type format a15
SELECT object_name, object_type, status
       FROM user_objects
       WHERE object_type IN ('JAVA SOURCE', 'JAVA CLASS', 'JAVA RESOURCE')
       ORDER BY object_type, object_name;
```

You can optionally use wildcards in querying `USER_OBJECTS`, as in the following example.

```
SELECT object_name, object_type, status
       FROM user_objects
       WHERE object_name LIKE '%Alerter';
```

This routine finds any `OBJECT_NAME` entries that end with the characters: `Alerter`.

For more information about `USER_OBJECTS`, see the *Oracle9i Java Stored Procedures Developer's Guide*.

## Publishing

Oracle9i enables clients and SQL to invoke Java methods that are loaded within the database, once published. You publish either the object itself or individual methods. If you write a Java stored procedure that you intend to invoke with a trigger, directly or indirectly in SQL DML or in PL/SQL, you must publish individual methods within the class. Specify how to access it through a call specification. Java programs consist of many methods in many classes; however, only a few static methods are typically exposed with call specifications. See the *Oracle9i Java Stored Procedures Developer's Guide* for more details.

## User Interfaces on the Server

Oracle9i furnishes all core Java class libraries on the server, including those associated with presentation of user interfaces (`java.awt` and `java.applet`). It is, however, inappropriate for code executing in the server to attempt to bring up or materialize a user interface in the server. Imagine thousands of users worldwide exercising an Internet application that executes code that requires someone to click on a dialog presented on the server hardware. You can write Java programs that reference and use `java.awt` classes as long as you do not attempt to materialize a user interface.

When building applets, you test them using the `java.awt` and the `Peer` implementation, which is a platform-specific set of classes for support of a specific windowing system. When the user downloads an applet, it dynamically loads the proper client `Peer` libraries, and the user sees a display appropriate for the operating system or windowing system in use on the client side. Oracle9i takes the same approach. We provide an Oracle-specific `Peer` implementation that throws an exception, `oracle.aurora.awt.UnsupportedOperation`, if you execute Java code on the Oracle9i server that attempts to materialize a user interface.

Oracle9i's lack of support for materializing user interfaces in the server means that we do not pass the Java 2 Compatibility Kit tests for `java.awt`, `java.awt.manual`, and `java.applet`. In the Oracle RDBMS, all user interfaces are supported only on client applications, although they might be displayed on the same physical hardware that supports the server—for example, in the case of Windows NT. Because it is inappropriate for the server to support user interfaces, we exclude these tests from our complete Java Compatibility Kit testing.

A similar issue exists for vendors of Java-powered embedded devices and in handheld devices (known as Personal Java). Future releases of Java and the Java Compatibility Kit will provide improved factorization of user interface support so that vendors of Java server platforms can better address this issue.

## Shortened Class Names

Each Java source, class, and resource is stored in its own schema object in the server. The name of the schema object is derived from the fully qualified name, which includes relevant path or package information. Dots are replaced by slashes. These fully qualified names (with slashes)—used for loaded sources, loaded classes, loaded resources, generated classes, and generated resources—are referred to in this chapter as schema object *full names*.

Schema object names, however, have a maximum of only 31 characters, and all characters must be legal and convertible to characters in the database character set. If any full name is longer than 31 characters or contains illegal or non-convertible characters, the Oracle9i server converts the full name to a *short name* to employ as the name of the schema object, keeping track of both names and how to convert between them. If the full name is 31 characters or less and has no illegal or inconvertible characters, then the full name is used as the schema object name.

Because Java classes and methods can have names exceeding the maximum SQL identifier length, Oracle9i uses abbreviated names internally for SQL access. Oracle9i provides a method within the DBMS\_JAVA package for retrieving the original Java class name for any truncated name.

```
FUNCTION longname (shortname VARCHAR2) RETURN VARCHAR2
```

This function returns the longname from a Java schema object. An example is to print the fully qualified name of classes that are invalid for some reason.

```
select dbms_java.longname (object_name) from user_objects
       where object_type = 'JAVA CLASS' and status = 'INVALID';
```

In addition, you can specify a full name to the database by using the `shortname()` routine of the DBMS\_JAVA package, which takes a full name as input and returns the corresponding short name. This is useful when verifying that your classes loaded by querying the USER\_OBJECTS view.

```
FUNCTION shortname (longname VARCHAR2) RETURN VARCHAR2
```



Refer to the *Oracle9i Java Stored Procedures Developer's Guide* for a detailed example of the use of this function and ways to determine which Java schema objects are present on the server.

## Class.forName() in Oracle9i

The Java Language Specification provides the following description of `Class.forName()`:

Given the fully-qualified name of a class, this method attempts to locate, load, and link the class. If it succeeds, a reference to the `Class` object for the class is returned. If it fails, a `ClassNotFoundException` is thrown.

Class lookup is always on behalf of a referencing class through a `ClassLoader`. The difference between the JDK implementation and the Oracle9i JVM implementation is the method on which the class is found:

- The JDK uses one `ClassLoader` that searches the set of directory tree roots specified by the environment variable `CLASSPATH`.
- Oracle9i JVM defines several resolvers, which define how to locate classes. Every class has a resolver associated with it, and each class can, potentially, have a different resolver. When you execute a method that calls `Class.forName()`, the resolver of the currently executing class (`this`) is used to locate the class. See "[Resolving Class Dependencies](#)" on page 2-12 for more information on resolvers.

You can receive unexpected results if you try to locate a class with an unexpected resolver. For example, if a class X in schema X requests a class Y in schema Y to look up class Z, you can experience an error if you expected class X's resolver to be used. Because class Y is performing the lookup, the resolver associated with class Y is used to locate class Z. In summary, if the class exists in another schema and you specified different resolvers for different classes—as would happen by default if they are in different schemas—you might not find the class.

You can solve this resolver problem as follows:

- Avoid any class name lookup by passing the `Class` object itself.
- Supply the `ClassLoader` in the `Class.forName` method.
- Supply the class and the schema it resides into `classForNameAndSchema` method.
- Supply the schema and class name to `ClassForName.lookupClass`.

- Serialize your objects with the schema name with the class name.

---

---

**Note:** Another unexpected behavior can occur if system classes invoke `Class.forName()`. The desired class is found only if it resides in `SYS` or in `PUBLIC`. If your class does not exist in either `SYS` or `PUBLIC`, you can declare a `PUBLIC` synonym for the class.

---

---

## Supply the ClassLoader in Class.forName

Oracle9i uses resolvers for locating classes within schemas. Every class has a specified resolver associated with it and each class can have a different resolver associated with it. Thus, the locating of classes is dependent on the definition of the associated resolver. The `ClassLoader` knows which resolver to use, based upon the class that is specified. When you supply a `ClassLoader` to `Class.forName()`, your class is looked up in the schemas defined within the resolver of the class. The syntax for this variant of `Class.forName` is as follows:

```
Class.forName (String name, boolean initialize, ClassLoader loader);
```

The following examples show how to supply the class loader of either the current class instance or the calling class instance.

### **Example 2-1 Retrieve Resolver from Current Class**

You can retrieve the class loader of any instance through the `Class.getClassLoader` method. The following example retrieves the class loader of the class represented by instance `x`.

```
Class c1 = Class.forName (x.whatClass(), true, x.getClass().getClassLoader());
```

### **Example 2-2 Retrieve Resolver from Calling Class**

You can retrieve the class of the instance that invoked the executing method through the `oracle.aurora.vm.OracleRuntime.getCallerClass` method. Once you retrieve the class, invoke the `Class.getClassLoader` method on the returned class. The following example retrieves the class of the instance that invoked the `workForCaller` method. Then, its class loader is retrieved and supplied to the `Class.forName` method. Thus, the resolver used for looking up the class is the resolver of the calling class.

```
void workForCaller() {  
    ClassLoader c1 =  
        oracle.aurora.vm.OracleRuntime.getCallerClass().getClassLoader();
```

```
...  
Class c = Class.forName (name, true, c1);
```

## Supply Class and Schema Names to `classForNameAndSchema`

You can resolve the problem of where to find the class by either supplying the resolver, which knows the schemas to search, or by supplying the schema in which the class is loaded. If you know in which schema the class is loaded, you can use the `classForNameAndSchema` method. Oracle9i provides a method in the `DbmsJava` class, which takes in both the name of the class and the schema in which the class resides. This method locates the class within the designated schema.

### *Example 2-3 Providing Schema and Class Names*

The following example shows how you can save the schema and class names in the `save` method. Both names are retrieved, and the class is located using the `DbmsJava.classForNameAndSchema` method.

```
import oracle.aurora.rdbms.ClassHandle;  
import oracle.aurora.rdbms.Schema;  
import oracle.aurora.rdbms.DbmsJava;  
  
void save (Class c1) {  
    ClassHandle handle = ClassHandle.lookup(c1);  
    Schema schema = handle.schema();  
    writeName (schema.getName());  
    writeName (c1.getName());  
}  
  
Class restore() {  
    String schemaName = readName();  
    String className = readName();  
    return DbmsJava.classForNameAndSchema (schemaName, className);  
}
```

## Supply Class and Schema Names to lookupClass

You can supply a single String, containing both the schema and class names, to the `oracle.aurora.util.Class.forName.lookupClass` method. When invoked, this method locates the class in the specified schema. The string must be in the following format:

```
"<schema>:<class>"
```

For example, to locate `com.package.myclass` in schema `SCOTT`, execute the following:

```
oracle.aurora.util.Class.forName.lookupClass("SCOTT:com.package.myclass");
```

---

---

**Note:** You must use uppercase characters for the schema name. In this case, the schema name is case-sensitive.

---

---

## Supply Class and Schema Names when Serializing

When you de-serialize a class, part of the operation is to lookup a class based on a name. In order to ensure that the lookup is successful, the serialized object must contain both the class and schema names.

Oracle9i provides the following classes for serializing and de-serializing objects:

- `oracle.aurora.rdbms.DbmsObjectOutputStream`

This class extends `java.io.ObjectOutputStream` and adds schema names in the appropriate places.

- `oracle.aurora.rdbms.DbmsObjectInputStream`

This class extends `java.io.ObjectInputStream` and reads streams written by `DbmsObjectOutputStream`. You can use this class in any environment. If used within Oracle9i, the schema names are read out and used when performing the class lookup. If used on a client, the schema names are ignored.

## Class.forName Example

The following example shows several methods for looking up a class.

- To use the resolver of this instance's class, invoke `lookupWithClassLoader`. This method supplies a class loader to the `Class.forName` method in the `from` variable. The class loader specified in the `from` variable defaults to this class.
- To use the resolver from a specific class, call `ForName` with the designated class name, followed by `lookupWithClassLoader`. The `ForName` method sets the `from` variable to the specified class. The `lookupWithClassLoader` method uses the class loader from the specified class.
- To use the resolver from the calling class, first invoke the `ForName` method without any parameters. It sets the `from` variable to the calling class. Then, invoke the `lookupWithClassLoader` to locate the class using the resolver of the calling class.
- To lookup a class in a specified schema, invoke the `lookupWithSchema` method. This provides the class and schema name to the `classForNameAndSchema` method.

```
import oracle.aurora.vm.OracleRuntime;
import oracle.aurora.rdbms.Schema;
import oracle.aurora.rdbms.DbmsJava;

public class ForName {

    private Class from;
    /* Supply an explicit class to the constructor */
    public ForName(Class from) {
        this.from = from;
    }
    /* Use the class of the code containing the "new ForName()" */
    public ForName() {
        from = OracleRuntime.getCallerClass();
    }

    /* lookup relative to Class supplied to constructor */
    public Class lookupWithClassLoader(String name) throws ClassNotFoundException
    {
        /* A ClassLoader uses the resolver associated with the class*/
        return Class.forName(name, true, from.getClassLoader());
    }
}
```

```
/* In case the schema containing the class is known */
static Class lookupWithSchema(String name, String schema) {
    Schema s = Schema.lookup(schema);
    return DbmsJava.class.forNameAndSchema(name, s);
}
}
```

## Managing Your Operating System Resources

Operating system resources are a limited commodity on any computer. Because Java is targeted at providing a computing platform as well as a programming language, it contains platform-independent classes and frameworks for accessing platform-specific resources. The Java class methods access operating system resources through the JVM. Java has potential problems with this model, because programmers rely on the garbage collector to manage all resources, when all that the garbage collector manages is Java objects, not the operating system resources that the Java object holds on to.

In addition, because the Oracle9i JVM is embedded in the database, your operating system resources, which are contained within Java objects, can be invalidated if they are maintained across calls within a session.

The following sections discuss these potential problems:

- [Overview of Operating System Resources](#)
- [Garbage Collection and Operating System Resources](#)
- [Operating System Resources Affected Across Calls](#)

### Overview of Operating System Resources

In general, your operating system resources contain the following:

- |        |   |
|--------|---|
| memory | Oracle9i manages memory internally, allocating memory as you create new objects and freeing objects as you no longer need them. The language and class libraries do not support a direct means to allocate and free memory. " <a href="#">Automated Storage Management</a> " on page 1-15 discusses garbage collection. |
| files  | Java contains classes that represent file resources. Instances of these classes hold on to your operating system's file constructs, such as file handles, which can become invalid between calls in a session.  |

sockets	Java contains classes that represent socket resources. Instances of these classes hold on to socket constructs, some of which can become invalid between calls in a session. See " <a href="#">Sockets</a> " on page 2-37 for information specific to maintaining sockets across calls.
threads	Threads are discouraged within the Oracle9i JVM because of scalability issues. However, you can have a multi-threaded application within the database. " <a href="#">Threading in Oracle9i</a> " on page 2-38 discusses in detail the Oracle9i JVM threading model.

### Operating System Resource Access

By default, a Java user does not have direct access to most operating system resources. A system administrator may give permission to a user to access these resources by modifying the JVM security restrictions. The JVM security enforced upon system resources conforms to Java 2 security. See "[Java 2 Security](#)" on page 5-3 for more information.

### Operating System Resource Lifetime

You access operating system resources using the standard core Java classes and methods. Once you access a resource, the time that it remains active (usable) varies according to the type of resource.

Resource	Lifetime
Files	The system closes all files left open when a database call ends.
Memory	Memory is garbage collected as described in " <a href="#">Automated Storage Management</a> " on page 1-15.
Threads	All threads are terminated when a call ends.
Objects that depend on operating system resources	<p>Regardless of the usable lifetime of the object (for example, the defined lifetime for a thread object), the Java object can be valid for the duration of the session. This can occur, for example, if the Java object is stored in a static class variable, or a class variable references it directly or indirectly. If you attempt to use one of these Java objects after its usable lifetime is over, Oracle9i throws an exception. This is true for the following examples:</p> <ul style="list-style-type: none"> <li>▪ If an attempt is made to read from a <code>java.io.FileInputStream</code> that was closed at the end of a previous call, a <code>java.io.IOException</code> is thrown.</li> <li>▪ <code>java.lang.Thread.isAlive()</code> is false for any Thread object running in a previous call and still accessible in a subsequent call.</li> </ul>

Resource	Lifetime
Sockets	<ul style="list-style-type: none"><li>■ Sockets can exist across calls.</li><li>■ ServerSockets on a shared server terminate when the call ends.</li><li>■ ServerSockets on a dedicated server can exist across calls.</li></ul> <p>See "<a href="#">Sockets</a>" on page 2-37 more information.</p>

## Referencing Files with Relative Path Names

Relative path names in file operations are interpreted as relative to `$ORACLE_HOME`.

## Garbage Collection and Operating System Resources

Imagine that memory is divided into two realms: Java object memory and operating system constructs. The Java object memory realm contains all objects and variables. Operating system constructs include resources that the operating system allocates to the object when it asks. These resources include files, sockets, and so on.

Basic programming rules dictate that you close all memory—both Java objects and operating system constructs. Java programmers incorrectly assume that all memory is freed by the garbage collector. The garbage collector was created to collect all unused Java object memory. However, it does not close any operating system constructs. All operating system constructs must be closed by the program before the Java object is collected.

For example, whenever an object opens a file, the operating system creates the file and gives the object a file handle. If the file is not closed, the operating system will hold the file handle construct open until the call ends or JVM exits. This can cause you to run out of these constructs earlier than necessary. There are a finite number of handles within each operating system. To guarantee that you do not run out of handles, close your resources before exiting the method. This includes closing the streams attached to your sockets. You should close the streams attached to the socket before closing the socket.

So why not expand the garbage collector to close all operating system constructs? For performance reasons, the garbage collector cannot examine each object to see if it contains a handle. Thus, the garbage collector collects Java objects and variables, but does not issue the appropriate operating system methods for freeing any handles.

[Example 2-4](#) shows how you should close the operating system constructs.



**Example 2-4 Closing Your Operating System Resources**

```
public static void addFile(String[] newFile) {
    File inFile = new File(newFile);
    FileReader in = new FileReader(inFile);
    int i;

    while ((i = in.read()) != -1)
        out.write(i);
    /*closing the file, which frees up the operating system file handle*/
    in.close();
}
```

If you do not close the `in` file, eventually the `File` object will be garbage collected. However, even if the `File` object is garbage collected, the operating system still believes that the file is in use, because it was not closed.

---

---

**Note:** You might want to use Java finalizers to close resources. However, finalizers are not guaranteed to run in a timely manner. Instead, finalizers are put on a queue to execute when the garbage collector has time. If you close your resources within your finalizer, it might not be freed up until the JVM exits. The best approach is to close your resources within the method.

---

---

## Operating System Resources Affected Across Calls

You should close resources that are local to a single call when the call ends. However, for static objects that hold on to operating system resources, you must be aware of how these resources are affected after the call ends.

The JVM automatically closes any open operating system constructs—in [Example 2-5](#), the file handle—when the call ends. This can affect any operating system resources within your Java object. For example, if you have a file opened within a static variable, the file handle is closed at the end of the call for you. So, if you hold on to the `File` object across calls, the next usage of the file handle throws an exception.

In [Example 2-5](#), class `Concat` enables multiple files to be written into a single file, `outFile`. On the first call, `outFile` is created. The first input file is opened, read, input into `outFile`, and the call ends. Because `outFile` is statically defined, it is moved into session space between call invocations. However, the file handle—that is, the `FileDescriptor`—is closed at the end of the call. The next time you call `addFile`, you will get an exception.

**Example 2-5 Compromising Your Operating System Resources**

```
public class Concat {
    static File outFile = new File("outme.txt");
    FileWriter out = new FileWriter(outFile);

    public static void addFile(String[] newFile) {
        File inFile = new File(newFile);
        FileReader in = new FileReader(inFile);
        int i;

        while ((i = in.read()) != -1)
            out.write(i);
        in.close();
    }
}
```

There is a workaround: to make sure that your handles stay valid, close your files, buffers, and so on, at the end of every call; reopen the resource at the beginning of the next call. Another option is to use the database rather than using operating system resources. For example, try to use database tables rather than a file. Or do not store operating system resources within static objects expected to live across calls; use operating system resources only within objects local to the call.

[Example 2-6](#) shows how you can perform concatenation, as in [Example 2-5](#), without compromising your operating system resources. The `addFile` method opens the `outme.txt` file within each call, making sure that anything written into the file is appended to the end. At the end of each call, the file is closed. Two things occur:

1. The `File` object no longer exists outside of a call.
2. The operating system resource, the `outme.txt` file, is reopened for each call. If you had made the `File` object a static variable, the closing of `outme.txt` within each call would ensure that the operating system resource is not compromised.

**Example 2-6 Correctly Managing Your Operating System Resources**

```
public class Concat {

    public static void addFile(String[] newFile) {
        /*open the output file each call; make sure the input*/
        /*file is written out to the end by making it "append=true"*/
        FileWriter out = new FileWriter("outme.txt", TRUE);
        File inFile = new File(newFile);
```

```
FileReader in = new FileReader(inFile);
int i;

while ((i = in.read()) != -1)
    out.write(i);
in.close();
/*close the output file between calls*/
out.close();
}
}
```

## Sockets

Sockets are used in setting up a connection between a client and a server. For each database connection, sockets are used at either end of the connection. Your application does not set up the connection; the connection is set up by the underlying networking protocol: Oracle Net's TTC or IIOIP. See "[Configuring Oracle JVM](#)" on page 4-2 for information on how to configure your connection.

You might also wish to set up another connection—for example, connecting to a specified URL from within one of the classes stored within the database. To do so, instantiate sockets for servicing the client and server sides of the connection.

- The `java.net.Socket()` constructor creates a client socket.
- The `java.net.ServerSocket()` constructor creates a server socket.

A socket exists at each end of the connection. The server-side of the connection that listens for incoming calls is serviced by a `ServerSocket`. The client-side of the connection that sends requests is serviced through a `Socket`. You can use sockets as defined within the JVM with the following restriction: a `ServerSocket` instance within a shared server cannot exist across calls.

Socket	Because the client-side of the connection is outbound, the <code>Socket</code> instance can be serviced across calls within either a shared or dedicated server.
--------	--

`ServerSocket` The server-side of the connection is a listener.

- **Dedicated server**—Your `ServerSocket` can listen across calls only within a dedicated server; the dedicated server exists solely for servicing the single client.
- **Shared server**—The `ServerSocket` is closed at the end of a call within a shared server; the shared servers move on to another client at the end of every call. You will receive an I/O exception stating that the socket was closed if you try to use the `ServerSocket` outside of the call it was created in.

## Threading in Oracle9i

The Oracle9i JVM implements a non-preemptive threading model. With this model, the JVM runs all Java threads on a single operating system thread. It schedules them in a round-robin fashion and switches between them only when they block. Blocking occurs when you, for example, invoke the `Thread.yield()` method or wait on a network socket by invoking `mySocket.read()`.

Advantages of Oracle9i's Threading Model	Disadvantages
<ul style="list-style-type: none"> <li>■ simple to program</li> <li>■ efficient to implement in the Java virtual machine, because a thread switch does not require any system calls</li> <li>■ safer, because the JVM can detect a deadlock that would hang a preemptive JVM and can then raise a runtime exception</li> </ul>	<ul style="list-style-type: none"> <li>■ does not exhibit any concurrency</li> <li>■ lack of portability</li> <li>■ performance considerations, because of the system calls required for locking when blocking the thread</li> <li>■ memory scalability, because efficient multi-threaded memory allocation requires a larger pool of memory</li> </ul>

Oracle chose this model because any Java application written on a single-processor system works identical to one written on a multi-processor system. Also, the lack of concurrency among Java threads is not an issue, because Oracle9i JVM is embedded in the database, which provides a higher degree of concurrency than any conventional JVM.

There is no need to use threads within the application logic because the Oracle server preemptively schedules the session JVMs. If you must support hundreds or thousands of simultaneous transactions, start each one in its own JVM. This is exactly what happens when you create a session in the Oracle9i JVM. The normal transactional capabilities of the Oracle database server accomplish coordination and

data transfer between the JVMs. This is not a scalability issue, because in contrast to the 6 MB-8 MB memory footprint of the typical Java virtual machine, the Oracle server can create thousands of JVMs, with each one taking less than 40 KB.

Threading is managed within the Oracle9i JVM by servicing a single thread until it completes or blocks. If the thread blocks, by yielding or waiting on a network socket, the JVM will service another thread. However, if the thread never blocks, it is serviced until completed.

The Oracle9i JVM has added the following features for better performance and thread management:

- System calls are at a minimum. Oracle9i JVM has exchanged some of the normal system calls with non-system solutions. For example, entering a monitor-synchronized block or method does not require a system call.
- Deadlocks are detected.
  - \* The Oracle9i JVM monitors for deadlocks between threads. If a deadlock occurs, the Oracle9i JVM terminates one of the threads and throws the `oracle.aurora.vm.DeadlockError` exception.
  - \* Single-threaded applications cannot suspend. If the application has only a single thread and you try to suspend it, the `oracle.aurora.vm.LimboError` exception is thrown.

## Thread Lifecycle

In the single-threaded execution case, the call ends when one of the following events occurs:

1. The thread returns to its caller.
2. An exception is thrown and is not caught in Java code.
3. The `System.exit()`, `oracle.aurora.vm.OracleRuntime.exitCall()` method is invoked.

If the initial thread creates and starts other Java threads, the rules about when a call ends are slightly more complicated. In this case, the call ends in one of the following two ways:

1. The main thread returns to its caller, or an exception is thrown and not caught in this thread, *and* all other non-daemon threads complete execution. Non-daemon threads complete either by returning from their initial method or because an exception is thrown and not caught in the thread.

2. Any thread invokes the `System.exit()` or `oracle.aurora.vm.OracleRuntime.exitCall()` method.

When a call ends because of a return and/or uncaught exceptions, the Oracle9i JVM throws a `ThreadDeathException` in all daemon threads. The `ThreadDeathException` essentially forces threads to stop execution.

When a call ends because of a call to `System.exit()` or `oracle.aurora.vm.OracleRuntime.exitCall()`, the Oracle9i JVM ends the call abruptly and terminates all threads, but does not throw `ThreadDeathException`.

During the execution of a single call, a Java program can recursively cause more Java code to be executed. For example, your program can issue a SQL query using JDBC or SQLJ that in turn causes a trigger written in Java to be invoked. All the preceding remarks regarding call lifetime apply to the top-most call to Java code, not to the recursive call. For example, a call to `System.exit()` from within a recursive call will exit the entire top-most call to Java, not just the recursive call.

---

## Invoking Java in the Database

This chapter gives you an overview and examples of how to invoke Java within the database.

- [Overview](#)
- [Invoking Java Methods](#)
- [Utilizing SQLJ and JDBC for Querying the Database](#)
- [Debugging Server Applications](#)
- [How To Tell You Are Executing in the Server](#)
- [Redirecting Output on the Server](#)

## Overview

In Oracle9i, you utilize Java in one of the following ways:

- [Invoking Java Methods](#)—Invoke Java methods in classes that are loaded within the database, such as Java stored procedures.
- [Utilizing SQLJ and JDBC for Querying the Database](#)—You can query the database from a Java client through utilizing [JDBC](#) or [SQLJ](#).

We recommend that you approach Java development in Oracle9i incrementally, building on what you learn at each step.

1. You should master the process of writing simple Java stored procedures, as explained in "[Preparing Java Class Methods for Execution](#)" on page 2-8. This includes writing the Java class, deciding on a resolver, loading the class into the database, and publishing the class.
2. You should understand how to access and manipulate SQL data from Java. Most Java server programs, and certainly Java programs executing on Oracle9i, interact with database-resident data. The two standard APIs for accomplishing this are JDBC and SQLJ. Because JDBC forms the foundation for SQLJ, you should understand how the two work together, even though you might be using only SQLJ in your code.

Java is a simple, general purpose language for writing stored procedures. JDBC and SQLJ allow Java to access SQL data. They support SQL operations and concepts, variable bindings between Java and SQL types, and classes that map Java classes to SQL types. You can write portable Java code that can execute on a client or a server without change. With JDBC and SQLJ, the dividing line between client and server is usually obvious—SQL operations happen in the server, and application program logic resides in the client.

As you write more complex Java programs, you can gain performance and scalability by controlling the location where the program logic executes. You can minimize network traffic and maximize locality of reference to SQL data. JDBC and SQLJ furnish ways to accomplish these goals. However, as you tend to leverage the object model in your Java application, a more significant portion of time is spent in Java execution, as opposed to SQL data access and manipulation. It becomes more important to understand and specify where Java objects reside and execute in an Internet application.



## Invoking Java Methods

The way your client calls a Java method depends on the type of Java application. The following sections discuss each of the Java APIs available for creating a Java class that can be loaded into the database and accessed by your client:

- [Utilizing Java Stored Procedures](#)
- [Utilizing Remote Method Invocation \(RMI\)](#)
- [Utilizing Java Native Interface \(JNI\) Support](#)
- [Utilizing SQLJ and JDBC for Querying the Database](#)

### Utilizing Java Stored Procedures

You execute Java stored procedures similarly to PL/SQL. Normally, calling a Java stored procedure is a by-product of database manipulation, because it is usually the result of a trigger or SQL DML call.

To invoke a Java stored procedure, you must publish it through a call specification. The following example shows how to create, resolve, load, and publish a simple Java stored procedure that echoes “Hello world”.

1. Write the Java class.

Define a class, `Hello`, with one method, `Hello.world()`, that returns the string “Hello world”.

```
public class Hello
{
    public static String world ()
    {
        return "Hello world";
    }
}
```

2. Compile the class on your client system. Using the Sun Microsystems JDK, for example, invoke the Java compiler, `javac`, as follows:

```
javac Hello.java
```

Normally, it is a good idea to specify your `CLASSPATH` on the `javac` command line, especially when writing shell scripts or make files. The Java compiler produces a Java binary file—in this case, `Hello.class`.

Keep in mind where this Java code will execute. If you execute `Hello.class` on your client system, it searches the `CLASSPATH` for all supporting core classes it must execute. This search should result in locating the dependent class in one of the following:

- as an individual file in a directory, where the directory is specified in the `CLASSPATH`
  - within a `.jar` or `.zip` file, where the directory is specified in the `CLASSPATH`
3. Decide on the resolver for your class.

In this case, you load `Hello.class` in the server, where it is stored in the database as a Java schema object. When you execute the `world()` method of the `Hello.class` on the server, it finds the necessary supporting classes, such as `String`, using a resolver—in this case, the default resolver. The default resolver looks for classes in the current schema first and then in `PUBLIC`. All core class libraries, including the `java.lang` package, are found in `PUBLIC`. You may need to specify different resolvers, and you can force resolution to occur when you use `loadjava`, to determine if there are any problems earlier, rather than at runtime. Refer to ["Resolving Class Dependencies"](#) on page 2-12 or [Chapter 7, "Schema Object Tools"](#) for more details on resolvers and `loadjava`.

4. Load the class on the Oracle9i server using `loadjava`. You must specify the username and password.

```
loadjava -user scott/tiger Hello.class
```

5. Publish the stored procedure through a call specification.

To invoke a Java static method with a `SQL CALL`, you must publish it with a call specification. A call specification defines for `SQL` which arguments the method takes and the `SQL` types it returns.

In `SQL*Plus`, connect to the database and define a top-level call specification for `Hello.world()`:

```
SQL> connect scott/tiger
connected
SQL> create or replace function HELLOWORLD return VARCHAR2 as
  2 language java name 'Hello.world () return java.lang.String';
  3 /
Function created.
```

6. Invoke the stored procedure.

```
SQL> variable myString varchar2[20];
SQL> call HELLOWORLD() into :myString;
Call completed.
SQL> print myString;
```

```
MYSTRING
```

```
-----
Hello world
```

```
SQL>
```

The call `HELLOWORLD() into :myString` statement performs a top-level call in Oracle9i. The Oracle-specific `select HELLOWORLD from DUAL` also works. Note that SQL and PL/SQL see no difference between a stored procedure that is written in Java, PL/SQL, or any other language. The call specification provides a means to tie inter-language calls together in a consistent manner. Call specifications are necessary only for entry points invoked with triggers or SQL and PL/SQL calls. Furthermore, JDeveloper can automate the task of writing call specifications.

For more information on Java stored procedures, using Java in triggers, call specifications, rights models, and inter-language calls, refer to the *Oracle9i Java Stored Procedures Developer's Guide*.

## Utilizing Remote Method Invocation (RMI)

Oracle9i supports Java Remote Method Invocation (RMI). All RMI classes and `java.net` support are in place. In general, RMI is not useful or scalable in Oracle9i Java applications. While the RMI Server that Sun Microsystems supplies does function on the Oracle9i JVM platform, it is useful only within the context of a single call. This is because the RMI Server forks daemon threads, which are killed off at the end of call (that is, when all non-daemon threads return). If the RMI server session is reentered in a subsequent call, these daemon threads aren't restarted and the RMI server won't function properly.

## Utilizing Java Native Interface (JNI) Support

The Java Native Interface (JNI) is a standard programming interface for writing Java native methods and embedding the Java virtual machine into native applications. The primary goal of JNI is to provide binary compatibility of Java applications that use platform-specific native libraries.

Oracle does not support the use of JNI in Oracle9i Java applications. If you use JNI, your application is not 100% pure Java, and the native methods require porting between platforms. Native methods have the potential for crashing the server, violating security, and corrupting data.

## Utilizing SQLJ and JDBC for Querying the Database

You can use one of two protocols for querying the database from a Java client. Both protocols establish a session with a given username/password to the database and execute SQL queries against the database.

**JDBC** Use this protocol for more complex or dynamic SQL queries. JDBC requires you to establish the session, construct the query, and so on.

**SQLJ** Use this protocol for static, easy SQL queries. SQLJ is typically a one-liner that executes against a known table with known column names.

### JDBC

JDBC is an industry-standard API developed by Sun Microsystems that allows you to embed SQL statements as Java method arguments. JDBC is based on the X/Open SQL Call Level Interface and complies with the SQL92 Entry Level standard. Each vendor, such as Oracle, creates its JDBC implementation by implementing the interfaces of the Sun Microsystems `java.sql` package. Oracle offers three JDBC drivers that implement these standard interfaces:

1. The JDBC Thin driver, a 100% pure Java solution you can use for either client-side applications or applets and requires no Oracle client installation.
2. The JDBC OCI drivers, which you use for client-side applications and requires an Oracle client installation.
3. The server-side JDBC driver embedded in the Oracle9i server.

For the developer, using JDBC is a step-by-step process of creating a statement object of some type for your desired SQL operation, assigning any local variables that you want to bind to the SQL operation, and then executing the operation. This process is sufficient for many applications but becomes cumbersome for any complicated statements. Dynamic SQL operations, where the operations are not known until runtime, require JDBC. In typical applications, however, this represents a minority of the SQL operations.

## SQLJ

SQLJ offers an industry-standard way to embed any static SQL operation directly into Java source code in one simple step, without requiring the individual steps of JDBC. Oracle SQLJ complies with ANSI standard X3H2-98-320.

SQLJ consists of a translator—a precompiler that supports standard SQLJ programming syntax—and a runtime component. After creating your SQLJ source code in a `.sqlj` file, you process it with the translator, which translates your SQLJ source code to standard Java source code, with SQL operations converted to calls to the SQLJ runtime. In the Oracle SQLJ implementation, the translator invokes a Java compiler to compile the Java source. When your Oracle SQLJ application runs, the SQLJ runtime calls JDBC to communicate with the database.

SQLJ also allows you to catch errors in your SQL statements before runtime. JDBC code, being pure Java, is compiled directly. The compiler has no knowledge of SQL, so it is unaware of any SQL errors. By contrast, when you translate SQLJ code, the translator analyzes the embedded SQL statements semantically and syntactically, catching SQL errors during development, instead of allowing an end-user to catch them when running the application.

## An Example Comparing JDBC and SQLJ

The following is an example of a simple operation, first in JDBC code and then SQLJ code.

### JDBC:

```
// (Presume you already have a JDBC Connection object conn)
// Define Java variables
String name;
int id=37115;
float salary=20000;

// Set up JDBC prepared statement.
PreparedStatement pstmt = conn.prepareStatement
    ("select ename from emp where empno=? and sal>?");
pstmt.setInt(1, id);
pstmt.setFloat(2, salary);

// Execute query; retrieve name and assign it to Java variable.
ResultSet rs = pstmt.executeQuery();
while (rs.next()) {
    name=rs.getString(1);
    System.out.println("Name is: " + name);
}
```

```
}  
  
// Close result set and statement objects.  
rs.close()  
pstmt.close();
```

1. Define the Java variables `name`, `id`, and `salary`.
2. Define a prepared statement (this presumes you have already established a connection to the database so that you can use the `prepareStatement()` method of the connection object).

You can use a prepared statement whenever values within the SQL statement must be dynamically set. You can use the same prepared statement repeatedly with different variable values. The question marks in the prepared statement are placeholders for Java variables and are given values in the `pstmt.setInt()` and `pstmt.setFloat()` lines of code. The first “?” is set to the `int` variable `id` (with a value of 37115). The second “?” is set to the `float` variable `salary` (with a value of 20000).

3. Execute the query and return the data into a JDBC result set object. (You can use result sets to gather query data.)
4. Retrieve the data of interest (the name) from the result set and print it. A result set usually contains multiple rows of data, although this example has only one row.

By comparison, here is some SQLJ code that performs the same task. Note that all SQLJ statements, both declarations and executable statements, start with the `#sql` token.

### SQLJ:

```
String name;  
int id=37115;  
float salary=20000;  
#sql {select ename into :name from emp where empno=:id and sal>:salary};  
System.out.println("Name is: " + name);
```

SQLJ, in addition to allowing SQL statements to be directly embedded in Java code, supports Java host expressions (also known as bind expressions) to be used directly in the SQL statements. In the simplest case, a host expression is a simple variable as in this example, but more complex expressions are allowed as well. Each host expression is preceded by “:” (colon). This example uses Java host expressions `name`, `id`, and `salary`. In SQLJ, because of its host expression support, you do not need a result set or equivalent when you are returning only a single row of data.

## Complete SQLJ Example

This section presents a complete example of a simple SQLJ program:

```
import java.sql.*;
import sqlj.runtime.ref.DefaultContext;
import oracle.sqlj.runtime.Oracle;
#sql iterator MyIter (String ename, int empno, float sal);

public class MyExample
{
    public static void main (String args[]) throws SQLException
    {
        Oracle.connect
            ("jdbc:oracle:thin:@ool1:5521:so12", "scott", "tiger");

        #sql { insert into emp (ename, empno, sal)
            values ('SALMAN', 32, 20000) };
        MyIter iter;

        #sql iter={ select ename, empno, sal from emp };
        while (iter.next()) {
            System.out.println
                (iter.ename()+" "+iter.empno()+" "+iter.sal());
        }
    }
}
```

1. Declare your iterators. SQLJ uses a strongly typed version of JDBC result sets, known as iterators. The main difference between the two is that an iterator has a specific number of columns of specific datatypes. You must define your iterator types beforehand, as in this example:

```
#sql iterator MyIter (String ename, int empno, float sal);
```

This declaration results in SQLJ creating an iterator class `MyIter`. Iterators of type `MyIter` can store results whose first column maps to a Java `String`, whose second column maps to a Java `int`, and whose third column maps to a Java `float`. This definition also names the three columns—`ename`, `empno`, and `sal`, respectively—to match the table column names in the database. `MyIter` is a named iterator. See Chapter 3 of the *Oracle9i SQLJ Developer's Guide and Reference* to learn about positional iterators, which do not require column names.

2. Connect to the database.

```
Oracle.connect("jdbc:oracle:thin:@oow11:5521:so12","scott", "tiger");
```

Oracle SQLJ furnishes the `Oracle` class, and its `connect()` method accomplishes three important things:

- a. Registers the Oracle JDBC drivers that SQLJ uses to access the database.
  - b. Opens a database connection for the specified schema (user `scott`, password `tiger`) at the specified URL (host `oow11`, port `5521`, SID `so12`, “thin” JDBC driver).
  - c. Establishes this connection as the default connection for your SQLJ statements. Although each JDBC statement must explicitly specify a connection object, a SQLJ statement can either implicitly use a default connection or optionally specify a different connection.
3. Execute a SQL statement.

- a. Insert a row into the `emp` table:

```
#sql {insert into emp (ename, empno, sal) values ('SALMAN', 32, 20000)};
```

- b. Instantiate and populate the iterator:

```
MyIter iter;  
#sql iter={select ename, empno, sal from emp};
```

4. Access the data that was populated within the iterator.

```
while (iter.next()){  
    System.out.println(iter.ename()+" "+iter.empno()+" "+iter.sal());  
}
```

The `next()` method is common to all iterators and plays the same role as the `next()` method of a JDBC result set, returning `true` and moving to the next row of data if any rows remain. You access the data in each row by calling iterator accessor methods whose names match the column names (this is a characteristic of all named iterators). In this example, you access the data using the methods `ename()`, `empno()`, and `sal()`.

### SQLJ Strong Typing Paradigm

SQLJ uses strong typing—such as iterators—instead of result sets, which allows your SQL instructions to be checked against the database during translation. For example, SQLJ can connect to a database and check your iterators against the database tables that will be queried. The translator will verify that they match, allowing you to catch SQL errors during translation that would otherwise not be



caught until a user runs your application. Furthermore, if changes are subsequently made to the schema, you can determine if this affects the application simply by re-running the translator.

### Translating a SQLJ Program

Integrated development environments such as Oracle JDeveloper, a Windows-based visual development environment for Java programming, can translate, compile, and customize your SQLJ program for you as you build it. If you are not using an IDE, then use the front-end SQLJ utility, `sqlj`. Run it as follows:

```
%sqlj MyExample.sqlj
```

The SQLJ translator checks the syntax and semantics of your SQL operations. You can enable online checking to check your operations against the database. If you choose to do this, you must specify an example database schema in your translator option settings. It is not necessary for the schema to have identical data to the one the program will eventually run against; however, the tables should have columns with corresponding names and datatypes. Use the `user` option to enable online checking and specify the username, password, and URL of your schema, as in the following example:

```
%sqlj -user=scott/tiger@jdbc:oracle:thin:@oow11:5521:sol2 MyExample.sqlj
```

### Running a SQLJ Program in the Server

Many SQLJ applications run on a client; however, SQLJ offers an advantage in programming stored procedures—which are usually SQL-intensive—to run in the server.

There is almost no difference between coding for a client-side SQLJ program and a server-side SQLJ program. The SQLJ runtime packages are automatically available on the server, and there are just the following few considerations:

- There are no explicit database connections for code running in the server, only a single implicit connection. You do not need the usual connection code. If you are porting an existing client-side application, you do not have to remove your connection code, because it will be ignored.
- The JDBC server-side internal driver does not support auto-commit functionality. Use SQLJ syntax for manual commits and rollbacks of your transactions.

- On the server, the default output device is a trace file, not the user screen. This is normally an issue or question only for development, because you would not write to `System.out` in a deployed server application.

To run a SQLJ program in the server, presuming you developed the code on a client, you have two options:

- Translate your SQLJ source code on the client and load the individual components (Java classes and resources) to the server. In this case, it is easiest to bundle them into a `.jar` file first.
- Load your SQLJ source code to the server for the embedded translator to translate.

In either case, use the Oracle `loadjava` utility to load the file or files to the server. See the *Oracle9i SQLJ Developer's Guide and Reference* for more information.

### Converting a Client Application to Run in the Server

The steps in converting an existing SQLJ client-side application to run in the server are as follows. Assume this is an application that has already been translated on the client:

1. Create a `.jar` file for your application components.
2. Use the `loadjava` utility to load the `.jar` file to the server.
3. Create a SQL wrapper in the server for your application. For example, to run the preceding `MyExample` application in the server:

```
create or replace procedure SQLJ_MYEXAMPLE as language java
name 'MyExample.main(java.lang.String[])';
```

You can then execute `SQLJ_MYEXAMPLE`, as with any other stored procedure.

### Interacting with PL/SQL

All the Oracle JDBC drivers communicate seamlessly with Oracle SQL and PL/SQL, and it is important to note that SQLJ interoperates with PL/SQL. You can start using SQLJ without having to rewrite any PL/SQL stored procedures. Oracle SQLJ includes syntax for calling PL/SQL stored procedures and also allows PL/SQL anonymous blocks to be embedded in SQLJ executable statements, just as with SQL operations.

## Debugging Server Applications

Oracle9i furnishes a debugging capability that is useful for developers who use the JDK's `jdb` debugger. Two interfaces are supported.

- The debug Agent protocol that was introduced in Oracle8i, and is supported by JDK 1.2 and later versions of JDB. The class `DebugProxy` makes remote Java programs appear to be local. It lets any debugger that supports the `sun.tools.debug.Agent` protocol connect to a program as if the program were local. The proxy forwards requests to the server and returns results to the debugger.

For detailed instructions, see the *Oracle9i Java Developer's Guide*.

- The Java Debug Wire Protocol supported by JDK 1.3 and later versions of the Sun Microsystems JDB debugger (<http://java.sun.com/j2se/1.3/docs/guide/jpda/>, <http://java.sun.com/j2se/1.4/docs/guide/jpda/>.) The use of this interface is documented on OTN. The JDWP protocol supports many new features, including the ability to listen for connections (no more `DebugProxy`), change the values of variables while debugging, and evaluate arbitrary Java expressions, including method evaluation.

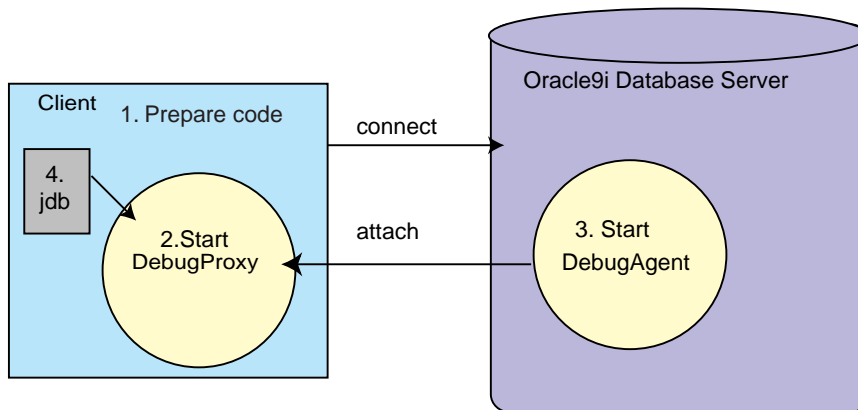
Oracle's JDeveloper provides a user-friendly integration with these debugging features. See the JDeveloper documentation for more information on how to debug your Java application through JDeveloper. Other independent IDE vendors will be able to integrate their own debuggers with Oracle9i.

### The Debug Agent Protocol

The Sun Microsystems `jdb` debugger attaches itself to an executing process, and helps you debug the executing process. The application that you are debugging must have been compiled with the debug option (`-g`).

In Oracle9i, your Java program executes remotely on a server. The server can reside on the same physical machine, but it typically resides on a separate machine. Oracle9i provides a method for `jdb` to debug a Java application loaded into Oracle9i.

This method involves an debug agent that is executing on the Oracle9i server and communicating with the executing Java application, a debug proxy that exists on the client and communicates with the Oracle9i server, and a way for `jdb` to attach itself to the debug proxy. [Figure 3-1](#) shows the relationship between the debug agent, the debug proxy, and the `jdb` debugger.

**Figure 3–1** *Debug Proxy and Debug Class Facilitate jdb Debugger*

As shown in [Figure 3–1](#), the steps for remotely debugging your Java application are as follows:

1. Prepare your code for debugging.
2. Start the `DebugProxy`. The `DebugProxy` waits for a `DebugAgent` to attach to it from the server.
3. Start the `DebugAgent` giving it the debug proxy address. This starts the communication between the debug agent and the debug proxy.
4. Attach the `jdb` debugger to the debug proxy. Once attached, use the regular `jdb` commands.

### 1. Prepare the Code for Debugging

The code must be compiled with the `-g` option and the source must be made available for the debug agent to locate.

You can cause your application to be compiled with the debug option (`-g`) in one of the two following ways:

- Inform the server to compile the class with the debug option through the `set_compiler_option` procedure, as follows:

```
SQL> call dbms_java.set_compiler_option('myPackage.myCode','debug','true');
```

---



---

**Note:** The `set_compiler_option` procedure specifies many different compiler options on a certain class, package, or all classes. This example shows setting the option for a single class. See ["loadjava"](#) on page 7-7 for more information on this procedure.

---



---

Then, you must load the source code using `loadjava`, as follows:

```
% loadjava -u SCOTT/TIGER -v -f -r myCode.java
```

The server will compile this class with the debug option. Also, the server now has access to both the source and the compiled binary, which the debug agent needs for showing the breakpoints.

- Compile your code on the client with the `-g` option, load the compiled class into the server, and copy the Java source file to the file system where Oracle9i exists, as follows:

```
% javac -g MyCode.java
% loadjava -u SCOTT/TIGER -v -f -r myCode.class
% ftp dbhost
> cd /private/sourcecode
> put myCode.java
```

When `jdb` starts, set the location of the source code with `jdb`'s `'use'` command. This enables the debug agent to find the source code.

```
> use /private/sourcecode
```

---



---

**Note:** In order to copy any files to the database file system, you must have the correct `FilePermission`. See the Security chapter for more information.

---



---

## 2. Start the Debug Proxy

The `DebugProxy` class enables your remote Java application appear to be local. The debug proxy forwards all `jdb` requests to the debug agent on the server and returns the results to the attached `jdb` debugger.

Once started, the debug proxy waits for the debug agent to attach itself. Assuming the `aurora_client.jar` file is part of your `CLASSPATH`, start the debug proxy as follows:

```
debugproxy
```

You can also specify a particular port to wait on.

```
debugproxy -port 2286
```

The proxy prints out its name, its address, and the port it is waiting on.

```
Proxy Name: yourmachinename  
Proxy Address: aaa.bbb.ccc.ddd  
Proxy Port: 2286
```

However, the easiest method to start the `DebugProxy` is to append a command to start up the `jdb` debugger at the end of the `debugproxy` command. The `debugproxy` command takes in any option given, beyond the optional port, as a command to execute after it has started. If you choose this method, you do not need to execute step 4.

For UNIX, provide the following within an executable shell script called `startjdb`:

```
#!/bin/sh  
xterm -e jdb -password &1 &
```

Then, you can automatically start up the `jdb` debugger within the `debugproxy` command, as follows:

```
debugproxy -port 1638 startjdb
```

For all Windows NT environments, provide the following within a batch file called `startjdb.bat`:

```
start jdb -password %1
```

Then, you can automatically start up the `jdb` debugger within the `debugproxy` command, as follows:

```
debugproxy -port 1638 startjdb.bat
```

### 3. Starting, Stopping, and Restarting the Debug Agent

After you connect to the server (starting a session) and start a debug proxy, start a debug agent on the server that will connect to the proxy. When the `DebugAgent` starts, the `DebugProxy` displays a password to use when attaching the debugger in step 4.

---

---

**Note:** You must have the debug permission, `JAVADEBUGPRIV`, granted to your user to run a debug agent. See "[Debugging Permissions](#)" in the *Oracle9i Java Developer's Guide* for more information.

---

---

Once a proxy is running, you can start a debug agent to connect to the proxy from SQL\*Plus. You must specify the IP address or URL for a machine running a debug proxy, the port the proxy is waiting on, and a timeout in seconds. You start and stop the debug agent using methods specified within the `DBMS_JAVA` package.

```
SQL> call dbms_java.start_debugging('yourmachinename', 2286, 66);
```

There is no way to cause server-resident code to execute and break, that is, execute and remain indefinitely in a halted mode. Instead, when you start the `DebugAgent`, you must specify a timeout period for the `DebugAgent` to wait before terminating. The start call waits until the timeout expires or until the main thread is suspended and resumed before it completes. Calculate a timeout that includes enough time for your debugger to start up, but not so much as to delay your session if you cannot connect a debugger.

---

---

**Note:** If an agent is already running, the Oracle9i JVM stops it and starts a new agent.

---

---

Stop the debug agent explicitly through the `stop_debugging` method.

```
SQL> call dbms_java.stop_debugging();
```

Once a debug agent starts, it runs until you stop it, the debugger disconnects, or the session ends.

Restart a stopped agent with any breakpoints still set with the `restart_debugging` method. The call waits until the timeout expires before it completes. You can also restart a running agent just to buy some seconds to suspend threads and set breakpoints.

```
SQL> call dbms_java.restart_debugging(66);
```

### OracleAgent Class

The `DBMS_JAVA` debug agent and proxy calls are published entry points to static methods that reside in `oracle.aurora.debug.OracleAgent` class. Start, stop,

and restart the debug agent in Java code, using the class `oracle.aurora.debug.OracleAgent` directly, through the following methods:

```
public static void start(String host, int port, long timeout_seconds);
public static void stop();
public static void restart(long timeout_seconds);
```

#### 4. Connecting a Debugger

Start `jdb` and attach it to the debug proxy using the password provided by the `DebugProxy` when the `DebugAgent` connected to it. In order to preserve your timeout, suspend all threads through `jdb`, set your breakpoints, and then resume.

Each time a debug agent connects to a debug proxy, the debug proxy starts a thread to wait for connections from a debugger. The thread prints out the number, name, and address of the connecting agent, the port it is waiting on, and the port encoded as a password. Here, a specific port and password are provided for illustration only:

```
Agent Number: 1
Agent Name: servername
Agent Address: eee.fff.jjj.kkk
Agent Port: 2286
Agent Password: 3i65bn
```

Then, pass the password to a `jdb`-compatible debugger (JDK 1.1.6 or later):

```
jdb -password 3i65bn
```

The first thing you should do in the debugger is suspend all threads. Otherwise, your `start_debugging` call might time out and complete before you get your breakpoints set.

If your code writes to `System.out` or `System.err`, then you may also want to use the `dbgtrace` flag to `jdb`, which redirects these streams to the debugging console:

```
jdb -dbgtrace -password 3i65bn
```

#### **Example 3-1 Starting a DebugAgent on the Server**

The following example shows how to debug an object that exists on the server. First, you need to start a proxy through the `debugproxy` command-line tool. This example starts up the proxy on the server, `tstHost`, and informs the `debugproxy` to start up the `jdb` debugger when contacted by the debug agent.

In another window, make sure that the debug agent user has the correct privileges and then start up the debug agent. Once the agent starts, the `debugproxy` starts up the `jdb` debugger and allows you to set your breakpoints. Since you have a



specified amount of time before the agent times out, the first thing you should do is suspend all threads. Then, set all of your breakpoints before resuming. This suspends the timeout until you are ready to execute.

window 1 on tstHost

```
SQL> call dbms_java.set_compiler_option('', 'debug', 'true');
SQL> exit
% loadjava -u SCOTT/TIGER -v -f -r myCode.java
% debugproxy -port 2286 start jdb -password
. (wait until a debug agent starts up and
.  contact this proxy... when it does, jdb
.  starts up automatically and you can set
.  breakpoints and debug the object, as follows:)
> suspend
> load SCOTT:myCode
> stop in myCode:updateAccount
> resume
> ...
```

window 2 on tstHost

```
SQL> grant JavaDebugPriv to SCOTT
SQL> call dbms_java.start_debugging('tstHost', 2286, 30);
```

## How To Tell You Are Executing in the Server

You might want to write Java code that executes in a certain way in the server and another way on the client. In general, Oracle does not recommend this. In fact, JDBC and SQLJ go to some trouble to enable you to write portable code that avoids this problem, even though the drivers used in the server and client are different.

If you must determine whether your code is executing in the server, use the `System.getProperty` method, as follows:

```
System.getProperty ("oracle.jserver.version")
```

The `getProperty` method returns the following:

- If executing in the server, it returns a `String` that represents the Oracle9i database release.
- If executing on the client, it returns `null`.

## Redirecting Output on the Server

`System.out` and `System.err` print to the current trace files. To redirect output to the SQL\*Plus text buffer, use this workaround:

```
SQL> SET SERVEROUTPUT ON  
SQL> CALL dbms_java.set_output(2000);
```

The minimum (and default) buffer size is 2,000 bytes; the maximum size is 1,000,000 bytes. In the following example, the buffer size is increased to 5,000 bytes:

```
SQL> SET SERVEROUTPUT ON SIZE 5000  
SQL> CALL dbms_java.set_output(5000);
```

Output prints at the end of the call.

For more information about SQL\*Plus, see the *SQL\*Plus User's Guide and Reference*.

---

# Java Installation and Configuration

This chapter describes what you need to know to install and configure Oracle JVM within your database. To configure Java memory, see the "[Java Memory Usage](#)" section in [Chapter 6, "Oracle9i Java Application Performance"](#).

- [Initializing a Java-Enabled Database](#)
- [Configuring Oracle JVM](#)
- [Using The DBMS\\_JAVA Package](#)
- [Enabling the Java Client](#)

## Initializing a Java-Enabled Database

If you install Oracle9i with the Oracle JVM option, the database is Java-enabled. That is, it is ready to run Java stored procedures, JDBC, and SQLJ.

### Oracle9i Database Template Configuration and Install

Configure the Oracle JVM option within the database template. This is the recommended method for Java installation.

The Oracle Database Configuration Assistant allows you to create database templates for defining what each database instance installation will contain. Choose the Oracle JVM option to have the Java platform installed within your database. See the Oracle Database Configuration Assistant documentation for more information on template creation.

### Modifying an Existing Oracle9i Database to Include Oracle JVM

If you have already installed your Oracle9i database without Oracle JVM, you can add Java to your database through the modify mode of the Oracle9i Database Configuration Assistant. The modify mode enables you to choose the features, such as Oracle JVM, that you would like installed on top of an existing Oracle9i database.

## Configuring Oracle JVM

When you install Oracle JVM as part of your normal Oracle9i installation, you will encounter configuration requirements for Oracle JVM within the Oracle9i Database Configuration Assistant and the Oracle Net Assistant.

The main configuration for Java classes within Oracle9i includes configuring Java memory requirements, the type of database processes, and the underlying connection protocol to the server.

- Java memory requirements—You must have at least 20 MB of `JAVA_POOL_SIZE` and 50 MB of `SHARED_POOL_SIZE`. See ["Java Memory Usage"](#) on page 6-19 for information on configuring these parameters.
- Database processes—You must decide whether to use dedicated server processes or shared server processes for your database server.
- Connection protocol—The networking protocol used for communication between the client and the database is TTC, which is an Oracle-specific protocol used for most database communication.

The networking protocol is referred to as the "presentation layer" within the Oracle9i documentation. However, it is not the same as the presentation layer in the OSI model. Instead, it is a protocol-based server framework that accepts incoming network requests and processes these requests.

The TTC protocol processes incoming Oracle Net requests for database SQL services from Oracle tools (such as SQL\*Plus) and customer-written applications (using Forms, Pro\*C, or the OCI). See "Configuring Multi-Threaded Server" in Chapter 9 of the *Oracle Net Services Administrator's Guide* for configuration information.

- Java stored procedures—These procedures require a different configuration for your database type and connection configuration. Java stored procedures can run either in dedicated server mode or shared server mode. If you are primarily developing Java stored procedures, you can run them in the dedicated server configuration. You can use Java clients or PL/SQL clients over a Oracle Net connection to trigger a Java stored procedure. See the *Oracle Net Services Administrator's Guide* for information on configuring an Oracle Net connection.

## Using The DBMS\_JAVA Package

Installing Oracle JVM creates the PL/SQL package DBMS\_JAVA. Some entrypoints of DBMS\_JAVA are for your use; others are only for internal use. The corresponding Java class DbmsJava provides methods for accessing RDBMS functionality from Java.

The DBMS\_JAVA package supplies the following entrypoints:

```
FUNCTION longname (shortname VARCHAR2) RETURN VARCHAR2
```

Return the full name from a Java schema object. Because Java classes and methods can have names exceeding the maximum SQL identifier length, Oracle JVM uses abbreviated names internally for SQL access. This function simply returns the original Java name for any (potentially) truncated name. An example of this function is to print the fully qualified name of classes that are invalid:

```
select dbms_java.longname (object_name) from user_objects
       where object_type = 'JAVA CLASS' and status = 'INVALID';
```

```
FUNCTION shortname (longname VARCHAR2) RETURN VARCHAR2
```

You can specify a full name to the database by using the shortname() routine of the DBMS\_JAVA package, which takes a full name as input and returns the

corresponding short name. This is useful when verifying that your classes loaded by querying the `USER_OBJECTS` view.

Refer to "[Shortened Class Names](#)" on page 2-26 and the *Oracle9i Java Stored Procedures Developer's Guide* for examples of these functions.

```
FUNCTION get_compiler_option(what VARCHAR2, optionName VARCHAR2)
PROCEDURE set_compiler_option(what VARCHAR2, optionName VARCHAR2,
                             value VARCHAR2)
PROCEDURE reset_compiler_option(what VARCHAR2, optionName VARCHAR2)
```

These three entry points control the options of the Oracle9i Java and SQLJ compiler that *Oracle9i* delivers. See "[Compiling Java Classes](#)" on page 2-8 for an example of these options. Additionally, both the *Oracle9i Java Stored Procedures Developer's Guide* and the *Oracle9i SQLJ Developer's Guide and Reference* document the options and these entry points.

```
PROCEDURE set_output (bufferSize NUMBER)
```

This procedure redirects the output of Java stored procedures and triggers to the `DBMS_OUTPUT` package. See "[Redirecting Output on the Server](#)" on page 3-20 for an example.

```
PROCEDURE loadjava(options varchar2)
PROCEDURE loadjava(options varchar2, resolver varchar2)
PROCEDURE dropjava(options varchar2)
```

These procedures allow you to load and drop classes within the database using a call, rather than through the `loadjava` or `dropjava` command-line tools. To execute within your Java application, do the following:

```
call dbms_java.loadjava('... options...');
call dbms_java.dropjava('... options...');
```

The options are identical to those specified for the `loadjava` and `dropjava` command-line tools. Each option should be separated by a blank. Do not separate the options with a comma. The only exception to this is the `loadjava -resolver` option, which contains blanks. For `-resolver`, specify all other options first, separate these options by a comma, and then specify the `-resolver` options, as follows:

```
call dbms_java.loadjava('... options...', 'resolver_options');
```

Do not specify the following options, because they relate to the database connection for the `loadjava` command-line tool: `-thin`, `-oci`, `-user`, `-password`. The

output is directed to `System.err`. The output typically goes to a trace file, but can be redirected.

For more information on the available options, see [Chapter 7, "Schema Object Tools"](#) for complete information on `loadjava`.

```
PROCEDURE grant_permission( grantee varchar2,
                           permission_type varchar2,
                           permission_name varchar2,
                           permission_action varchar2 )

PROCEDURE restrict_permission( grantee varchar2,
                              permission_type varchar2,
                              permission_name varchar2,
                              permission_action varchar2)

PROCEDURE grant_policy_permission( grantee varchar2,
                                   permission_schema varchar2,
                                   permission_type varchar2,
                                   permission_name varchar2)

PROCEDURE revoke_permission(permission_schema varchar2,
                            permission_type varchar2,
                            permission_name varchar2,
                            permission_action varchar2)

PROCEDURE disable_permission(key number)

PROCEDURE enable_permission(key number)

PROCEDURE delete_permission(key number)
```

These entry points control the JVM permissions. See ["Setting Permissions"](#) on page 5-5 for a description and example of these options.

```
PROCEDURE start_debugging(host varchar2, port number,
                          timeout number)

PROCEDURE stop_debugging

PROCEDURE restart_debugging(timeout number)
```

These entry points start and stop the debug agent when debugging. See ["Debugging Server Applications"](#) on page 3-13 for a description and example of these options.

## Enabling the Java Client

To run Java between the client and server, your client system must perform the following:

1. [Install JDK on the Client.](#)
2. [Set up Environment Variables.](#)
3. [Test Install with Samples.](#)

### 1. Install JDK on the Client

The client requires JDK 1.1.6 or later. To confirm what version of the JDK you are using, perform the following:

```
$ which java
/usr/local/packages/jdk1.2.1/bin/java
$ which javac
/usr/local/packages/jdk1.2.1/bin/javac
$ java -version
java version "1.2.1"
```

### 2. Set up Environment Variables

After installing the JDK on your client, you must add the directory path to the following environment variables:

---

---

**Note:** For NT users, the syntax for the environment variables is %ORACLE\_HOME%, %JAVA\_HOME%, %PATH%, and %LIB%.

---

---

- \$JAVA\_HOME—must be set to the top directory of the installed JDK base
- \$PATH—requires \$JAVA\_HOME/bin
- \$LD\_LIBRARY\_PATH for Solaris or %LIB% for Windows NT—must include \$JAVA\_HOME/lib

#### JAR Files Necessary for JDK 1.1 Clients

For a JDK 1.1 client to communicate with the Java 2 server, you must include the following JVM JAR file:

```
$JAVA_HOME/lib/classes.zip
```



For any interaction with JDBC, include the following ZIP file:

```
$ORACLE_HOME/jdbc/lib/classes111.zip
```

For any client that uses SSL, include the following JAR files:

```
$ORACLE_HOME/jlib/jssl-1_1.jar  
$ORACLE_HOME/jlib/javax-ssl-1_1.jar
```

For any client that uses Java Transaction API (JTA) functionality, include the following JAR file:

```
$ORACLE_HOME/jlib/jta.jar
```

For any client that uses JNDI functionality, include the following JAR file:

```
$ORACLE_HOME/jlib/jndi.jar
```

### JAR Files Necessary for Java 2 Clients

For a Java 2 client to communicate with the Java 2 server, you must make sure that one of the following JVM JAR files are in the CLASSPATH:

- For JDK 1.2, include `$JAVA_HOME/lib/dt.jar`
- For JRE 1.2, include `$JAVA_HOME/lib/rt.jar`

For any interaction with JDBC, include the following ZIP file:

```
$ORACLE_HOME/jdbc/lib/classes12.zip
```

For any client that uses SSL, include the following JAR files:

```
$ORACLE_HOME/jlib/jssl-1_2.jar  
$ORACLE_HOME/jlib/javax-ssl-1_2.jar
```

For any client that uses Java Transaction API (JTA) functionality, include the following JAR file:

```
$ORACLE_HOME/jlib/jta.jar
```

For any client that uses JNDI functionality, include the following JAR file:

```
$ORACLE_HOME/jlib/jndi.jar
```

If you are using the Accelerator for native compilation, include `$JAVA_HOME/lib/tools.jar`

### JAR Files Included for Clients that use SQLJ

`$ORACLE_HOME/sqlj/lib/translator.zip`

In addition to this file, add the appropriate `runtimeX.zip` file, as follows:

- Java 2 client using the current release of JDBC—  
`$ORACLE_HOME/sqlj/lib/runtime12.zip`
- Java 2 Enterprise Edition client using the current release of JDBC—  
`$ORACLE_HOME/sqlj/lib/runtime12ee.zip`
- JDK 1.1 client using the current release of JDBC—  
`$ORACLE_HOME/sqlj/lib/runtime11.zip`
- Any JDK client using JDBC 8.1.7 or previous version—  
`$ORACLE_HOME/sqlj/lib/runtime.zip`

### Server Application Development on the Client

If you develop and compile your server applications on the client and you want to use the same JAR files that are loaded on the server, include `$ORACLE_HOME/lib/aurora.zip` in the CLASSPATH. This is not required for running Java clients.

## 3. Test Install with Samples

We provide a set of samples in the `$ORACLE_HOME/javavm/demo` directory. These samples compile and run for a database installed with the Oracle JVM option. Execute these samples as a test of your installation.

`$ORACLE_HOME/javavm/demo/examples/jsproc/helloworld`

If these samples do not compile or run, your environment is incorrect. Similarly, if these samples compile and run, but your code does not, then a problem exists within your build environment or code.

---

---

**Note:** It is important that you run these examples using the supplied Makefiles (or batch files on NT) when verifying your installation.

---

---

Verify that the samples work before using more complex build environments, such as Visual Cafe, JDeveloper, or VisualAge.

---

# Security For Oracle9i Java Applications

Security is a large arena that includes network security for the connection, access and execution control of operating system resources or of JVM and user-defined classes, and bytecode verification of imported JAR files from an external source. The following sections describe the various security support available for Java applications within Oracle9i.

- [Network Connection Security](#)
- [Database Contents and JVM Security](#)
  - [Java 2 Security](#)
  - [Setting Permissions](#)
  - [Debugging Permissions](#)
  - [Permission for Loading Classes](#)

## Network Connection Security

The two major aspects to network security are authentication and data confidentiality. The type of authentication and data confidentiality is dependent on how you connect to the database—through Oracle Net or JDBC connection.

---

Connection Security	Description
Oracle Net	<p>The database can require both authentication and authorization before allowing a user to connect to it. Oracle Net database connection security can require one or more of the following:</p> <ul style="list-style-type: none"><li>■ Use a username and password for client verification. Each incoming connection into the database has to provide the correct username/password configured within Oracle Net. For more information, see the <i>Oracle Net Services Administrator's Guide</i>.</li><li>■ Use Advanced Networking Option for encryption, kerberos, or secureId. See the <i>Oracle Advanced Security Administrator's Guide</i>.</li><li>■ Use SSL for certificate authentication. See the <i>Oracle Advanced Security Administrator's Guide</i>.</li></ul>
JDBC	<p>The JDBC connection security that is required is similar to the constraints required on an Oracle Net database connection. In addition to the books listed in the Oracle Net database connection section, see the <i>Oracle9i JDBC Developer's Guide and Reference</i>.</p>

---

## Database Contents and JVM Security

Once you are connected to the database, you still must have the correct Java 2 Permissions and database privileges to access the resources stored within the database. These resources include the following:

- database resources, such as tables and PL/SQL packages
- operating system resources, such as files and sockets
- Oracle9i JVM classes
- user-loaded classes

These resources can be protected by the following two methods:

Resource Security	Description
Database Resource Security	<p>Authorization for database resources requires that database privileges (not the same as the Java 2 security permissions) are granted to resources. For example, database resources include tables, classes, and PL/SQL packages. For more information, see the <i>Oracle9i Application Developer's Guide - Fundamentals</i>.</p> <p>All user-defined classes are secured against users from other schemas. You can grant execution permission to other users/schemas through an option on the <code>loadjava</code> command. For more information on setting execution rights when loading classes, see the <code>-grant</code> option discussed in "Loading Classes" on page 2-16 or Chapter 7, "Schema Object Tools" for complete information on <code>loadjava</code>.</p>
JVM Security	<p>Oracle9i JVM uses Java 2 security, which uses Permission objects to protect operating system resources. Java 2 security is automatically installed upon startup and protects all operating system resources and JVM classes from all users, except <code>JAVA_ADMIN</code>. <code>JAVA_ADMIN</code> can grant permission to other users to access these classes.</p> <p>See "Java 2 Security" on page 5-3 for how to manage and modify Java 2 Permissions and policies.</p>

## Java 2 Security

Each user or schema must be assigned the proper permissions to access operating system resources. For example, this includes sockets, files, and system properties.

Java 2 security was created to provide a flexible, configurable security for Java applications. With Java 2 security, you can define exactly what permissions on each loaded object that a schema or role will have. In release 8.1.5, the security provided you the choice of two secure roles:

- `JAVAUSERPRIV`—few Permissions, including examining properties
- `JAVASYSPRIV`—major Permissions, including updating JVM protected packages

---

**Note:** Both roles still exist within this release for backward compatibility; however, Oracle recommends that you specify each Permission explicitly, rather than utilize these roles.

---

Because Oracle9i JVM security is based on Java 2 security, you assign Permissions on a class by class basis. Permissions contains two string attributes:

- target (name) attribute
- action attribute

These permissions are assigned through database management tools. Each permission is encapsulated in a Permission object and is stored within a Permission table. The methods for managing all permissions are the subject for most of this chapter.

Java security was created for the non-database world. When you apply the Java 2 security model within the database, certain differences manifest themselves. For example, Java 2 security defines that all applets are implicitly untrusted, and all classes within the CLASSPATH are trusted. In Oracle9i, all classes are loaded within a secure database; thus, no classes are trusted.

The following table briefly describes the differences between the Sun Microsystems Java 2 security and the Oracle9i security implementation. This table assumes that you already understand the Sun Microsystems Java 2 security model. For more information, we recommend the following books:

- *Inside Java 2 Platform Security* by Li Gong
- *Java Security* by Scott Oaks

<b>Java 2 Security Standard</b>	<b>Oracle9i Security Implementation</b>
Java classes located within the CLASSPATH are trusted.	All Java classes are loaded within the database. Classes are trusted on a class by class basis according to the Permission granted.
You can specify the policy through the -usepolicy flag on the java command line.	You must specify the policy within the PolicyTable.
You can write your own SecurityManager or use the Launcher.	You can write your own SecurityManager; Oracle recommends that you use only the Oracle9i SecurityManager or that you extend the Oracle9i SecurityManager. If you want to modify the behavior, you should not define a SecurityManager; instead, you should extend <code>oracle.aurora.rdbms.SecurityManagerImpl</code> and override specific methods.

Java 2 Security Standard	Oracle9i Security Implementation
<code>SecurityManager</code> is not initialized for you. You must initialize the <code>SecurityManager</code> .	The Oracle9i JVM always initializes <code>SecurityManager</code> at startup.
Permissions are determined by the location where the application or applet is loaded (the URL) or keycode (signed code).	Permissions are determined by the schema in which the class is loaded. Oracle9i does not support signed code.
The security policy is defined in a file.	The <code>PolicyTable</code> definition is contained within a secure database table.
You can update the security policy file through a text editor (if you have the correct Permissions) or through a tool.	You can update the <code>PolicyTable</code> through <code>DBMS_JAVA</code> procedures. After initialization, only <code>JAVA_ADMIN</code> has permission to modify the <code>PolicyTable</code> . <code>JAVA_ADMIN</code> must grant you the right to modify the <code>PolicyTable</code> for you to grant Permissions to others.
Permissions are assigned to a protection domain, which classes can belong to.	All classes within the same schema are within the same protection domain.
You can use the <code>CodeSource</code> class for identifying code.	You can use the <code>CodeSource</code> class for identifying schema.
<ul style="list-style-type: none"> <li>■ The <code>equals</code> method returns true if the URL and certificates are equal.</li> <li>■ The <code>implies</code> method returns true if the first <code>CodeSource</code> is a generic representation that includes the specific <code>CodeSource</code> object.</li> </ul>	<ul style="list-style-type: none"> <li>■ The <code>equals</code> method returns true if the schemas are the same.</li> <li>■ The <code>implies</code> method returns true if the schemas are the same.</li> </ul>
Supports positive Permissions only (grant).	Supports both positive (grant) and limitation (restrict) Permissions.

## Setting Permissions

As with Java 2 security, Oracle9i supports the security classes. Normally, you set the Permissions for the code base either through a tool or by editing the security policy file. In Oracle9i, you set the Permissions dynamically through `DBMS_JAVA` procedures. These procedures modify a policy table, which is a new table within the database that exclusively manages Java 2 security Permissions.

Two views have been created for you to view the policy table: `USER_JAVA_POLICY` and `DBA_JAVA_POLICY`. Both views contain information about granted and limitation Permissions. The `DBA_JAVA_POLICY` view can see all rows within the policy table; the `USER_JAVA_POLICY` table can see only Permissions relevant to the current user. The following is a description of the rows within each view:

Table Column	Description
Kind	GRANT or RESTRICT. Shows whether this Permission is a positive (GRANT) or a limitation (RESTRICT) Permission.
Grantee	The name of the user, schema, or role to which the Permission object is assigned.
Permission_schema	The schema in which the Permission object is loaded.
Permission_type	The Permission class type, which is designated by a string containing the full class name, such as, <code>java.io.FilePermission</code> .
Permission_name	The target attribute (name) of the Permission object. You use this name when defining the Permission. When defining the target for a Permission of type <code>PolicyTablePermission</code> , the name can become quite complicated. See " <a href="#">Acquiring Administrative Permission to Update Policy Table</a> " on page 5-12 for more information.
Permission_action	The action attribute for this Permission. Many Permissions expect a null value if no action is appropriate for the Permission.
Status	ACTIVE or INACTIVE. After creating a row for a Permission, you can disable or re-enable it. This column shows the status of whether the Permission is enabled (ACTIVE) or disabled (INACTIVE).
Key	Sequence number you use to identify this row. This number should be supplied when disabling, enabling, or deleting the Permission.

There are two ways to set your Permissions:

- **Fine-Grain Definition for Each Permission**—You grant each Permission individually for specific users or roles. If you do not grant a Permission for access, the schema will be denied access.
- **General Permission Definition Assigned to Roles**—If you do not want to grant specific Permissions for each user, you can grant roles, which grants a collection of Permissions to the user. Oracle9i supplies the roles: `JAVASYSPRIV` or `JAVASYSPRIV`.



---



---

**Note:** For absolute certainty about your security, implement the fine-grain definition. The general definition is easier; but you might not get the exact security you require.

---



---

### Fine-Grain Definition for Each Permission

To set individual Permissions within the policy table, you must provide the following information:

Parameter	Description
Grantee	The name of the user, schema, or role to which you want the grant to apply. PUBLIC specifies that the row applies to all users.
Permission type	The Permission class on which you are granting Permission. For example, if you were defining access to a file, the Permission type would be <code>FilePermission</code> . This parameter requires a fully-qualified name of a class that extends <code>java.lang.security.Permission</code> . If the class is not within SYS, the name should be prefixed by <code>&lt;schema&gt;.</code> . For example, <code>mySchema:myPackage.MyPermission</code> is a valid name for a user-generated Permission.
Permission name	The meaning of the target attribute is defined by the Permission class. Examine the appropriate Permission class for the relevant name.
Permission action	The type of action that you can specify varies according to the Permission type. For example, <code>FilePermission</code> can have the action of read or write.
Key	Number returned from grant or limit to use on enable, disable, or delete methods.

You can either grant Java 2 Permissions or create your own. The Java 2 Permissions are listed in [Table 5-1](#). If you would like to create your own Permissions, see "[Creating Permissions](#)" on page 5-14.

#### **Table 5-1** *Permission Types*

- `java.util.PropertyPermission`
- `java.io.SerializablePermission`
- `java.io.FilePermission`
- `java.net.NetPermission`

**Table 5–1 Permission Types**

---

■	<code>java.net.SocketPermission</code>
■	<code>java.lang.RuntimePermission</code>
■	<code>java.lang.reflect.ReflectPermission</code>
■	<code>java.security.SecurityPermission</code>
■	<code>oracle.aurora.rdbms.security.PolicyTablePermission</code>
■	<code>oracle.aurora.security.JServerPermission</code>

---

You can grant permissions using either SQL or Java, as shown below. However, each returns a row key identifier that identifies the row within the permission table. In the Java version of `DBMS_JAVA`, each method returns the row key identifier, either as a returned parameter or as an OUT variable in the parameter list. In the PL/SQL `DBMS_JAVA` package, the row key is returned only in the procedure that defines the key OUT parameter. This key is used to enable and disable specific Permissions. See ["Enabling or Disabling Permissions"](#) on page 5-18 for more information.

If, after executing the grant, a row already exists for the exact Permission, no update occurs, but the key for that row is returned. If the row was disabled, executing the grant enables the existing row.

---

---

**Note:** If granting `FilePermission`, you must provide the physical name of the directory or file, such as `/private/oracle`. You cannot provide either an environment variable, such as `$ORACLE_HOME`, or a symbolic link. Also, to denote all files within a directory, provide the `*` symbol, as follows:  
`'/private/oracle/*'`. To denote all directories and files within a directory, provide the `'-'` symbol, as follows:  
`'/private/oracle/-'`.

---

---

Granting Permissions using the `DBMS_JAVA` package:

```
procedure grant_permission( grantee varchar2, permission_type varchar2,  
                           permission_name varchar2,  
                           permission_action varchar2 )
```

```
procedure grant_permission( grantee varchar2, permission_type varchar2,
```

```
permission_name varchar2,  
permission_action varchar2, key OUT number)
```

### Granting Permissions using Java:

```
long oracle.aurora.rdbms.security.PolicyTableManager.grant(  
    java.lang.String grantee,  
    java.lang.String permission_type,  
    java.lang.String permission_name,  
    java.lang.String permission_action);
```

```
void oracle.aurora.rdbms.security.PolicyTableManager.grant(  
    java.lang.String grantee,  
    java.lang.String permission_type,  
    java.lang.String permission_name,  
    java.lang.String permission_action,  
    long[] key);
```

### Limiting Permissions using the DBMS\_JAVA package:

```
procedure restrict_permission( grantee varchar2, permission_type varchar2,  
    permission_name varchar2,  
    permission_action varchar2)
```

```
procedure restrict_permission( grantee varchar2, permission_type varchar2,  
    permission_name varchar2,  
    permission_action varchar2, key OUT number)
```

### Limiting Permissions using Java:

```
long oracle.aurora.rdbms.security.PolicyTableManager.restrict(  
    java.lang.String grantee,  
    java.lang.String permission_type,  
    java.lang.String permission_name,  
    java.lang.String permission_action);
```

```
void oracle.aurora.rdbms.security.PolicyTableManager.restrict(  
    java.lang.String grantee,  
    java.lang.String permission_type,  
    java.lang.String permission_name,  
    java.lang.String permission_action,  
    long[] key);
```

**Example 5-1 Granting Permissions**

Assuming that you have appropriate Permissions to modify the policy table, you use the `grant_permission` method within the `DBMS_JAVA` package to modify the `PolicyTable` to allow the user access to the indicated file. In this example, the user, Larry, has `PolicyTable` modification Permission. Within a SQL package, Larry grants permission to read and write a file to the user Dave.

```
connect larry/larry

REM Grant DAVE permission to read and write the Test1 file.
call dbms_java.grant_permission('DAVE',
                                'java.io.FilePermission', '/test/Test1',
                                'read,write');

REM commit the changes to the PolicyTable
commit;
```

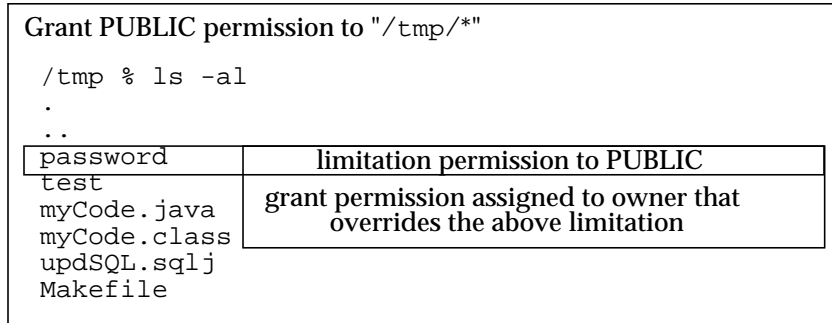
**Example 5-2 Limiting Permissions**

You use the `restrict` method for specifying a limitation or exception to general rules. A general rule is a rule where, in most cases, the Permission is true. However, there may be exceptions to this rule. For these exceptions, you specify a limitation Permission.

That is, if you have defined a general rule that no one can read or write for an entire directory, you can define a limitation on an aspect of this rule through the `restrict` method. For example, if you want to allow access to all files within the `/tmp` directory—except for your `password` file that exists in that directory—you would grant permission for read and write to all files within `/tmp` and limit read and write access to the `password` file.

If you want to specify an exception to the limitation, you would create an explicit grant Permission to override the limitation Permission. In the scenario mentioned above, if you want the file owner to still be able to modify the `password` file, you can grant a more explicit Permission to allow access to one user, which will override

the limitation. Oracle9i JVM security combines all rules to understand who really has access to the `password` file. This is demonstrated in the following diagram:



The explicit rule is as follows:

If the limitation Permission implies the request, then for a grant to be effective, the limitation Permission must also imply the grant.

The following is the code that implements this example:

1. Grant everyone (PUBLIC) read and write permission to all files in `/tmp`.
2. Limit everyone (PUBLIC) from reading or writing only the `password` file in `/tmp`.
3. Grant only Larry (owner) explicit permission to read and write the `password` file.

```
connect larry/larry
```

```
REM Grant permission to all users (PUBLIC) to be able to read and write
REM all files in /tmp.
```

```
call dbms_java.grant_permission('PUBLIC',
                                'java.io.FilePermission',
                                '/tmp/*',
                                'read,write');
```

```
REM Limit permission to all users (PUBLIC) from reading or writing the
REM password file in /tmp.
```

```
call dbms_java.restrict_permission('PUBLIC',
                                    'java.io.FilePermission',
                                    '/tmp/password',
                                    'read,write');
```

```
REM By providing a more specific rule that overrides the limitation,
REM Larry can read and write /tmp/password.
call dbms_java.grant_permission('LARRY',
                                'java.io.FilePermission',
                                '/tmp/password',
                                'read,write');

commit;
```

### Acquiring Administrative Permission to Update Policy Table

All Permissions are rows within the policy table. As it is a table within the database and thus a resource, permission is needed to modify it. Specifically, the `PolicyTablePermission` object is required to modify the table. After the first initialization for Oracle9i JVM, only a single role—`JAVA_ADMIN`—is granted the `PolicyTablePermission` to modify the policy table. The `JAVA_ADMIN` role is immediately assigned to `DBA`; thus, if you are assigned to the `DBA` group, you will automatically take on all `JAVA_ADMIN` Permissions.

For you to be able to add Permissions as rows to this table, `JAVA_ADMIN` must grant your schema update rights for the `PolicyTablePermission`. This Permission defines that your schema can add rows to the table. Each `PolicyTablePermission` is for a specific Permission type. For example, for you to add a Permission that controls access to a file, you must have a `PolicyTablePermission` that allows you to grant or limit a Permission on a `FilePermission`. Once this occurs, you have administrative Permission for `FilePermission`.

The administrator could grant and limit the `PolicyTablePermissions` in the same manner as other Permissions, but the syntax is complicated. For ease of use, use one of the following methods within the `DBMS_JAVA` package to grant administrative Permissions.

#### Granting policy table administrative Permissions using `DBMS_JAVA`:

```
procedure grant_policy_permission( grantee varchar2, permission_schema varchar2,
                                  permission_type varchar2,
                                  permission_name varchar2)

procedure grant_policy_permission( grantee varchar2, permission_schema varchar2,
                                  permission_type varchar2,
                                  permission_name varchar2,
                                  key OUT number)
```

#### Granting policy table administrative permission using Java:

```
long oracle.aurora.rdbms.security.PolicyTableManager.grantPolicyPermission(
    java.lang.String grantee,
    java.lang.String permission_type,
    java.lang.String permission_name);
```

```
void oracle.aurora.rdbms.security.PolicyTableManager.grantPolicyPermission(
    java.lang.String grantee,
    java.lang.String permission_type,
    java.lang.String permission_name,
    long[] key);
```

Parameter	Description
Grantee	The name of the user, schema, or role to which you want the grant to apply. PUBLIC specifies that the row applies to all users.
Permission_schema	The <i>&lt;schema&gt;</i> where the Permission class is loaded.
Permission_type	The Permission class on which you are granting Permission. For example, if you were defining access to a file, the Permission type would be FilePermission. This parameter requires a fully-qualified name of a class that extends java.lang.security.Permission. If the class is not within SYS, the name should be prefixed by <i>&lt;schema&gt;.</i> For example, mySchema:myPackage.MyPermission is a valid name for a user generated Permission.
Permission_name	The meaning of the target attribute is defined by the Permission class. Examine the appropriate Permission class for the relevant name.
Row_number	Number returned from grant or limitation to use on enable, disable, or delete methods.

---

**Note:** When looking at the policy table, the name within the PolicyTablePermission rows contains both the Permission type and the Permission name, which are separated by a "#". For example, to grant a user administrative rights for reading a file, the name in the row contains java.io.FilePermission#read. The "#" separates the Permission class from the Permission name.

---

**Example 5-3 Granting PolicyTable Permission**

The following example shows JAVA\_ADMIN (as SYS) giving Larry permission to update the PolicyTable for FilePermission. Once this Permission is granted, Larry can grant permissions to other users for reading, writing, and deleting files.

```
REM Connect as SYS, which is assigned JAVA_ADMIN role, to give Larry permission
REM to modify the PolicyTable
connect SYS/SYS as SYSDBA
```

```
REM SYS grants Larry the right to administer permissions for
REM FilePermission
call dbms_java.grant_policy_permission('LARRY', 'SYS',
                                     'java.io.FilePermission', '**');
```

**Creating Permissions**

Create your own Permission type by performing the following steps:

1. [Create and load the user Permission.](#)
2. [Grant administrative and action Permissions to specified users.](#)
3. [Implement security checks using the Permission.](#)

**1. Create and load the user Permission** Create your own Permission by extending the Java 2 Permission class. Any user-created Permission must extend Permission. The following example creates MyPermission, which extends BasicPermission, which in turn extends Permission.

```
package test.larry;
import java.security.Permission;
import java.security.BasicPermission;

public class MyPermission extends BasicPermission {

    public MyPermission(String name) {
        super(name);
    }

    public boolean implies(Permission p) {
        boolean result = super.implies(p);
        return result;
    }
}
```



**2. Grant administrative and action Permissions to specified users** When you create a Permission, you are designated as owner of that Permission. The owner is implicitly granted administrative Permission. This means that the owner can be an administrator for this Permission and can execute `grant_policy_permission`. Administrative Permission permits the user to update the policy table for the user-defined Permission.

For example, if LARRY creates a Permission, `MyPermission`, only LARRY can invoke `grant_policy_permission` for himself or another user. This method updates the `PolicyTable` on who can grant rights to `MyPermission`. The following code demonstrates this:

```
REM Since Larry is the user that owns MyPermission, Larry connects to
REW the database to assign permissions for MyPermission.
connect larry/larry
```

```
REM As the owner of MyPermission, Larry grants himself the right to
REM administer permissions for test.larry.MyPermission within the JVM
REM security PolicyTable. Only the owner of the user-defined permission
REM can grant administrative rights.
```

```
call dbms_java.grant_policy_permission('LARRY', 'LARRY',
                                     'test.larry.MyPermission', '*');
```

```
REM commit the changes to the PolicyTable
commit;
```

Once you have granted administrative rights, you can grant action Permissions for the user-created Permission. For example, the following SQL grants permission for LARRY to execute anything within `MyPermission` and for DAVE to execute only actions that start with "act."

```
REM Since Larry is the user that creates MyPermission, Larry connects to
REW the database to assign permissions for MyPermission.
connect larry/larry
```

```
REM Once able to modify the PolicyTable for MyPermission, Larry grants himself
REM full permission for MyPermission. Notice that the Permission is prepended
REM with its owner schema.
```

```
call dbms_java.grant_permission( 'LARRY',
                                 'LARRY:test.larry.MyPermission', '*', null);
```

```
REM Larry grants Dave permission to do any actions that start with 'act.*'.
call dbms_java.grant_permission
    ('DAVE', 'LARRY:test.larry.MyPermission', 'act.*', null);
```

```
REM commit the changes to the PolicyTable
commit;
```

**3. Implement security checks using the Permission** Once you have created, loaded, and assigned Permissions for `MyPermission`, you must implement the call to `SecurityManager` to have the Permission checked. There are four methods in the following example: `sensitive`, `act`, `print`, and `hello`. Because of the Permissions granted in the SQL example in step 2, the following users can execute methods within the example class:

- LARRY can execute any of the methods.
- DAVE is given permission to execute only the `act` method.
- Anyone can execute the `print` and `hello` methods. The `print` method does not check any Permissions, so anyone can execute the `print` method. The `hello` method executes `AccessController.doPrivileged`, which means that the method executes with LARRY's Permissions. This is referred to as *definer's rights*.

```
package test.larry;
import java.security.AccessController;
import java.security.Permission;
import java.security.PrivilegedAction;

import java.sql.Connection;
import java.sql.SQLException;

/**
 * MyActions is a class with a variety of public methods that
 * have some security risks associated with them. We will rely
 * on the Java security mechanisms to ensure that they are
 * performed only by code that is authorized to do so.
 */

public class Larry {

    private static String secret = "Larry's secret";

    MyPermission sensitivePermission = new MyPermission("sensitive");

    /**
     * This is a security sensitive operation. That is it can
     * compromise our security if it is executed by a "bad guy".
     * Only larry has permission to execute sensitive.
     */
```

```
public void sensitive() {
    checkPermission(sensitivePermission);
    print();
}

/**
 * Will print a message from Larry. We need to be
 * careful about who is allowed to do this
 * because messages from Larry may have extra impact.
 * Both larry and dave have permission to execute act.
 */
public void act(String message) {
    MyPermission p = new MyPermission("act." + message);
    checkPermission(p);
    System.out.println("Larry says: " + message);
}

/**
 * Print our secret key
 * No permission check is made; anyone can execute print.
 */
private void print() {
    System.out.println(secret);
}

/**
 * Print "Hello"
 * This method invokes doPrivileged, which makes the method run
 * under definer's rights. So, this method runs under Larry's
 * rights, so anyone can execute hello.
 * Only Larry can execute hello
 */
public void hello() {
    AccessController.doPrivileged(new PrivilegedAction() {
        public Object run() { act("hello"); return null; }
    });
}

/**
 * If a security manager is installed ask it to check permission
 * otherwise use the AccessController directly
 */
void checkPermission(Permission permission) {
    SecurityManager sm = System.getSecurityManager();
    sm.checkPermission(permission);
}
```

```
}  
}
```

### Enabling or Disabling Permissions

Once you have created a row that defines a Permission, you can disable it so that it is no longer applied. However, if you decide you want the row action again, you can enable the row. You can delete the row from the table if you believe that it will never be used again. To delete, you must first disable the row. If you do not disable the row, the deletion will not occur.

To disable rows, you can use either the `disable_permission` or the `revoke` method.

- The `revoke_permission` method takes in parameters similar to the `grant` and `restrict` methods. It searches the entire policy table for all rows that match the supplied parameters.
- The `disable_permission` method disables only a single row within the policy table. To do this, it takes in the policy table key. This key is also necessary to enable or delete a Permission. To retrieve the Permission key number, perform one of the following:
  - \* Save the key when it is returned on the `grant` or `limit` calls. If you do not foresee a need to ever enable or disable the Permission, you can use the `grant` and `limit` calls that do not return the Permission number.
  - \* View `DBA_JAVA_POLICY` or `USER_JAVA_POLICY` for the appropriate Permission key number.

Disabling Permissions using DBMS\_JAVA:

```
procedure revoke_permission(permission_schema varchar2,  
                             permission_type varchar2,  
                             permission_name varchar2,  
                             permission_action varchar2)
```

```
procedure disable_permission(key number)
```

Disabling Permissions using Java:

```
void revoke(String schema, String type, String name, String action);  
  
void oracle.aurora.rdbms.security.PolicyTableManager.disable(long number);
```

Enabling Permissions using DBMS\_JAVA:

procedure **enable\_permission**(key number)

#### Enabling Permissions using Java:

```
void oracle.aurora.rdbms.security.PolicyTableManager.enable(long number);
```

#### Deleting Permissions using DBMS\_JAVA:

```
procedure delete_permission(key number)
```

#### Deleting Permissions using Java:

```
void oracle.aurora.rdbms.security.PolicyTableManager.delete(long number);
```

### Permission Types

[Table 5-2](#) lists the installed Permission types. Whenever you want to grant or limit a Permission, you must provide the Permission type within the DBMS\_JAVA method. The Permission types with which you control access are the following:

- Oracle-provided Permission types listed in [Table 5-2](#)
- user created Permission types that extend `java.security.Permission`

**Table 5-2 Permission Types**

---

■	<code>java.util.PropertyPermission</code>
■	<code>java.io.SerializablePermission</code>
■	<code>java.io.FilePermission</code>
■	<code>java.net.NetPermission</code>
■	<code>java.net.SocketPermission</code>
■	<code>java.lang.RuntimePermission</code>
■	<code>java.lang.reflect.ReflectPermission</code>
■	<code>java.security.SecurityPermission</code>
■	<code>oracle.aurora.rdbms.security.PolicyTablePermission</code>
■	<code>oracle.aurora.security.JServerPermission</code>

---

All the Java Permission types are documented in the Sun Microsystems Java 2 documentation.

---

---

**Note:** SYS is granted permission to load libraries that come with Oracle. However, Oracle9i JVM does not support other users loading libraries, because loading C within the database is insecure. Therefore, you are not allowed to grant permission for `loadLibrary.*` of `RuntimePermission`.

---

---

The Oracle-specific Permissions, `PolicyTablePermission` and `JServerPermission`, are described below:

**oracle.aurora.rdbms.security.PolicyTablePermission** This Permission controls who can update the policy table. Once granted the right to update the policy table for a certain `Permission` type, the user can control other user's access to some resource.

After Oracle9i JVM initialization, only the `JAVA_ADMIN` role can grant administrative rights for the policy table through `PolicyTablePermission`. Once it grants this right to other users, these users can in turn update the policy table with their own grant and limitation Permissions.

To grant policy table updates, use the `DBMS_JAVA` method: `grant_policy_permission`, as discussed in "[Acquiring Administrative Permission to Update Policy Table](#)" on page 5-12. Once you have updated the table, you can view either the `DBA_JAVA_POLICY` or `USER_JAVA_POLICY` views to see who has been granted Permissions.

**oracle.aurora.security.JServerPermission** Use this Permission to grant and limit access to Oracle9i JVM resources. The `JServerPermission` extends from `BasicPermission`. The following table lists the names for which `JServerPermission` grants access:

Permission Name	Description
<code>LoadClassInPackage.&lt;package_name&gt;</code>	grants the ability to load a class within the specified package
<code>Verifier</code>	grants the ability to turn the bytecode verifier on or off
<code>Debug</code>	grants the ability for debuggers to connect to a session
<code>JRIExtensions</code>	grants the use of <code>MEMSTAT</code>
<code>Memory.Call</code>	grants rights to call certain methods in <code>oracle.aurora.vm.OracleRuntime</code> on call settings

Permission Name	Description
Memory.Stack	grants rights to call certain methods in <code>oracle.aurora.vm.OracleRuntime</code> on stack settings
Memory.SGASIntern	grants rights to call certain methods in <code>oracle.aurora.vm.OracleRuntime</code> on SGA settings
Memory.GC	grants rights to call certain methods in <code>oracle.aurora.vm.OracleRuntime</code> on garbage collector settings

### Initial Permission Grants

When you first initialize Oracle9i JVM, several roles are populated with certain Permission grants. The following tables show these roles and their initial Permissions:

1. The `JAVA_ADMIN` role is given access to modify the policy table for all Permissions. All DBAs, including `SYS`, are granted `JAVA_ADMIN`. Full administrative rights to update the policy table are granted for the following Permissions:

- 
- `java.util.PropertyPermission`
  - `java.io.SerializablePermission`
  - `java.io.FilePermission`
  - `java.net.NetPermission`
  - `java.net.SocketPermission`
  - `java.lang.RuntimePermission`
  - `java.lang.reflect.ReflectPermission`
  - `java.security.SecurityPermission`
  - `oracle.aurora.rdbms.security.PolicyTablePermission`
  - `oracle.aurora.security.JServerPermission`
- 

2. In addition to the `JAVA_ADMIN` Permissions, `SYS` is also granted the following Permissions:

---



---

**Note:** Within the `RuntimePermission` grants, there seems to be unnecessary granting of more specific `Permission` for `loadLibrary.<package>`. The reason for this is to override the limitation given to `PUBLIC` for `loadLibrary.*`.

---



---

**Table 5–3 SYS Initial Permissions**

Permission Type	Permission Name	Action Granted
<code>oracle.aurora.rdbms.security. PolicyTablePermission</code>	*	Administrative rights to modify the policy table
<code>oracle.aurora.security.JServerPermission</code>	*	null
<code>java.net.NetPermission</code>	*	null
<code>java.security.SecurityPermission</code>	*	null
<code>java.util.PropertyPermission</code>	*	write
<code>java.lang.reflect.ReflectPermission</code>	*	null
<code>java.lang.RuntimePermission</code>	*	null
	<code>loadLibrary.xaNative</code>	null
	<code>loadLibrary.corejava</code>	null
	<code>loadLibrary.corejava_d</code>	null

- All users are initially granted the following Permissions. For the `JServerPermission`, all users can load classes, except for the list of classes specified in the table. These exceptions are limitation Permissions. For more information on limitation Permissions, see [Example 5–2](#).

**Table 5–4 PUBLIC Default Permissions**

Permission Type	Permission Name	Granted Action
<code>oracle.aurora.rdbms.security. PolicyTablePermission</code>	<code>java.lang.RuntimePermission. loadLibrary.*</code>	null
<code>java.util.PropertyPermission</code>	*	read
	<code>user.language</code>	write



**Table 5–4 PUBLIC Default Permissions**

Permission Type	Permission Name	Granted Action
java.lang.RuntimePermission	_	null
	exitVM	null
	createSecurityManager	null
	modifyThread	null
	modifyThreadGroup	null
oracle.aurora.security. JServerPermission	loadClassInPackage.* except for loadClassInPackage.java.*, loadClassInPackage.oracle.aurora.*, and loadClassInPackage.jdbc.*	null

**Table 5–5 JAVAUSERPRIV Permissions**

Permission Type	Permission Name	Action
java.net.SocketPermission	*	connect, resolve
java.io.FilePermission	<<ALL FILES>>	read
java.lang.RuntimePermission	modifyThreadGroup, stopThread, getProtectionDomain, readFileDescriptor, accessClassInPackage.*, and defineClassInPackage.*	null

**Table 5–6 JAVASYSPRIV Permissions**

Permission Type	Permission Name	Action
java.io.SerializablePermission	*	no applicable action
java.io.FilePermission	<<ALL FILES>>	read, write, execute, delete
java.net.SocketPermission	*	accept, connect, listen, resolve

**Table 5–6 JAVASYSPRIV Permissions (Cont.)**

Permission Type	Permission Name	Action
java.lang.RuntimePermission	createClassLoader	null
	getClassLoader	null
	setContextClassLoader	null
	setFactory	null
	setIO	null
	setFileDescriptor	null
	readFileDescriptor	null
writeFileDescriptor	null	

---

**Table 5–7 JAVADEBUGPRIV Permissions**

Permission Type	Permission Name	Action
oracle.aurora.security.JServerPermission	Debug	null
java.net.SocketPermission	*	connect, resolve

---

### General Permission Definition Assigned to Roles

In release 8.1.5, Oracle9i JVM security was controlled by granting the roles of JAVASYSPRIV, JAVAUSERPRIV, or JAVADEBUGPRIV to schemas. In the current version, these roles still exist as Permission groups. See the previous section, "[Initial Permission Grants](#)" on page 5-21 for the explicit Permissions set for each role. You can set up and define your own collection of Permissions. Once defined, you can grant any collection of Permissions to any user. That user will then have the same Permissions that exist within the role. In addition, if you need additional Permissions, you can add individual Permissions to either your specified user or role. Permissions defined within the policy table have a cumulative effect. See "[Fine-Grain Definition for Each Permission](#)" on page 5-7 for information on how to grant Permissions to a user or a role.

---

---

**Note:** The ability to write to properties, granted through the write action on `PropertyPermission`, is no longer granted to all users. Instead, you must have either `JAVA_ADMIN` grant this Permission to you or you can receive it by being granted the role of `JAVASYSPRIV`.

---

---

The following example gives Larry and Dave the following Permissions:

- Larry receives JAVASYSPRIV Permissions.
- Dave receives JAVADEBUGPRIV Permissions and the ability to read and write all files on the system.

```
REM Granting Larry the same permissions as exist within JAVASYSPRIV
grant javasyspriv to larry;
```

```
REM Granting Dave the ability to debug
grant javadebugpriv to dave;
```

```
commit;
```

```
REM I also want Dave to be able to read and write all files on the system
call dbms_java.grant_permission('DAVE', 'SYS:java.io.FilePermission',
                               '<<ALL FILES>>', 'read,write', null);
```

## Debugging Permissions

A debug role, JAVADEBUGPRIV, was created to grant Permissions for running the debugger. The Permissions assigned to this role are listed in [Table 5-7](#). To receive permission to invoke the debug agent, the caller must have been granted JAVADEBUGPRIV or the debug JServerPermission as follows:

```
REM Granting Dave the ability to debug
grant javadebugpriv to dave;
```

```
REM Larry grants himself permission to start the debug agent.
call dbms_java.grant_permission
    ('LARRY', 'oracle.aurora.security.JServerPermission', 'Debug', null);
```

Although a debugger provides extensive access to both code and data on the server, its use should be limited to development environments. Refer to the discussion in ["Debugging Server Applications"](#) on page 3-13 for information on using the debugging facilities in this release.

## Permission for Loading Classes

To load classes, you must have the following Permission:

```
JServerPermission("LoadClassInPackage." + <class_name>)
```

The class name is the fully qualified name of the class that you are loading.

This excludes loading into system packages or replacing any system classes. Even if you are granted permission to load a system class, Oracle9i prevents you from performing the load. System classes are classes that are installed by Oracle9i with CREATE JAVA SYSTEM. The following error is thrown if you try to replace a system class:

```
ORA-01031 "Insufficient privileges"
```

The following shows the ability of each user after database installation, including Permissions and Oracle9i JVM restrictions:

- SYS can load any class except for system classes.
- Any user can load classes in its own schema that do not start with the following patterns: `java.*`, `oracle.aurora.*`, `oracle.jdbc.*`. If the user wants to load such classes into another schema, it must be granted the `JServerPermission(LoadClassInPackage.<class>)` Permission.

The following example shows how to grant SCOTT Permission to load classes into the `oracle.aurora.*` package:

```
dbms_java.grant_permission('SCOTT', 'SYS:oracle.aurora.tools.*', null);
```

---

# Oracle9i Java Application Performance

You can increase your Java application performance through one of the following methods:

- [Natively Compiled Code](#)
- [Java Memory Usage](#)
- [End-of-Call Migration](#)
- [Memory Profiling Utility](#)

## Natively Compiled Code

The Java language was designed for a platform-independent, secure development model. To accomplish these goals, some execution performance was sacrificed. Translating Java bytecodes into machine instructions degrades performance. To regain some of the performance loss, you may choose to natively compile certain classes. For example, you may decide to natively compile code with CPU intensive classes.

Without native compilation, the Java code you load to the server is interpreted, and the underlying core classes upon which your code relies (`java.lang.*`) are natively compiled.

Native compilation provides a speed increase ranging from two to ten times the speed of the bytecode interpretation. The exact speed increase is dependent on several factors, including:

- use of numerics
- degree of polymorphic message sends
- use of direct field access, as opposed to accessor methods
- amount of Array accessing
- casts

Because Java bytecodes were designed to be compact, natively compiled code can be considerably larger than the original bytecode. However, because the native code is stored in a shared library, it is shared among all users of the database.

Most JVMs use Just-In-Time compilers that convert the Java bytecodes to native machine instructions when methods are invoked. The Accelerator uses an Ahead-Of-Time approach to recompiling the Java classes.

---

<b>Native Compiler</b>	<b>Description</b>
Just-In-Time	Provides the JVM the ability to translate the Java instructions just before needed by the JDK. The benefits depends on how accurately the native compiler anticipates code branches and the next instruction. If incorrect, no performance gain is realized.

---

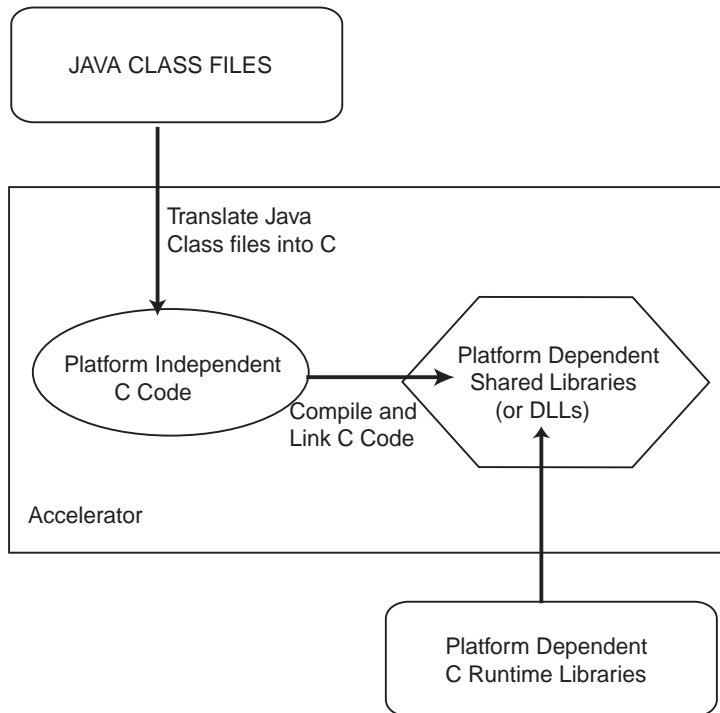
Native Compiler	Description
Ahead-Of-Time	The Accelerator natively compiles all Java code within a JAR file into native shared libraries, which are organized by Java package, before execution time. At runtime, Accelerator checks if a Java package has been natively compiled; and if so, uses the machine code library instead of interpreting the deployed Java code.

---

This static compilation approach provides a large, consistent performance gain, regardless of the number of users or the code paths they traverse on the server. After compilation, the tool loads the statically compiled libraries into Oracle9i, which are then shared between users, processes, and sessions.

## Accelerator Overview

Most Ahead-Of-Time native compilers compile directly into a platform-dependent language. For portability requirements, this was not feasible. [Figure 6-1](#) illustrates how the Accelerator translates the Java classes into a version of C that is platform-independent. The C code is compiled and linked to supply the final platform-dependent, natively compiled shared libraries or DLLs.

**Figure 6–1 Native Compilation Using Accelerator**

Given a JAR file, the Accelerator performs the following:

1. Verifies the classes that are loaded in the database.
2. Retrieves the Java bytecodes for these classes from the database and stores them in a project directory where the Accelerator was invoked.
3. Translates the Java bytecodes to C code.
4. Compiles and links the C code using the C compiler for your platform.

The Accelerator translates, compiles, and links the retrieved classes on the client. For this reason, you must natively compile on the intended platform environment to which this application will be deployed. The result is a single deployment JAR file for all classes within the project.

5. The resulting shared library is loaded into the `$ORACLE_HOME/javavm/admin` directory.



---

---

**Note:** The Accelerator natively compiled libraries can be used only within Oracle9i. Also, these libraries can only be used within the same version of Oracle9i in which it was produced. If you want your application to be natively compiled on subsequent releases, you must recompile these classes. That is, native recompilation of existing libraries will not be performed automatically by any upgrade process.

---

---

## Oracle9i Core Java Class Libraries

All core Java class libraries and Oracle-provided Java code within Oracle9i is natively compiled for greater execution speed. Java classes exist as shared libraries in `$ORACLE_HOME/javavm/admin`, where each shared library corresponds to a Java package. For example, `orajox8java_lang.so` on Solaris and `orajox8java_lang.dll` on Windows NT hold `java.lang` classes. Specifics of packaging and naming can vary by platform. The Oracle9i JVM uses natively compiled Java files internally and opens them, as necessary, at runtime.

## Natively Compiling Java Application Class Libraries

The Accelerator can be used by Java application products that need performance increased and are deployed in Oracle9i. The Accelerator command-line tool, `ncomp`, natively compiles your code and loads it in Oracle9i. However, in order to use `ncomp`, you must first provide some initial setup.

### Installation Requirements

You must install the following before invoking Accelerator:

1. Install a C compiler for the intended platform on the machine where you are running `ncomp`.
2. Verify that the correct compiler and linker commands are referenced within the `System*.properties` file located in the `$ORACLE_HOME/javavm/jahome` directory. Since the compiler and linker information is platform-specific, the configuration for these items is detailed in the README for your platform.
3. Add the appropriate JDK JAR files, library, and binary information in the following environment variables:

Environment Variables	Addition Required
JAVA_HOME	Set to the location where your JDK is installed.
CLASSPATH	Include the appropriate JDK JAR files in your CLASSPATH as follows: <ul style="list-style-type: none"> <li>For JDK 1.1, include <code>\$JAVA_HOME/lib/classes.zip</code>.</li> <li>For JDK 1.2, include the <code>\$JAVA_HOME/lib/tools.jar</code> and <code>\$JAVA_HOME/lib/dt.jar</code> files.</li> </ul>
PATH	Add the JDK binary path: <code>\$JAVA_HOME/bin</code>
LD_LIBRARY_PATH	Add the JDK library path: <code>\$JAVA_HOME/lib</code> .

4. Grant the user that executes `ncomp` the following role and security permissions:

---

**Note:** DBA role contains both the `JAVA_DEPLOY` role and the `FilePermission` for all files under `$ORACLE_HOME`.

---

- a. `JAVA_DEPLOY`: The user must be assigned to the `JAVA_DEPLOY` role in order to be able to deploy the shared libraries on the server, which both the `ncomp` and `deploync` utilities perform. For example, the role is assigned to DAVE, as follows:

```
SQL> GRANT JAVA_DEPLOY TO DAVE;
```

- b. `FilePermission`: Accelerator stores the shared libraries with the natively compiled code on the server. In order for Accelerator to store these libraries, the user must be granted `FilePermission` for read and write access to directories and files under `$ORACLE_HOME` on the server. One method for granting `FilePermission` for all desired directories is to grant the user the `JAVASYSPRIV` role, as follows:

```
SQL> GRANT JAVASYSPRIV TO DAVE;
```

See the Security chapter in the *Oracle9i Java Developer's Guide* for more information `JAVASYSPRIV` and granting `FilePermission`.

---

## Executing Accelerator

The following sections show how to do basic native compilation using Accelerator.

---

**Note:** Before you natively compile your Java server code, you must have already loaded and tested it within Oracle9i. Native compilation of untested code is not recommended.

Keep in mind that debuggers, such as the debugger provided with JDeveloper, are useful only with interpreted Java code. You cannot debug a natively compiled library.

---

All the Java classes contained within a JAR file must already be loaded within the database. Execute the `ncomp` tool to instruct Accelerator to natively compile all these classes. The following code natively compiles all classes within the `pubProject.JAR` file:

```
ncomp -user scott/tiger pubProject.JAR
```

---

**Note:** Because native compilation must compile and link all your Java classes, this process may execute over the span of a few hours. The time involved in natively compiling your code depends on the number of classes to compile and the type of hardware on your machine.

---

If you change any of the classes within this JAR file, Accelerator recompiles the shared library for the package that contains the changed classes. It will not recompile all shared libraries. However, if you want all classes within a JAR file to be recompiled—regardless of whether they were previously natively compiled—execute `ncomp` with the `-force` option, as follows:

```
ncomp -user scott/tiger -force pubProject.JAR
```

## ncomp

Accelerator, implemented within the `ncomp` tool, natively compiles all classes within the specified JAR, ZIP, or list of classes. Accelerator natively compiles these classes and places them into shared libraries according to their package. Note that these classes must first be loaded into the database.

If the classes are designated within a JAR file and have already been loaded in the database, you can natively compile your Java classes by executing the following:

```
ncomp -user SCOTT/TIGER myClasses.jar
```

---

---

**Note:** Because native compilation must compile and link all of your Java classes, this process may execute over the span of a few minutes or a few hours. The time involved depends on the number of classes to compile and the type of hardware on your machine.

---

---

There are options that allow you control over how the details of native compilation are handled.

### Syntax

```
ncomp [ options ] <class_designation_file>
  -user | -u <username>/<password>[@<database_url>]
  [-load]
  [-projectDir | -d <project_directory>]
  [-force]
  [-lightweightDeployment]
  [-noDeploy]
  [-outputJarFile | -o <jar_filename>]
  [-thin]
  [-oci | -oci8]
  [-update]
  [-verbose]
```

---

---

**Note:** These options are demonstrated within the scenarios described in "[Native Compilation Usage Scenarios](#)" on page 6-13.

---

---

### Argument Summary

**Table 6-1** summarizes the `ncomp` arguments. The `<class_designation_file>` can be a `<file>.jar`, `<file>.zip`, or `<file>.classes`.

**Table 6–1 ncomp Argument Summary**

Argument	Description and Values
<file>.jar	The full pathname and filename of a JAR file that contains the classes that are to be natively compiled. If you are executing in the directory where the JAR file exists and you do not specify the <code>-projectDir</code> option, you may give only the name of the JAR file.
<file>.zip	The full pathname and filename of a ZIP file that contains the classes that are to be natively compiled. If you are executing in the directory where the ZIP file exists and you do not specify the <code>-projectDir</code> option, you may give only the name of the ZIP file.
<file>.classes	The full pathname and filename of a classes file, which contains the list of classes to be natively compiled. If you are executing in the directory where the classes file exists and you do not specify the <code>-projectDir</code> option, you may give only the name of the classes file. See <a href="#">"Natively Compiling Specific Classes"</a> on page 6-15 for a description of a classes file.
<code>-user   -u</code> <username>/<password> [@<database>]	Specifies a user, password, and database connect string; the files will be loaded into this database instance. The argument has the form <username>/<password>[@<database>]. If you specify the database URL on this option, you must specify it with OCI syntax. To provide a JDBC Thin database URL, use the <code>-thin</code> option.
<code>-force</code>	The native compilation is performed on all classes. Previously compiled classes are not passed over.
<code>-lightweightDeployment</code>	Provides an option for deploying shared libraries and native compilation information separately. This is useful if you need to preserve resources when deploying. See <a href="#">"lightweightDeployment"</a> on page 6-11 for more information.
<code>-load</code>	Executes <code>loadjava</code> on the specified class designation file. You cannot use this option in combination with a <file>.classes file.
<code>-outputJarFile</code> <jar_filename>	All natively compiled classes output into a deployment JAR file. This option specifies the name of the deployment JAR file and its destination directory. If omitted, the <code>ncomp</code> tool names the output deployment JAR file the same name as the input <file> with <code>"_depl.jar"</code> appended as the suffix. If directory is not supplied, it stores the output JAR file into the project directory (denoted by <code>-projectDir</code> ).

**Table 6–1** *ncomp* Argument Summary

Argument	Description and Values
<code>-noDeploy</code>	Specifies that the native compilation results only in the output deployment JAR file, which is not deployed to the server. The resulting deployment JAR can be deployed to any server using the <a href="#">deploync</a> tool.
<code>-thin</code>	The database URL that is provided on the <code>-user</code> option uses a JDBC Thin URL address for the database URL syntax.
<code>-oci</code>   <code>-oci8</code>	The database URL that is provided on the <code>-user</code> option uses an OCI URL address for the database URL syntax. However, if neither <code>-oci</code> or <code>-thin</code> are specified, the default assumes that you used an OCI database URL.
<code>-projectDir</code>   <code>-d</code> <absolute_path>	Specifies the full path for the project directory. If not specified, Accelerator uses the directory from which <code>ncomp</code> is invoked as the project directory. This directory must exist; the tool will not create this directory for you. If it does not exist, the current directory is used.
<code>-update</code>	If you add more classes to a <class_designation_file> that has already been natively compiled, this flag informs Accelerator to update the deployment JAR file with the new classes. Thus, Accelerator compiles the new classes and adds them to the appropriate shared libraries. The deployment JAR file is updated.
<code>-verbose</code>	Output native compilation text with detail.

## Argument Details

### user

{`-user` | `-u`} <user>/<password>[@<database>]

The permissible forms of @<database> depend on whether you specify `-oci` or `-thin`; `-oci` is the default.

- `-oci: @<database>` is optional; if you do not specify, then `ncomp` uses the user's default database. If specified, then <database> can be a TNS name or a Oracle Net Services name-value list.
- `-thin: @<database>` is required. The format is <host>:<lport>:<SID>.
  - <host> is the name of the machine running the database.
  - <lport> is the listener port that has been configured to listen for Oracle Net Services connections; in a default installation, it is 5521.

- <SID> is the database instance identifier; in a default installation, it is ORCL.

### lightweightDeployment

Accelerator places compilation information and the compiled shared libraries in one JAR file, copies the shared libraries to `$ORACLE_HOME/javavm/admin` directory on the server, and deploys the compilation information to the server. If you want to place the shared libraries on the server yourself, you can do so through the `lightweightDeployment` option. The `lightweightDeployment` option enables you to do your deployment in two stages:

1. Natively compile your JAR file with `-noDeploy` and `-lightweightDeployment` options. This creates an deployment JAR file with only `ncomp` information, such as transitive closure information. The shared libraries are not saved within the deployment JAR file. Thus, the deployment JAR file is much smaller.
2. Deploy as follows:
  - a. Copy all output shared libraries from the `lib` directory of the native compilation project directory to the server's `$ORACLE_HOME/javavm/admin` directory.

---

---

**Note:** You need to have `FilePermission` to write to this directory. `FilePermission` is included in the `DBA` or `JAVASYSPRIV` roles.

---

---

- b. Deploy the lightweight deployment JAR file to the server using `deploync`.

### Errors

Any errors that occur during native compilation are printed to the screen. Any errors that occur during deployment of your shared libraries to the server or during runtime can be viewed with the `statusnc` tool or by referring to the `JACCELERATOR$DLL_ERRORS` table.

If an error is caught while natively compiling the designated classes, Accelerator denotes these errors, abandons work on the current package, and continues its compilation task on the next package. The native compilation continues for the rest of the packages. The package with the class that contained the error will not be natively compiled at all.

After fixing the problem with the class, you can choose to do one of the following:

- recompile the shared library
- reload the Java class into the database

If you choose not to recompile the classes, but to load the correct Java class into the database instead, then the corrected class and all classes that are included in the resolution validation for that class—whether located within the same shared library or a different shared library—will be executed in interpreted mode. That is, the JVM will not run these classes natively. All the other natively compiled classes will continue to execute in native format. When you execute the `statusnc` command on the reloaded class or any of its referred classes, they will have an `NEED_NCOMPING` status message.

Possible errors for a Java class:

1. The Java class does not exist in the database. If you do not load the Java class into Oracle9i, Accelerator does not include the class in the shared library. The class is simply skipped.
2. The Java class is invalid; that is, one of its references may not be found.
3. Any Java class that is unresolved, Accelerator will try to resolve it before natively compiling. However, if the class cannot be resolved, it is ignored by Accelerator.

Possible errors for deployment of native compilation JAR file:

- The native compilation of your JAR file executes correctly, but the deployment fails. In this case, do not recompile the JAR file, but deploy the output natively compiled JAR file with the `deploync` command.



## Native Compilation Usage Scenarios

The following scenarios demonstrate how you can use each of the options for the `ncomp` tool can be used:

- [Natively Compiling on Test Platform—Java Classes Already Loaded in the Database](#)
- [Natively Compiling Java Classes Not Loaded in the Database](#)
- [Clean Compile and Generate Output for Future Deployment](#)
- [Controlling Native Compilation Build Environment](#)
- [Natively Compiling Specific Classes](#)
- [Natively Compiling Packages That Are Fully or Partially Modified](#)

### Natively Compiling on Test Platform—Java Classes Already Loaded in the Database

If all classes are loaded into the database and you have completed your testing of the application, you can request Accelerator to natively compile the tested classes. Accelerator takes in a JAR, ZIP, or list of classes to determine the packages and classes to be included in the native compilation. The Accelerator then retrieves all of the designated classes from the server and natively compiles them into shared libraries—each library containing a single package of classes.

Assuming that the classes have already been loaded within the server, you execute the following command to natively compile all classes listed within a class designation file, such as the `pubProject.jar` file, as follows:

```
ncomp -user SCOTT/TIGER pubProject.jar
```

If you change any of the classes within the class designation file and ask for recompilation, Accelerator recompiles only the packages that contain the changed classes. It will not recompile all packages.

### Natively Compiling Java Classes Not Loaded in the Database

Once you have tested the designated classes, you may wish to natively compile them on a host other than the test machine. Once you transfer the designated class file to this platform, the classes in this file must be loaded into the database before native compilation can occur. The following loads the classes through `loadjava` and then executes native compilation for the class designation file—`pubProject.jar`:

```
ncomp -user SCOTT/TIGER@dbhost:5521:orcl -thin -load pubProject.jar
```

### Clean Compile and Generate Output for Future Deployment

If you want all classes within a class designation file to be recompiled—regardless of whether they were previously natively compiled—execute `ncomp` with the `-force` option. You might want to use the `-force` option to ensure that all classes are compiled, resulting in a deployment JAR file that can be deployed to other Oracle9i databases. You can specify the native compilation deployment JAR file with the `-outputJarFile` option. The following forces a recompilation of all Java classes within the class designation file—`pubProject.jar`—and creates a deployment JAR file with the name of `pubworks.jar`:

```
ncomp -user SCOTT/TIGER -force -outputJarFile pubworks.jar pubProject.jar
```

The deployment JAR file contains the shared libraries for your classes, and installation classes specified to these shared libraries. It does not contain the original Java classes. To deploy the natively compiled deployment JAR file to any Oracle9i (of the appropriate platform type), you must do the following:

1. Load the original Java classes into the destination server. In the previous example, the `pubProject.jar` file would be loaded into the database using the `loadjava` tool.
2. Deploy the natively compiled deployment JAR file with the Accelerator `deploync` tool, which is described in [deploync](#) on page 6-16.

### Controlling Native Compilation Build Environment

By default, the Accelerator uses the directory where `ncomp` is executed as its build environment. The Accelerator downloads several class files into this directory and then uses this directory for the compilation and linking process.

If you do not want to have Accelerator put any of its files into the current directory, create a working directory, and specify this working directory as the project directory with the `-projectDir` option. The following directs Accelerator to use `/tmp/jaccel/pubComped` as the build directory. This directory must exist before specifying it within the `-projectDir` option. Accelerator will not create this directory for you.

```
ncomp -user SCOTT/TIGER -projectDir /tmp/jaccel/pubComped pubProject.jar
```

## Natively Compiling Specific Classes

You can specify one or more classes that are to be natively compiled, within a text-based `<file>.classes` file. Use the following Java syntax to specify packages and/or individual classes within this file:

- To specify classes within one or more packages, as follows:

```
import COM.myDomain.myPackage.*;
import COM.myDomain.myPackage.mySubPackage.*;
```

---

---

**Note:** Java has no formal notion of a sub-package. You must specify each package independently.

---

---

- To specify an individual class, as follows:

```
import COM.myDomain.myPackage.myClass;
```

Once explicitly listed, specify the name and location of this class designation file on the command line. Given the following `pubworks.classes` file:

```
import COM.myDomain.myPackage.*;
import COM.myDomain.hisPackage.hisSubPackage.*;
import COM.myDomain.herPackage.herClass;
import COM.myDomain.petPackage.petClass;
```

The following directs Accelerator to compile all classes designated within this file: all classes in `myPackage`, `hisSubPackage` and the individual classes, `herClass` and `myClass`. These classes must have already been loaded into the database:

```
ncomp -user SCOTT/TIGER /tmp/jaccel/pubComped/pubworks.classes
```

## Natively Compiling Packages That Are Fully or Partially Modified

If you change any of the classes within this JAR file, Accelerator will only recompile shared libraries that contain the changed classes. It will not recompile all shared libraries designated in the JAR file. However, if you want all classes within a JAR file to be recompiled—regardless of whether they were previously natively compiled—you execute `ncomp` with the `-force` option, as follows:

```
ncomp -user scott/tiger -force pubProject.JAR
```

## deploync

You can deploy any deployment JAR file with the `deploync` command. This includes the default output JAR file, `<file>_depl.jar` or the JAR created when you used the `ncomp -outputJarFile` option. The operating system and Oracle9i database version must be the same as the platform where it was natively compiled.

---



---

**Note:** The list of shared libraries deployed into Oracle9i are listed within the JACCELERATOR\$DLLS table.

---



---

### Syntax

```
deploync [options] <deployment>.jar
  -user | -u <username>/<password>[@<database_url>]
  [-projectDir | -d <project_directory>]
  [-thin]
  [-oci | -oci8]
```

### Argument Summary

[Table 6–2](#) summarizes the `deploync` arguments.

**Table 6–2** *deploync* Argument Summary

Argument	Description and Values
<code>&lt;deployment&gt;.jar</code>	The full pathname and filename of a deployment JAR file. This JAR file is created when you specify the <code>-outputJarFile</code> option on the <code>ncomp</code> tool. Note that <code>deploync</code> does not verify that this is a native compilation deployment JAR.
<code>-user   -u</code> <code>&lt;username&gt;/&lt;password&gt;</code> <code>[@&lt;database&gt;]</code>	Specifies a user, password, and database connect string; the files will be loaded into this database instance. The argument has the form <code>&lt;username&gt;/&lt;password&gt;[@&lt;database&gt;]</code> . If you specify the database URL on this option, you must specify it with OCI syntax. To provide a JDBC Thin database URL, use the <code>-thin</code> option.
<code>-projectDir   -d</code> <code>&lt;absolute_path&gt;</code>	Specifies the full path for the project directory. If not specified, Accelerator uses the directory from which <code>ncomp</code> is invoked as the project directory.
<code>-thin</code>	The database URL that is provided on the <code>-user</code> option uses a JDBC Thin URL address for the database URL syntax.

**Table 6–2** *deploync Argument Summary*

Argument	Description and Values
<code>-oci</code>   <code>-oci8</code>	The database URL that is provided on the <code>-user</code> option uses an OCI URL address for the database URL syntax. However, if neither <code>-oci</code> or <code>-thin</code> are specified, the default assumes that you used an OCI database URL.

**Example**

Deploy the natively compiled deployment JAR file `pub.jar` to the `dbhost` database as follows:

```
deploync -user SCOTT/TIGER@dbhost:5521:orcl -thin /tmp/jaccel/PubComped/pub.jar
```

**statusnc**

After the native compilation is completed, you can check the status for your Java classes through the `statusnc` command. This tool will print out—either to the screen or to a designated file—the status of each class. In addition, the `statusnc` tool always saves the output within the `JACCELERATOR$STATUS` table. The values can be the following:

Class Native Compilation Status	Description
<code>ALREADY_NCOMPED</code>	The class is currently natively compiled.
<code>NEED_NCOMPING</code>	A class within the shared library was reloaded after native compilation. Thus, you should recompile this shared library.
<code>INVALID</code>	A class loaded in the database is invalid. Accelerator tried to validate it and failed. The class will be excluded from the natively compiled shared library.

---

**Note:** The `JACCELERATOR$STATUS` table contains only the output from the last execution of the `statusnc` command. When executed, the `statusnc` command cleans out this table before writing the new records into it.

---

## Syntax

```
statusnc [ options ] <class_designation_file>
  -user <user>/<password>[@database]
  [-output | -o <filename>]
  [-projectDir | -d <directory>]
  [-thin]
  [-oci | -oci8]
```

## Argument Summary

[Table 6–3](#) summarizes the `statusnc` arguments. The `<class_designation_file>` can be a `<file>.jar`, `<file>.zip`, or `<file>.classes`.

**Table 6–3** *statusnc* Argument Summary

---

Argument	Description
<code>&lt;file&gt;.jar</code>	The full pathname and filename of a JAR file that was natively compiled.
<code>&lt;file&gt;.zip</code>	The full pathname and filename of a ZIP file that was natively compiled.
<code>&lt;file&gt;.classes</code>	The full pathname and filename of a classes file, which contains the list of classes that was natively compiled. See <a href="#">"Natively Compiling Specific Classes"</a> on page 6-15 for a description of a classes file.
<code>-user   -u</code> <code>&lt;username&gt;/&lt;password&gt;</code> <code>[@&lt;database&gt;]</code>	Specifies a user, password, and database connect string where the files are loaded. The argument has the form <code>&lt;username&gt;/&lt;password&gt;[@&lt;database&gt;]</code> . If you specify the database URL on this option, you must specify it with OCI syntax. To provide a JDBC Thin database URL, use the <code>-thin</code> option.
<code>-output &lt;filename&gt;</code>	Designates that the <code>statusnc</code> should output to the specified text file rather than to the screen.
<code>-projectDir   -d</code> <code>&lt;absolute_path&gt;</code>	Specifies the full path for the project directory. If not specified, Accelerator uses the directory from which <code>ncomp</code> is invoked as the project directory.
<code>-thin</code>	The database URL that is provided on the <code>-user</code> option uses a JDBC Thin URL address for the database URL syntax.
<code>-oci   -oci8</code>	The database URL that is provided on the <code>-user</code> option uses an OCI URL address for the database URL syntax. However, if neither <code>-oci</code> or <code>-thin</code> are specified, the default assumes that you used an OCI database URL.

---

### Example

```
statusnc -user SCOTT/TIGER -output pubStatus.txt /tmp/jaccel/PubComped/pub.jar
```

## Java Memory Usage

The typical and custom database installation process furnishes a database that has been configured for reasonable Java usage during development. However, runtime use of Java should be determined by the usage of system resources for a given deployed application. Resources you use during development can vary widely, depending on your activity. The following sections describe how you can configure memory, how to tell how much SGA memory you are using, and what errors denote a Java memory issue:

- [Configuring Memory Initialization Parameters](#)
- [Java Pool Memory](#)
- [Displaying Used Amounts of Java Pool Memory](#)
- [Correcting Out of Memory Errors](#)

## Configuring Memory Initialization Parameters

You can modify the following database initialization parameters to tune your memory usage to reflect more accurately your application needs:

- **SHARED\_POOL\_SIZE**—Shared pool memory is used by the class loader within the JVM. The class loader uses an average of about 8 KB for each loaded class. Shared pool memory is used when loading and resolving classes into the database. It is also used when compiling source in the database or when using Java resource objects in the database.

The memory specified in **SHARED\_POOL\_SIZE** is consumed transiently when you use `loadjava`. The database initialization process (executing `initjvm.sql` against a clean database, as opposed to the installed seed database) requires **SHARED\_POOL\_SIZE** to be set to 50 MB as it loads the Java binaries for approximately 8,000 classes and resolves them. The **SHARED\_POOL\_SIZE** resource is also consumed when you create call specifications and as the system tracks dynamically loaded Java classes at runtime.

- **JAVA\_POOL\_SIZE**—The Oracle9i JVM memory manager allocates all other Java state during runtime execution from the amount of memory allocated using **JAVA\_POOL\_SIZE**. This memory includes the shared in-memory representation of Java method and class definitions, as well as the Java objects

migrated to session space at end-of-call. In the first case, you will be sharing the memory cost with all Java users. In the second case, in a shared server, you must adjust `JAVA_POOL_SIZE` allocation based on the actual amount of state held in static variables for each session. See ["Java Pool Memory"](#) on page 6-21 for more information on `JAVA_POOL_SIZE`.

- **`JAVA_SOFT_SESSIONSPACE_LIMIT`**—This parameter allows you to specify a soft limit on Java memory usage in a session, which will warn you if you must increase your Java memory limits. Every time memory is allocated, the total memory allocated is checked against this limit.

When a user's session-duration Java state exceeds this size, Oracle9i JVM generates a warning that is written into the trace files. While this warning is simply an informational message and has no impact on your application, you should understand and manage the memory requirements of your deployed classes, especially as they relate to usage of session space.

- **`JAVA_MAX_SESSIONSPACE_SIZE`**—If a user-invokable Java program executing in the server can be used in a way that is not self-limiting in its memory usage, this setting may be useful to place a hard limit on the amount of session space made available to it. The default is 4 GB. This limit is purposely set extremely high to be normally invisible.

When a user's session-duration Java state attempts to exceeds this size, your application can receive an out-of-memory failure.

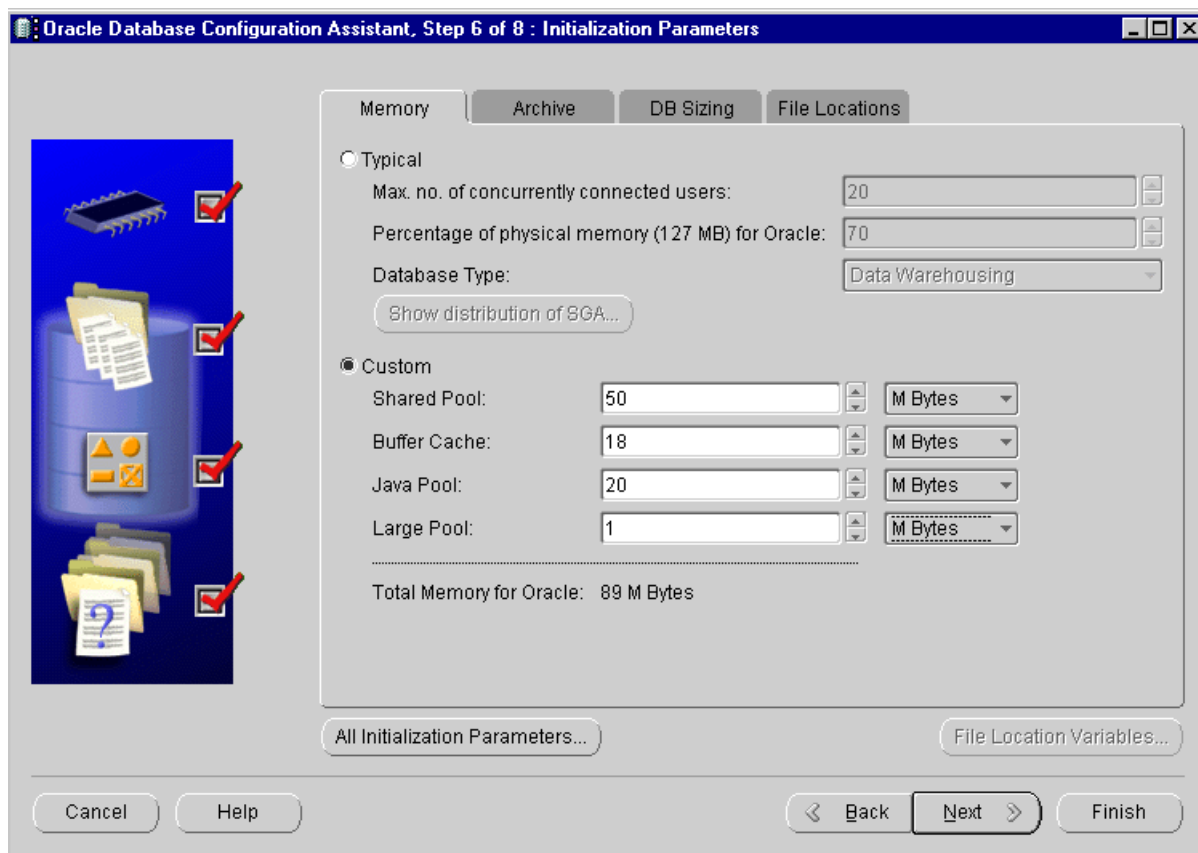
Oracle9i's unique memory management facilities and sharing of read-only artifacts (such as bytecodes) enables `HELLOWORLD` to execute with a per-session incremental memory requirement of only 35 KB. More stateful server applications have a per-session incremental memory requirement of approximately 200 KB. Such applications must retain a significant amount of state in static variables across multiple calls. Refer to the discussion in the ["End-of-Call Migration"](#) section on page 6-25 for more information on understanding and controlling migration of static variables at end-of-call.

### Initializing Pool Sizes within Database Templates

You can set the defaults for `JAVA_POOL_SIZE` and `SHARED_POOL_SIZE` in the database installation template. The Database Configuration Assistant (DBCA) allows you to modify these values within the Memory section, as shown below in [Figure 6-2](#).



**Figure 6–2 Configuring Oracle9i JVM Memory Parameters**



## Java Pool Memory

Java pool memory is used in server memory for all session-specific Java code and data within the JVM. Java pool memory is used in different ways, depending on what mode the Oracle9i server is running in.

### Java pool memory used within a dedicated server

The following is what constitutes the Java pool memory used within a dedicated server:

- The shared part of each Java class used per session

This includes readonly memory, such as code vectors, and methods. In total, this can average about 4 KB-8 KB for each class.

- None of the per-session Java state of each session.

For a dedicated server, this is stored in UGA within the PGA—not within the SGA.

Under dedicated servers, the total required Java pool memory depends on the applications running and may range between 10 and 50 MB.

### Java pool memory used within a shared server

The following is what constitutes the Java pool memory used within a shared server:

- The shared part of each Java class that is used per session

This includes readonly memory, such as vectors, and methods. In total, this can average about 4 KB-8 KB for each class.

- Some of the UGA used for per-session state of each session is allocated from the Java pool memory within the SGA

Because Java pool memory size is fixed, you must estimate the total requirement for your applications and multiply by the number of concurrent sessions the applications want to create to calculate the total amount of necessary Java pool memory. Each UGA grows and shrinks as necessary; however, all UGAs combined must be able to fit within the entire fixed Java pool space.

Under shared servers, this figure could be large. Java-intensive, multi-user benchmarks could require more than 100 MB.

---

---

**Note:** If you are compiling code on the server, rather than compiling on the client and loading to the server, you might need a bigger `JAVA_POOL_SIZE` than the default 20 MB.

---

---

## Displaying Used Amounts of Java Pool Memory

You can find out how much of Java pool memory is being used by viewing the `V$SGASTAT` table. Its rows include pool, name, and bytes. Specifically, the last two rows show the amount of Java pool memory used and how much is free. The total of these two items equals the number of bytes that you configured in the database initialization file.

```
SVRMGR> select * from v$sgastat;
```

POOL	NAME	BYTES
	fixed_sga	69424
	db_block_buffers	2048000
	log_buffer	524288
shared pool	free memory	22887532
shared pool	miscellaneous	559420
shared pool	character set object	64080
shared pool	State objects	98504
shared pool	message pool freequeue	231152
shared pool	PL/SQL DIANA	2275264
shared pool	db_files	72496
shared pool	session heap	59492
shared pool	joxlod: init P	7108
shared pool	PLS non-lib hp	2096
shared pool	joxlod: in ehe	4367524
shared pool	VIRTUAL CIRCUITS	162576
shared pool	joxlod: in phe	2726452
shared pool	long op statistics array	44000
shared pool	table definiti	160
shared pool	KGK heap	4372
shared pool	table columns	148336
shared pool	db_block_hash_buckets	48792
shared pool	dictionary cache	1948756
shared pool	fixed allocation callback	320
shared pool	SYSTEM PARAMETERS	63392
shared pool	joxlod: init s	7020
shared pool	KQLS heap	1570992
shared pool	library cache	6201988
shared pool	trigger inform	32876
shared pool	sql area	7015432
shared pool	sessions	211200
shared pool	KGFF heap	1320
shared pool	joxs heap init	4248
shared pool	PL/SQL MPCODE	405388
shared pool	event statistics per sess	339200
shared pool	db_block_buffers	136000
<b>java pool</b>	<b>free memory</b>	<b>30261248</b>
<b>java pool</b>	<b>memory in use</b>	<b>19742720</b>

37 rows selected.

## Correcting Out of Memory Errors

The two common memory errors that can occur are as follows:

- [Running out of memory while compiling](#)
- [Running out of memory while loading](#)

### Running out of memory while compiling

If you run out of memory while compiling (within `loadjava`), you will see the following error:

```
A SQL exception occurred while compiling: : ORA-04031: unable to allocate bytes
of shared memory ("shared pool","unknown object","joxlod: init h", "JOX: ioc_
allocate_pal")
```

The solution is to shut down your database and reset `JAVA_POOL_SIZE` to a larger value. The mention of "shared pool" in the error message is a misleading reference to running out of memory in the "Shared Global Area". It does not mean that you should increase your `SHARED_POOL_SIZE`. Instead, you must increase your `JAVA_POOL_SIZE`, restart your server, and try again.

### Running out of memory while loading

If you run out of memory while loading classes, it can fail silently, leaving invalid classes in the database. Later, if you try to invoke or resolve any invalid classes, you will see `ClassNotFoundException` or `NoClassDefFoundException` exceptions being thrown at runtime. You would get the same exceptions if you were to load corrupted class files. You should perform the following:

- Verify that the class was actually included in the set you are loading to the server. Many people have accidentally forgotten to load just one class out of hundreds and spend considerable time chasing this down.
- Use the `loadjava -force` option to force the new class being loaded to replace the class already resident in the server.
- Use the `loadjava -resolve` option to attempt resolution of a class during the load process. This allows you to catch missing classes at load time, not run time.
- Double check the status of a newly loaded class by connecting to the database in the schema containing the class, and execute the following:

```
select * from user_objects where object_name = dbms_java.shortname('');
```

The STATUS field should be "VALID". If `loadjava` complains about memory problems or failures such as "connection lost", increase `SHARED_POOL_SIZE` and `JAVA_POOL_SIZE`, and try again.

## End-of-Call Migration

Oracle9i preserves the state of your Java program between calls by migrating all objects that are reachable from static variables into session space at the end of the call. Session space exists within the client's session to store static variables and objects that exist between calls. Oracle9i JVM performs this migration operation at the end of every call, without any intervention by you.

This migration operation is a memory and performance consideration; thus, you should be aware of what you designate to exist between calls, and keep the static variables and objects to a minimum. If you store objects in static variables needlessly, you impose an unnecessary burden on the memory manager to perform the migration and consume per-session resources. By limiting your static variables to only what is necessary, you help the memory manager and improve your server's performance.

To maximize the number of users who can execute your Java program at the same time, it is important to minimize the footprint of a session. In particular, to achieve maximum scalability, an inactive session should take up as little memory space as possible. A simple technique to minimize footprint is to release large data structures at the end of every call. You can lazily recreate many data structures when you need them again in another call. For this reason, the Oracle9i JVM has a mechanism for calling a specified Java method when a session is about to become inactive, such as at end-of-call time.

This mechanism is the `EndOfCallRegistry` notification. It enables you to clear static variables at the end of the call and reinitialize the variables using a lazy initialization technique when the next call comes in. You should execute this only if you are concerned about the amount of storage you require the memory manager to store in between calls. It becomes a concern only for more complex stateful server applications you implement in Java.

The decision of whether to null-out data structures at end-of-call and then recreate them for each new call is a typical time and space trade-off. There is some extra time spent in recreating the structure, but you can save significant space by not holding on to the structure between calls. In addition, there is a time consideration, because objects—especially large objects—are more expensive to access after they have been migrated to session space. The penalty results from the differences in representation of session, as opposed to call-space based objects.

Examples of data structures that are candidates for this type of optimization include:

- Buffers or caches.
- Static fields, such as Arrays, that once initialized, can remain unchanged during the course of the program.
- Any dynamically built data structure that could have a space-efficient representation between calls and a more speed-efficient representation for the duration of a call. Because this can be tricky and complicate your code, making it hard to maintain, so you should consider doing this only after demonstrating that the space saved is worth the effort.

## Oracle-Specific Support for End-of-Call Optimization

You can register the static variables that you want cleared at the end of the call when the buffer, field, or data structure is created. Within the Oracle-specified `oracle.aurora.memoryManager.EndOfCallRegistry` class, the `registerCallback` method takes in an object that implements a `Callback` object. The `registerCallback` object stores this object until the end of the call. When end-of-call occurs, Oracle9i JVM invokes the `act` method within all registered `Callback` objects. The `act` method within the `Callback` object is implemented to clear the user-defined buffer, field, or data structure. Once cleared, the `Callback` is removed from the registry.

---

---

**Note:** If the end of the call is also the end of the session, callbacks are not invoked, because the session space will be cleared anyway.

---

---

The way that you use the `EndOfCallRegistry` depends on whether you are dealing with objects held in static fields or instance fields.

- **Static fields**—You use `EndOfCallRegistry` to clear state associated with an entire class. In this case, the `Callback` object should be held in a private static field. Any code that requires access to the cached data that was dropped between calls must invoke a method that lazily creates—or recreates—the cached data. The example below does the following:
  1. Creates a `Callback` object within a static field, `think`.
  2. Registers this `Callback` object for end-of-call migration.

3. Implements the `Callback.act` method to free up all static variables, including the `Callback` object itself.
4. Provides a method, `createCachedField`, for lazily recreating the cache.

When the user creates the cache, the `Callback` object is automatically registered within the `getCachedField` method. At end-of-call, Oracle9i JVM invokes the registered `Callback.act` method, which frees the static memory.

```
import oracle.aurora.memoryManager.Callback;
import oracle.aurora.memoryManager.EndOfCallRegistry;

class Example {
    static Object cachedField = null;
    private static Callback thunk = null;

    static void clearCachedField() {
        // clear out both the cached field, and the thunk so they don't
        // take up session space between calls
        cachedField = null;
        thunk = null;
    }

    private static Object getCachedField() {
        if (cachedField == null) {
            // save thunk in static field so it doesn't get reclaimed
            // by garbage collector
            thunk = new Callback () {
                public void act(Object obj) {
                    Example.clearCachedField();
                }
            };

            // register thunk to clear cachedField at end-of-call.
            EndOfCallRegistry.registerCallback(thunk);
            // finally, set cached field
            cachedField = createCachedField();
        }
        return cachedField;
    }

    private static Object createCachedField() {
        ....
    }
}
```

- Instance fields—Use `EndOfCallRegistry` to clear state in data structures held in instance fields. For example, when a state is associated with each instance of a class, each instance has a field that holds the cached state for the instance and fills in the cached field as necessary. You can access the cached field with a method that ensures the state is cached.
  1. Implements the instance as a `Callback` object.
  2. Implements the `Callback.act` method to free up the instance's fields.
  3. When the user requests a cache, the `Callback` object registers itself for end-of-call migration.
  4. Provides a method, `createCachedField`, for lazily recreating the cache.

When the user creates the cache, the `Callback` object is automatically registered within the `getCachedField` method. At end-of-call, Oracle9i JVM invokes the registered `Callback.act` method, which frees the cache.

This approach ensures that the lifetime of the `Callback` object is identical to the lifetime of the instance, because they are the same object.

```
import oracle.aurora.memoryManager.Callback;
import oracle.aurora.memoryManager.EndOfCallRegistry;

class Example2 implements Callback {
    private Object cachedField = null;

    public void act(Object obj) {
        // clear cached field
        cachedField = null;
        obj = null;
    }

    // our accessor method
    private static Object getCachedField() {
        if (cachedField == null) {
            // if cachedField is not filled in then we need to
            // register self, and fill it in.
            EndOfCallRegistry.registerCallback(self);
            cachedField = createCachedField();
        }
        return cachedField;
    }

    private Object createCachedField() {
        ....
    }
}
```



```

    }
}

```

A weak table holds the registry of end-of-call callbacks. If either the `Callback` object or value are not reachable (see JLS section 12.6) from the Java program, both object and value will be dropped from the table. The use of a weak table to hold callbacks also means that registering a callback will not prevent the garbage collector from reclaiming that object. Therefore, you must hold on to the callback yourself if you need it—you cannot rely on the table holding it back.

You can find other ways in which end-of-call notification will be useful to your applications. The following sections give the details for methods within the `EndOfCallRegistry` class and the `Callback` interface:

### **EndOfCallRegistry.registerCallback method**

The `registerCallback` method installs a `Callback` object within a registry. At the end of the call, Oracle9i JVM invokes the `act` methods of all registered `Callback` objects.

You can register your `Callback` object by itself or with a `value` object. If you need additional information stored within an object to be passed into `act`, you can register this object within the `value` parameter.

```

public static void registerCallback(Callback thunk, Object value);
public static void registerCallback(Callback thunk);

```

Parameter	Description
<code>thunk</code>	The <code>Callback</code> object to be invoked at end-of-call migration.
<code>value</code>	If you need additional information stored within an object to be passed into <code>act</code> , you can register this object within the <code>value</code> parameter. In some cases, the <code>value</code> parameter is necessary to hold state the callback needs. However, most users do not need to specify a <code>value</code> .

### **EndOfCallRegistry.runCallbacks method**

```

static void runCallbacks()

```

The JVM calls this method at end-of-call and calls `act` for every `Callback` object registered using `registerCallback`. You should never call this method in your code. It is called at end-of-call, before object migration and before the last finalization step.

### Callback Interface

`Interface oracle.aurora.memoryManager.Callback`

Any object you want to register using `EndOfCallRegistry.registerCallback` implements the `Callback` interface. This interface can be useful in your application, where you require notification at end-of-call.

### Callback.act method

`public void act(Object value)`

You can implement any activity that you require to occur at the end of the call. Normally, this method will contain procedures for clearing any memory that would be saved to session space.

## Memory Profiling Utility

The purpose of the Memory Profiling Utility (MemStat) is to trace, profile, and report on the allocated memory that is accessible through static variables in your Oracle9i Java program. You can then use the information in this report to locate and eliminate unnecessary static data in your Java classes, thereby reducing the static footprint of your Java program and improving the performance of repeated Java calls into the database.

The Oracle9i JVM uses three kinds of memory:

- *call memory*, which exists for the duration of a (possibly recursive) call into the database
- *session memory*, which exists for the duration of the session connected to the database
- *permanent or global memory*, which persists as long as the database instance is running

Java language semantics specify that static variables persist across calls. At the end of each call, the Oracle9i JVM copies the *call* memory that is accessible through the static variables in each class into *session* memory so that it can be saved and restored on subsequent calls to methods in those Java classes. If there is a lot of static data or a complex graph of interconnected objects, then there is considerable overhead during the end-of-call processing while the JVM allocates session memory and copies the static data to it.

A typical technique for tuning object-oriented programs for faster performance is to eliminate the allocation of unnecessary objects from your program. For example, you can create a static instance of a commonly used object and reuse it rather than creating a new one every time you need it. However, the interactions among the different database memories complicate such techniques, and can require analysis of the speed trade-off for allocating dynamic objects versus the space trade-off for the end-of-call copying of static objects. If a static object is large, or if there are many such objects, or if there are many calls, then the speed advantage gained by caching the object may be lost, due to the traversal of the object graph during end-of-call processing.

## How MemStat Works

Depending on how you invoke it, MemStat will analyze either a single class or all classes that are loaded into the current session. For each class, MemStat enumerates the static variables of the class. These variables are known as the *roots*. Depending on the structure of each variable, MemStat performs three different analyses:

- If the variable is a primitive object, such as an integer, MemStat records its class and size.
- If the variable is a non-primitive object (for example, one that refers to another object), MemStat follows the reference and recursively enumerates all objects to which it refers.
- If the variable is an array, MemStat enumerates all elements of the array.

This process is repeated recursively until all objects reachable from all static variables have been recorded. Because it is possible for large object graphs to contain cycles, MemStat also records any circular references it encounters during the analysis.

## Using MemStat

The purpose of MemStat is to analyze and report on the object graph that is accessible from the static variables in your program. You can invoke the analysis directly from any point in your program, and you can also register it to run at the end of a call.

Because there is no *standard* output mechanism for database calls, MemStat produces its report in the form of HTML files, in a directory that you specify. When the report is finished, you can view these files with any HTML-capable Web browser.

MemStat is implemented in three static methods on the class `oracle.aurora.memstat.MemStat`.

You can call it in three different ways:

- to report immediately on the static variables in a single class
- to report immediately on the static variables of all classes used in the current session
- to report at end-of-call on the static variables of all classes used in the current session

The method call for reporting on a single class is:

```
MemStat.writeDump (Class MyClass, String outputPath, String filePrefix);
```

The method call for reporting on all loaded classes is:

```
MemStat.writeDump (String outputPath, String filePrefix);
```

The method call for reporting on all loaded classes at the end-of-call is:

```
MemStat.writeDumpAtEOC (String outputPath, String filePrefix);
```

The `outputPath` parameter represents the directory in which the MemStat reports are generated. The `outputPath` string must be in a file name format that is suitable to the platform on which the report is generated. For example, `/home/base/memstat` is suitable for a Solaris platform; the Windows format might be `c:\\base\\memstat`. Note that Java requires doubling of the backslashes inside a string, but not the forward slashes.

The `filePrefix` is the base file name for the HTML files that are generated in the `outputPath` directory. Because MemStat reports can be voluminous, and many Web browsers have limitations on the size of the files they can browse, MemStat breaks long reports into separate files. The `filePrefix` is the basis for all file names in a given report and is augmented by an incremental numeric suffix. If, for example, the `test` report produces three files, the main report file will be named `test.htm`, and additional report files will be named `test1.htm` and `test2.htm`.

If you call MemStat more than once in a given call, be careful to use different base names or different output directories, lest the subsequent reports overwrite the previous ones. For example, if you call MemStat before and after you perform some memory-consuming operation, naming the first report `before` and the second report `after` will prevent name collisions, while still writing the report files into the same directory. Using multiple directories is more complicated: you must

remember to grant separate FilePermissions (see below) for each directory in which you want to write.

Here are some sample MemStat calls:

```
MemStat.writeDump (MyClass.class, "c:\\base\\memstat", "myclass");
MemStat.writeDump ("/home/base/memstat", "test");
MemStat.writeDumpAtEOC ("/home/base/memstat", "eoc");
```

## MemStat Permissions

MemStat requires certain permissions to be granted to the user or role under which it runs. Because MemStat runs in the Oracle server process, these permissions grant access to the resources that MemStat requires:

- Access to the private variables of the objects in the graph. If this permission is not granted, MemStat will still run, but it will not trace any objects that are pointed to by private variables.
- Access to the Java run-time system for determining which classes are loaded in the current session. If this permission is not granted, MemStat will find zero classes loaded and will generate an empty report.
- Access to the server file system where the MemStat HTML reports are generated. If this permission is not granted, MemStat will raise an exception when it tries to create the report files.

The following SQL statements grant these permissions to user JIM:

```
call dbms_java.grant_permission ('JIM',
    'SYS:java.lang.reflect.ReflectPermission', 'suppressAccessChecks', null);

call dbms_java.grant_permission ('JIM',
    'SYS:oracle.aurora.security.JServerPermission', 'JRIExtensions', null);

call dbms_java.grant_permission ('JIM', 'SYS:java.io.FilePermission',
    '/home/base/memstat', 'read,write');           // Solaris

call dbms_java.grant_permission ('JIM', 'SYS:java.io.FilePermission',
    'c:\\base\\memstat', 'read,write');           // Windows
```

If the Oracle Server is running on a Windows platform, the output file path named in the MemStat call is subtly different from the path in the SQL `grant_permission` call. In Java strings, you must use double backslashes; in SQL you need only one backslash.

## The MemStat Report Format

This section describes the format of the MemStat report. You can browse the MemStat output report with any HTML-capable Web browser. To do this, point the browser at the base file name that is specified. For example, the following points the browser at the `test.htm` file:

```
c:\base\memstat\test.htm.
```

The report begins with a summary of the memory usage at the time MemStat is invoked. This summary should give you an overall idea of the amount of memory used by the Java call that you are analyzing.

Following the summary is a list of the unique classes that are traversed during the MemStat analysis. For every object found during the memory analysis, MemStat has recorded its class and its size in each of call, session, and permanent memory. The largest objects are sorted first, because eliminating these will yield the largest performance improvement. The list is actually sorted by the largest of these three sizes, calculated as *max (call, max (session, permanent))*. For each class, this table also shows how many bytes are occupied by objects of that class, how many objects there are, their minimum, maximum and average size, and for arrays, the standard deviation of the sizes.

Following the class summary is one or more tables describing each *root* object. The title of the object describes the package and class of the object. Each row of the table describes:

- a field of the object
- a description of the object in that field
- the total size of the object in each of the three memory spaces

Following the root objects are the objects pointed to by the roots; the objects are separated by a dividing rule. One, two, or three tables describe each object:

- the object itself
- any other objects that the object refers to
- any objects that refer to this object

The title for each object describes the memory in which the object resides: Call, Session, or Permanent. Each object is described by:

- a unique identifier
- the output of applying the `toString()` method to the object

- the object's direct size: the size of the object header and the fields of the object
- the object's total size: the sum of the sizes of all the objects to which it refers

An object that refers to another object is linked by an HTML link to the tables representing the object to which it refers. You can navigate the object graph using these links, as you would navigate hyperlinks in a text document.

The following shows an example of the output of the MemStat tool:

### MemStat Results

**2000-06-01 17:07:05.645**

Run-Time	Value
Session Size	143360
NewSpace Size	262144
NewSpace Enabled	true
Intern Table Size	261814

Total Memory Allocation	Call	Session	Permanent
Objects	726	926	3217
Total Size	54861	39348	127418
Minimum	12	12	12
Maximum	16396	2060	8076
Average	75.6	42.5	39.6
Std Deviation	679.2	93.7	233.7

**Table 6–4 Allocated Objects by Class (C=Call, S=Session, P=Permanent)**

Class	Bytes			Objects			MIN			MAX			AVE			STD DEV.		
	(C)	(S)	(P)	(C)	(S)	(P)	(C)	(S)	(P)	(C)	(S)	(P)	(C)	(S)	(P)	(C)	(S)	(P)
char[]	25316	5134	43296	161	104	1177	2	0	0	16384	800	8064	157.2	49.4	36.8	1,283.2	105.0	276.9
java.lang.String	3816	3240	30528	159	135	1272												
java.util.Hash table\$Entry	4956	10696	12460	177	382	445												
byte[]	8195	2421	2107	2	34	57	3	0	0	8192	2048	1024	4,097.5	71.2	37.0	4,094.5	344.2	143.3

**Table 6–5 Objects Accessible From java.util.Properties**

Field	Reference	Size	Size	Size
keyValueSeparators	946: java.lang.String	0	0	50
strictKeyValueSeparators	948: java.lang.String	0	0	40
specialSaveChars	950: java.lang.String	0	0	54
whiteSpaceChars	952: java.lang.String	0	0	46
hexDigit	954: char[16]	0	0	44



---

---

# Schema Object Tools

This chapter describes the schema object tools that you use in the Oracle9i Java environment. You run these tools from a UNIX shell or the Windows NT DOS prompt.

---

---

**Note:** All names supplied within these tools are case sensitive. Thus, the schema, username, and password will not be uppercased.

---

---

The following sections describe the schema object tools:

- [Schema Object Tool Overview](#)
- [What and When to Load](#)
- [Resolution](#)
- [Digest Table](#)
- [Compilation](#)
- [loadjava](#)
- [dropjava](#)
- [ojvmjava](#)

## Schema Object Tool Overview

Unlike a conventional JVM, which compiles and loads Java files, the Oracle9i JVM compiles and loads schema objects. The three kinds of Java schema objects are as follows:

- *Java class schema objects*, which correspond to Java class files.
- *Java source schema objects*, which correspond to Java source files.
- *Java resource schema objects*, which correspond to Java resource files.

To make a class file runnable by the Oracle9i JVM, you use the `loadjava` tool to create a Java class schema object from the class file or the source file and load it into a schema. To make a resource file accessible to the Oracle9i JVM, you use `loadjava` to create and load a Java resource schema object from the resource file.

The `dropjava` tool does the reverse of the `loadjava` tool; it deletes schema objects that correspond to Java files. You should always use `dropjava` to delete a Java schema object that was created with `loadjava`; dropping by means of SQL DDL commands will not update auxiliary data maintained by `loadjava` and `dropjava`.

## What and When to Load

You must load resource files with `loadjava`. If you create `.class` files outside the database with a conventional compiler, then you must load them with `loadjava`. The alternative to loading class files is to load source files and let the Oracle9i system compile and manage the resulting class schema objects. In the current Oracle9i release, the most productive approach is to compile and debug most of your code outside the database, and then load the `.class` files. For a particular Java class, you can load either its `.class` file or its `.java` file, but not both.

The `loadjava` tool accepts JAR files that contain either source and resource files or class and resource files. You can load a class's source or its class file but not both. When you pass `loadjava` a JAR file or a ZIP file, `loadjava` opens the archive and loads its members individually; there are no JAR or ZIP schema objects. A file whose content has not changed since the last time it was loaded is not reloaded; therefore, there is little performance penalty for loading JARs. Loading JAR files is the simplest and most foolproof way to use `loadjava`.

It is illegal for two schema objects in the same schema to define the same class. For example, suppose `a.java` defines class `x` and you want to move the definition of `x` to `b.java`. If `a.java` has already been loaded, then `loadjava` will reject an attempt to load `b.java` (which also defines `x`). Instead, do either of the following:

- Drop `a.java`, load `b.java` (which defines `x`), then load the new `a.java` (which does not define `x`).
- Load the new `a.java` (which does not define `x`), then load `b.java` (which defines `x`).

## Resolution

All Java classes contain references to other classes. A conventional JVM searches for classes in the directories, ZIP files, and JARs named in the CLASSPATH. The Oracle9i JVM, by contrast, searches schemas for class schema objects. Each Oracle9i class has a *resolver spec*, which is the Oracle9i counterpart to the CLASSPATH. For a hypothetical class, `alpha`, its resolver spec is a list of schemas to search for classes that `alpha` uses. Notice that resolver specs are per-class, whereas in a classic JVM, CLASSPATH is global to all classes.

In addition to a resolver spec, each class schema object has a list of interclass reference bindings. Each reference list item contains a reference to another class and one of the following:

- the name of the class schema object to invoke when class uses the reference
- a code indicating whether the reference is unsatisfied; in other words, whether the referent schema object is known

An Oracle9i facility known as the *resolver* maintains reference lists. For each interclass reference in a class, the resolver searches the schemas specified by the class's resolver spec for a valid class schema object that satisfies the reference. If all references are resolved, the resolver marks the class *valid*. A class that has never been resolved, or has been resolved unsuccessfully, is marked *invalid*. A class that depends on a schema object that becomes invalid is also marked invalid at the time the first class is marked invalid; in other words, invalidation cascades upward from a class to the classes that use it and the classes that use them, and so on. When resolving a class that depends on an invalid class, the resolver first tries to resolve the referenced class, because it may be marked invalid only because it has never been resolved. The resolver does not re-resolve classes that are marked valid.

A class developer can direct `loadjava` to resolve classes or can defer resolution until run time. The resolver runs automatically when a class tries to load a class that is marked invalid. It is best to resolve before run time to learn of missing classes early; unsuccessful resolution at run time produces a "class not found" exception. Furthermore, run-time resolution can fail for the following reasons:

- lack of database resources if the tree of classes is very large

- deadlocks due to circular dependencies

The `loadjava` tool has two resolution modes:

1. **Load-and-resolve** (`-resolve` option): Loads all classes you specify on the command line, marks them invalid, and then resolves them. Use this mode when initially loading classes that refer to each other, and in general when reloading isolated classes as well. By loading all classes and then resolving them, this mode avoids the error message that occurs if a class refers to a class that will be loaded later in the execution of the command.
2. **Load-then-resolve** (no `-resolve` option): Resolves each class at runtime.

---

---

**Note:** As with a Java compiler, `loadjava` resolves references to classes but not to resources; be sure to correctly load the resource files your classes need.

---

---

If you can, defer resolution until all classes have been loaded; this technique avoids the situation in which the resolver marks a class invalid because a class it uses has not yet been loaded.

## Digest Table

The schema object digest table is an optimization that is usually invisible to developers. The digest table enables `loadjava` to skip files that have not changed since they were last loaded. This feature improves the performance of makefiles and scripts that invoke `loadjava` for collections of files, only some of which need to be reloaded. A reloaded archive file might also contain some files that have changed since they were last loaded and some that have not.

The `loadjava` tool detects unchanged files by maintaining a digest table in each schema. The digest table relates a file name to a *digest*, which is a shorthand representation of the file's content (a hash). Comparing digests computed for the same file at different times is a fast way to detect a change in the file's content—much faster than comparing every byte in the file. For each file it processes, `loadjava` computes a digest of the file's content and then looks up the file name in the digest table. If the digest table contains an entry for the file name that has the identical digest, then `loadjava` does not load the file, because a corresponding schema object exists and is up to date. If you invoke `loadjava` with the `-verbose` option, then it will show you the results of its digest table lookups.

Normally, the digest table is invisible to developers, because `loadjava` and `dropjava` keep the table synchronized with schema object additions, changes, and deletions. For this reason, always use `dropjava` to delete a schema object that was created with `loadjava`, even if you know how to drop a schema object using DDL. If the digest table becomes corrupted (`loadjava` does not update a schema object whose file has changed), use `loadjava`'s `-force` option to bypass the digest table lookup or delete all rows from the table, which is named `JAVA$CLASS$MD5$TABLE`.

## Compilation

Loading a source file creates or updates a Java source schema object and invalidates the class schema object(s) previously derived from the source. If the class schema objects do not exist, `loadjava` creates them. The `loadjava` tool invalidates the old class schema objects because they were not compiled from the newly loaded source. Compilation of a newly loaded source, called for instance A, is automatically triggered by any of the following conditions:

- The resolver, working on class B, finds that it refers to class A, but class A is invalid.
- The compiler, compiling source B, finds that it refers to class A, but A is invalid.
- The class loader, trying to load class A for execution, finds that it is invalid.

To force compilation when you load a source file, use `loadjava -resolve`.

The compiler writes error messages to the predefined `USER_ERRORS` view; `loadjava` retrieves and displays the messages produced by its compiler invocations.

The compiler recognizes some options. There are two ways to specify options to the compiler. If you run `loadjava` with the `-resolve` option (which may trigger compilation), you can specify compiler options on the command line.

You can additionally specify persistent compiler options in a per-schema database table known as `JAVA$OPTIONS`, which you create as described shortly. You can use the `JAVA$OPTIONS` table for default compiler options, which you can override selectively with a `loadjava` command-line option.

---

---

**Note:** A command-line option both overrides and clears the matching entry in the `JAVA$OPTIONS` table.

---

---

A `JAVA$OPTIONS` row contains the names of source schema objects to which an option setting applies; you can use multiple rows to set the options differently for different source schema objects. The compiler looks up options in the `JAVA$OPTIONS` table when it has been invoked without a command line—that is, by the class loader—or when the command line does not specify an option. When compiling a source schema object for which there is neither a `JAVA$OPTIONS` entry nor a command-line value for an option, the compiler assumes a default value as follows:

- `encoding = System.getProperty("file.encoding");`
- `online = true`: See the *Oracle9i SQLJ Developer's Guide and Reference* for a description of this option, which applies only to Java sources that contain SQLJ constructs.
- `debug = true`: This option is equivalent to `javac -g`.

You can set `JAVA$OPTIONS` entries by means of the following functions and procedures, which are defined in the database package `DBMS_JAVA`:

- `PROCEDURE set_compiler_option(name VARCHAR2, option VARCHAR2, value VARCHAR2);`
- `FUNCTION get_compiler_option(name VARCHAR2, option VARCHAR2) RETURNS VARCHAR2;`
- `PROCEDURE reset_compiler_option(name VARCHAR2, option VARCHAR2);`

The `name` parameter is a Java package name, or a fully qualified class name, or the empty string. When the compiler searches the `JAVA$OPTIONS` table for the options to use for compiling a Java source schema object, it uses the row whose name most closely matches the schema object's fully qualified class name. A name whose value is the empty string matches any schema object name.

The `option` parameter is either `'online'` or `'encoding'`. For the values you can specify for these options, see the *Oracle9i SQLJ Developer's Guide and Reference*.

A schema does not initially have a `JAVA$OPTIONS` table. To create a `JAVA$OPTIONS` table, use the `DBMS_JAVA` package's `java.set_compiler_option` procedure to set a value; the procedure will create the table if it does not exist. Specify parameters in single quotes. For example:

```
SQL> execute dbms_java.set_compiler_option('x.y', 'online', 'false');
```

[Table 7-1](#) represents a hypothetical `JAVA$OPTIONS` database table. Because the table has no entry for the `encoding` option, the compiler will use the default or the

value specified on the command line. The `online` options shown in the table match schema object names as follows:

- The name `a.b.c.d` matches class and package names beginning with `a.b.c.d`; they will be compiled with `online = true`.
- The name `a.b` matches class and package names beginning with `a.b`, but not `a.b.c.d`; they will be compiled with `online = false`.
- All other packages and classes will match the empty string entry and will be compiled with `online = true`.

**Table 7-1 Example JAVA\$OPTIONS Table**

Name	Option	Value	Match Examples
<code>a.b.c.d</code>	<code>online</code>	<code>true</code>	<ul style="list-style-type: none"> <li>■ <code>a.b.c.d</code>—matches the pattern exactly.</li> <li>■ <code>a.b.c.d.e</code>—first part matches the pattern exactly; no other rule matches full name.</li> </ul>
<code>a.b</code>	<code>online</code>	<code>false</code>	<ul style="list-style-type: none"> <li>■ <code>a.b</code>—matches the pattern exactly</li> <li>■ <code>a.b.c.x</code>—first part matches the pattern exactly; no other rule matches beyond specified rule name.</li> </ul>
(empty string)	<code>online</code>	<code>true</code>	<ul style="list-style-type: none"> <li>■ <code>a.c</code>—no pattern match with any defined name; defaults to (empty string) rule</li> <li>■ <code>x.y</code>—no pattern match with any defined name; defaults to (empty string) rule</li> </ul>

## loadjava

The `loadjava` tool creates schema objects from files and loads them into a schema. Schema objects can be created from Java source, class, and data files. `loadjava` can also create schema objects from SQLJ files; the *Oracle9i SQLJ Developer's Guide and Reference* describes how to use `loadjava` with SQLJ.

You must have the following SQL database privileges to load classes:

- `CREATE PROCEDURE` and `CREATE TABLE` privileges to load into your schema.
- `CREATE ANY PROCEDURE` and `CREATE ANY TABLE` privileges to load into another schema.
- `oracle.aurora.security.JServerPermission.loadLibraryInClass.<classname>`. See the "Database Contents and JVM Security" section in Chapter 5 of the *Oracle9i Java Developer's Guide* for more information.

You can execute the `loadjava` tool either through the command line (as described below) or through the `loadjava` method contained within the `DBMS_JAVA` class. To execute within your Java application, do the following:

```
call dbms_java.loadjava('... options...');
```

where the options are the same as specified below. Separate each option with a blank. Do not separate the options with a comma. The only exception for this is the `-resolver` option, which contains blanks. For `-resolver`, specify all other options in the first input parameter, and the `-resolver` options in the second parameter. This is demonstrated below:

```
call dbms_java.loadjava('..options...', 'resolver_options');
```

Do not specify the following options, because they relate to the database connection for the `loadjava` command-line tool: `-thin`, `-oci`, `-user`, `-password`. The output is directed to `stderr`. Set `serveroutput` on, and call `dbms_java.set_output` as appropriate.

---

---

**Note:** The `loadjava` tool is located in the `bin` subdirectory under `$ORACLE_HOME`.

---

---

Just before the `loadjava` tool exits, it checks whether the execution was successful. All failures are summarized preceded by the following header:

```
The following operations failed
```

Some conditions, such as losing the connection to the database, cause `loadjava` to terminate prematurely. There errors are printed with the following syntax:

```
exiting: <error_reason>
```

## Syntax

```
loadjava {-user | -u} <user>/<password>[@<database>] [options]
<file>.java | <file>.class | <file>.jar | <file>.zip |
<file>.sqlj | <resourcefile> ...
[-action]
[-andresolve]
[-casesensitivepub]
[-cleargrants]
[-debug]
[-d | -definer]
[-dirprefix <prefix>]
```



```

[-e | -encoding <encoding_scheme>]
[-fileout <file>]
[-f | -force]
[-g | -grant <user> [, <user>]...]
[-genmissing]
[-genmissingjar <jar_file>]
[-help]
[-jarasresource]
[-noaction]
[-nocasesensitivepub]
[-nocleargrants]
[-nodefiner]
[-nogrant]
[-norecursivejars]
[-noschema]
[-noserverside]
[-nosynonym]
[-nousage]
[-noverify]
[-o | -oci | oci8]
[-optionfile <file>]
[-optiontable <table_name>]
[-publish <package>]
[-pubmain <number>]
[-recursivejars]
[-r | -resolve]
[-R | -resolver "resolver_spec"]
[-resolveonly]
[-S | -schema <schema>]
[-stdout]
[-stoponerror]
[-s | -synonym]
[-tableschema <schema>]
[-t | -thin]
[-time]
[-unresolvedok]
[-v | -verbose]

```

## Argument Summary

**Table 7-2** summarizes the `loadjava` arguments. If you execute `loadjava` multiple times specifying the same files and different options, the options specified in the most recent invocation hold. There are two exceptions:

1. If `loadjava` does not load a file because it matches a digest table entry, most options on the command line have no effect on the schema object. The exceptions are `-grant` and `-resolve`, which are always obeyed. Use the `-force` option to direct `loadjava` to skip the digest table lookup.
2. The `-grant` option is cumulative; every user specified in every `loadjava` invocation for a given class in a given schema has the EXECUTE privilege.

**Table 7–2 loadjava Argument Summary**

Argument	Description
<filenames>	You can specify any number and combination of <code>.java</code> , <code>.class</code> , <code>.sqlj</code> , <code>.ser</code> , <code>.jar</code> , <code>.zip</code> , and resource file name arguments, in any order.
<code>-action</code>	Perform all actions. This is the default behavior. This option can be used to override a <code>-noaction</code> option, which may be specified in an option file.
<code>-andresolve</code>	To be used in place of <code>-resolve</code> . This option causes files to be compiled or resolved at the time that they are loaded—rather than in a separate pass (as <code>-resolve</code> does). Resolving at the time of loading the class will not invalidate dependent classes.  This option should be used only to replace classes that were previously loaded. If you changed only the code for existing methods within the class, you should use this option instead of the <code>-resolve</code> option.
<code>-casesensitivepub</code>	Publishing will create case sensitive names. Unless the names are already all upper case, it will usually require quoting the names in PL/SQL.
<code>-cleargrants</code>	The <code>-grant</code> option causes <code>loadjava</code> to grant execute privileges to classes, sources, and resources. However, it does not cause it to revoke any privileges. If <code>-cleargrants</code> is specified, <code>loadjava</code> will revoke any existing grants of execute privilege before it grants execute privilege to the users and roles specified by the <code>-grant</code> operand. For example, if the intent is to have execute privilege granted to SCOTT and only SCOTT, then the proper options are the following: <code>-grant SCOTT</code> <code>-cleargrants</code> .
<code>-debug</code>	Turns on SQL logging.
<code>-definer</code>	By default, class schema objects run with the privileges of their invoker. This option confers definer (the developer who invokes <code>loadjava</code> ) privileges upon classes instead. (This option is conceptually similar to the UNIX <code>setuid</code> facility.)

**Table 7–2 loadjava Argument Summary (Cont.)**

Argument	Description
-dirprefix <prefix>	For any files or JAR entries that start with <prefix>, this prefix will be deleted from the name before the name of the schema object is determined. For classes and sources, the name of the schema object is determined by their contents, so this option will only have an effect for resources.
-encoding	Identifies the source file encoding for the compiler, overriding the matching value, if any, in the JAVA\$OPTIONS table. Values are the same as for the javac -encoding option. If you do not specify an encoding on the command line or in a JAVA\$OPTIONS table, the encoding is assumed to be <code>System.getProperty("file.encoding");</code> . The -encoding option is relevant only when loading a source file.
-fileout <file>	Prints all message to the designated file.
-force	Forces files to be loaded, even if they match digest table entries.
-grant	<p>Grants the EXECUTE privilege on loaded classes to the listed users. (To call the methods of a class, users must have the EXECUTE privilege.) Any number and combination of user names can be specified, separated by commas but not spaces (-grant Bob,Betty not -grant Bob, Betty). Note: -grant is a “cumulative” option; users are added to the list of those with the EXECUTE privilege. To remove privileges, use the -cleargrants option.</p> <p>To grant the EXECUTE privilege on an object in someone else’s schema requires that the original CREATE PROCEDURE privilege was granted with WITH GRANT options.</p> <p><b>Note:</b> You must uppercase the schema name.</p>

**Table 7-2 loadjava Argument Summary (Cont.)**

Argument	Description
-genmissing	<p>Determines what classes and methods are referred to by the classes that <code>loadjava</code> is asked to process. Any classes not found in the database or file arguments are called "missing" classes. This option generates dummy definitions for missing classes containing all referred to methods. It then loads the generated classes into the database. This processing happens before the class resolution.</p> <p>Because detecting references from source is more difficult than detecting references from classfiles, and because source is not generally used for distributing libraries, <code>loadjava</code> will not attempt to do this processing for source files.</p> <p>The schema in which the missing classes are loaded will be the one specified by the <code>-user</code> command-line option, even when referring classes are created in some other schema. The created classes will be flagged as such so that tools can recognize them. In particular, this is needed, so that the verifier can recognize generated classes.</p>
-genmissingjar <jar_file>	<p>This option performs the same actions as <code>-genmissing</code>. In addition, it creates a JAR file, named &lt;jar_file&gt;, that contains the definitions of any generated classes.</p>
-help	<p>Prints the usage message on how to use the <code>loadjava</code> tool and its options.</p>
-jarasresource	<p>Instead of unpacking the JAR file and loading each class within it, loads the whole JAR file into the schema as a resource.</p>
-noaction	<p>Take no action on the files. Actions include creating the schema objects, granting execute permissions, and so on. The normal use is within an option file to suppress creation of specific classes in a JAR. When used on the command-line (unless overridden in the option file), it will cause <code>loadjava</code> to ignore all files. Except that JAR files will still be examined to determine if they contain a <code>META-INF/loadjava-options</code> entry. If so, then the option file is processed. An <code>-action</code> option contained in the option file will override a <code>-noaction</code> option specified on the command-line.</p>
-nocasesensitivepub	<p>All lower case characters are converted to upper case. Transitions from lower to upper case characters will cause an underscore (<code>_</code>) to be inserted. For example, the method name <code>IsXCharView</code> becomes <code>IS_XCHAR_VIEW</code>. This command only modifies the <code>-publish</code> option.</p>
-nocleargrants	<p>Causes <code>loadjava</code> to omit revoking of execute privileges. This option can be used to override a <code>-cleargrants</code> option.</p>

**Table 7–2 loadjava Argument Summary (Cont.)**

Argument	Description
-nodefiner	Make the loaded classes (or classes derived from loaded sources) invoker's rights classes. This is the default behavior. This option can be used to override a -definer option.
-nogrant	Do not grant any execute privileges to the loaded classes. This is the default behavior. This option is used to override a -grant option.
-norecursivejars	Treat JARs contained in other JARs as resources. This is the default behavior. This option can be used to override a -recursivejars option.
-noschema	Place the loaded classes, sources, and resources into the schema associated with the user specified in a -user option. This is the default behavior. It can be used to override a -schema option.
-nosynonym	Do not create a public synonym for the classes. This is the default behavior. This overrides a -synonym option.
-noserverside	Changes the behavior of dbms_java.loadjava to use a JDBC driver to access objects. Normally, server-side loadjava has a performance enhancement that it will modify the object directly—without using a JDBC driver to access the schemas. However, if you want the server-side to use a JDBC driver, use this option.
-nousage	Suppresses the usage message that is given if either no option is specified or if the -help option is specified.
-noverify	Causes the classes to be loaded without bytecode verification. You must be granted oracle.aurora.security.JServerPermission("Verifier") to execute this option. To be effective, this option must be used in conjunction with -resolve.
-oci   -oci8	Directs loadjava to communicate with the database using the OCI JDBC driver. -oci and -thin are mutually exclusive; if neither is specified, -oci is used by default. Choosing -oci implies the syntax of the -user value. You do not need to provide the URL.
-optionfile <file>	A file can be provided with loadjava options. See <b>optionfile</b> discussion below for full information.

**Table 7-2 loadjava Argument Summary (Cont.)**

Argument	Description
<code>-optiontable &lt;tablename&gt;</code>	This option works like <code>-optionfile</code> except that the source for the patterns and options is a SQL table rather than a file. It is intended to allow people to specify the properties of classes persistently. No mechanism is provided for loading the table. The table name must contain three character columns named PATTERN, OPTION, and VALUE. The value of PATTERN is interpreted in the same way as a pattern in an option file. The other two columns specify a command-line option (including the dash) and for options that take an operand, the value of the operand. For options that do not take an operand, the VALUE column should be null. The rows are processed just like lines of an option file would be. To determine the options for a given schema object, the rows are examined (shortest pattern first) and for any that match the option is appended to the list of options. If two rows have the same pattern and contradictory options, such as <code>-synonym</code> and <code>-nosynonym</code> , it is unspecified which will prevail. If two rows have the same pattern and option columns, it is unspecified which VALUE will prevail.
<code>-publish &lt;package&gt;</code>	The <code>&lt;package&gt;</code> is created (or replaced) by <code>loadjava</code> . Wrappers for the eligible methods will be defined in this package. Through the use of option files, a single invocation of <code>loadjava</code> can be instructed to create more than one package. Each package will undergo the same name transformations as the methods. See the <b>publish</b> section below for more information.
<code>-pubmain &lt;number&gt;</code>	A special case applied to methods with a single argument, which is of type <code>java.lang.String</code> . Multiple variants of the SQL procedure or function will be created, each of which takes a different number of arguments of type <code>VARCHAR</code> . In particular, variants are created taking all numbers of arguments up to and including <code>&lt;number&gt;</code> . The default value is three. This option applies to <code>main</code> , as well as any method that has exactly one argument of type <code>java.lang.String</code> .
<code>-recursivejars</code>	Normally, if <code>loadjava</code> encounters an entry in a JAR with a <code>.jar</code> extension, it will load the entry as a resource. If this option is specified, then <code>loadjava</code> will process contained JARs as if they were top-level JARs. That is, it will read their entries and load classes, sources, and resources.
<code>-resolve</code>	Compiles (if necessary) and resolves external references in classes after all classes on the command line have been loaded. If you do not specify <code>-resolve</code> , <code>loadjava</code> loads files but does not compile or resolve them.

**Table 7–2 loadjava Argument Summary (Cont.)**

Argument	Description
-resolver	Specifies an explicit resolver spec, which is bound to the newly loaded classes. If -resolver is not specified, the default resolver spec, which includes current user's schema and PUBLIC, is used. See "resolver" on page 7-21 for details.
-resolveonly	Causes loadjava to skip the initial creation step. It will still perform grants, resolves, create synonyms, and so on.
-schema	Designates the schema where schema objects are created. If not specified, the -user schema is used. To create a schema object in a schema that is not your own, you must have the CREATE PROCEDURE or CREATE ANY PROCEDURE privilege. You must have CREATE TABLE or CREATE ANY TABLE privilege. Finally, you must have the JServerPermission loadLibraryInClass for the class.
-stdout	Causes the output to be directed to stdout, rather than to stderr.
-stoponerror	Normally, if an error occurs while loadjava is processing files, it will issue a message and continue to process other classes. This option stops when an error occurs. In addition, it reports all errors that apply to Java objects and are contained in the USER_ERROR table of the schema in which classes are being loaded. Except that it does not report ORA-29524 errors. These are errors that are generated when a class cannot be resolved because a referred to class could not be resolved. Thus, these errors are a secondary effect of whatever caused a referred to class to be unresolved. This usually makes it easy to pinpoint the underlying cause of the failure.
-synonym	Creates a PUBLIC synonym for loaded classes making them accessible outside the schema into which they are loaded. To specify this option, you must have the CREATE PUBLIC SYNONYM privilege. If -synonym is specified for source files, classes compiled from the source files are treated as if they had been loaded with -synonym.
-tableschema <schema>	Creates the loadjava internal tables within this specified schema, rather than in the Java file destination schema.
-thin	Directs loadjava to communicate with the database using the thin JDBC driver. -oci and -thin are mutually exclusive; if neither is specified, then -oci is used by default. Choosing -thin implies the syntax of the -user value. You do need to specify the appropriate URL through the -user option.
-time	Prints a timestamp on every message.

**Table 7-2 loadjava Argument Summary (Cont.)**

Argument	Description
-unresolvedok	When combined with <code>-resolve</code> , will ignore unresolved errors.
-user	Specifies a user, password, and database connect string; the files will be loaded into this database instance. The argument has the form <code>&lt;username&gt;/&lt;password&gt;[@&lt;database&gt;]</code> .
-verbose	Directs <code>loadjava</code> to print detailed status messages while running. Use <code>-verbose</code> to learn when <code>loadjava</code> does not load a file because it matches a digest table entry.

## Argument Details

This section describes the details of `loadjava` arguments whose behavior is more complex than the summary descriptions contained in [Table 7-2](#).

### File Names

You can specify as many `.class`, `.java`, `.sqlj`, `.jar`, `.zip`, and resource files as you like, in any order. If you specify a JAR or ZIP file, then `loadjava` processes the files in the JAR or ZIP; there is no JAR or ZIP schema object. If a JAR or ZIP contains a JAR or ZIP, `loadjava` does not process them.

The best way to load files is to put them in a JAR or ZIP and then load the archive. Loading archives avoids the resource schema object naming complications described later in this section. If you have a JAR or ZIP that works with the JDK, then you can be sure that loading it with `loadjava` will also work, without having to learn anything about resource schema object naming.

Schema object names are slightly different from file names, and `loadjava` names different types of schema objects differently. Because class files are self-identifying (they contain their names), `loadjava`'s mapping of class file names to schema object names is invisible to developers. Source file name mapping is also invisible to developers; `loadjava` gives the schema object the fully qualified name of the first class defined in the file. JAR and ZIP files also contain the names of their files; however, resource files are not self-identifying. `loadjava` generates Java resource schema object names from the *literal* names you supply as arguments (or the literal names in a JAR or ZIP file). Because running classes use resource schema objects, it is important that you specify resource file names correctly on the command line, and the correct specification is not always intuitive. The surefire way to load individual resource files correctly is:



Run `loadjava` from the top of the package tree and specify resource file names relative to that directory. (The “top of the package tree” is the directory you would name in a Java CLASSPATH list.)

If you do not want to follow this rule, observe the details of resource file naming that follow. When you load a resource file, `loadjava` generates the resource schema object name from the resource file name as *literally specified on the command line*. Suppose, for example you type:

```
% cd /home/scott/javastuff
% loadjava options alpha/beta/x.properties
% loadjava options /home/scott/javastuff/alpha/beta/x.properties
```

Although you have specified the same file with a relative and an absolute path name, `loadjava` creates *two* schema objects, one called `alpha/beta/x.properties`, the other `ROOT/home/scott/javastuff/alpha/beta/x.properties`. (`loadjava` prepends `ROOT` because schema object names cannot begin with the “/” character; however, that is an implementation detail that is unimportant to developers.) The important point is that a resource schema object’s name is generated from the file name as *entered*.

Classes can refer to resource files relatively (for example, `b.properties`) or absolutely (for example, `/a/b.properties`). To ensure that `loadjava` and the class loader use the same name for a schema object, follow this rule when loading resource files:

*Enter the name on the command line that the class passes to `getResource()` or `getResourceAsString()`.*

Instead of remembering whether classes use relative or absolute resource names and changing directories so that you can enter the correct name on the command line, you can load resource files in a JAR as follows:

```
% cd /home/scott/javastuff
% jar -cf alpharesources.jar alpha/*.properties
% loadjava options alpharesources.jar
```

Or, to simplify further, put both the class and resource files in a JAR, which makes the following invocations equivalent:

```
% loadjava options alpha.jar
% loadjava options /home/scott/javastuff/alpha.jar
```

The two `loadjava` commands in this example make the point that you can use any pathname to load the contents of a JAR file. Even if you did execute the redundant commands shown above, `loadjava` would realize from the digest table that it did not need to load the files twice. That means that reloading JAR files is not as time-consuming as it might seem, even when few files have changed between `loadjava` invocations.

**definer**

```
{-definer | -d}
```

The `-definer` option is identical to `definer`'s rights in stored procedures and is conceptually similar to the UNIX `setuid` facility; however, whereas `setuid` applies to a complete program, you can apply `-definer` class by class. Moreover, different definers may have different privileges. Because an application may consist of many classes, you must apply `-definer` with care to achieve the results desired, namely classes that run with the privileges they need,<sup>0</sup> but no more. For more information on `definer`'s rights, see the *Oracle9i Java Stored Procedures Developer's Guide*.

**noverify**

[-noverify]

Causes the classes to be loaded without bytecode verification. You must be granted `oracle.aurora.security.JServerPermission(Verifier)` to execute this option. In addition, this option must be used in conjunction with `-r`.

The verifier ensures that incorrectly formed Java binaries cannot be loaded for execution in the server. If you know that the JAR or classes you are loading are valid, use of this option will speed up the `loadjava` process. Some Oracle9i-specific optimizations for interpreted performance are put in place during the verification process. Thus, interpreted performance of your application may be adversely affected by using this option.

**optionfile**

[-optionfile &lt;file&gt;]

A file can be provided with `loadjava` options. This <file> is read and processed by `loadjava` before any other `loadjava` options are processed. This <file> may contain one or more lines, each of which contains a pattern and a sequence of options. Each line must be terminated by a newline (`\n`). For each file (or JAR entry) that is processed by `loadjava`, the long name of the schema object that is going to be created (typically, the name of the class with a dot "." replaced by a slash "/" ) is checked against the patterns. Patterns can end in a wildcard (\*) to indicate an arbitrary sequence of characters; otherwise, they must match the name exactly. Options to be applied to matching Java schema objects are supplied on the rest of the line. Options are appended to the command-line options, they do not replace them. In case more than one line matches a name, the matching rows are sorted by length of pattern, with the shortest first, and the options from each row are appended. In general, `loadjava` options are not cumulative. Rather, later options override earlier ones. This means that an option specified on a line with a longer pattern will override a line with a shorter pattern.

This file is parsed by a `java.io.StreamTokenizer`.

Java comments (both `/**/` and `//`) are allowed. A line comment begins with a `#`. Empty lines are ignored. The quote character is a double quote (`"`). That is, options containing spaces (common in `-resolver` options, for example) should be surrounded by double quotes. Certain options, such as `-user` or `-verbose`, affect the overall processing of `loadjava` and not the actions performed for individual Java schema objects. Such options are ignored if they appear in an option file.

As an aid in packaging applications, `loadjava` looks for an entry named `META-INF/loadjava-options` in each JAR it processes. If it finds such an entry, it treats it as an options file that is applied for all other entries in the option file.

However, `loadjava` does some processing on entries in the order in which they occur in the JAR.

In case it has partially processed entities before it processes the `META-INF/loadjava-options`, the `loadjava` tool will attempt to patch up the schema object to conform to the applicable options. For example, by altering classes that were created with invoker's rights when they should have been created with definer's rights. The fix for `-noaction` will be to drop the created schema object. This will yield the correct effect except that if a schema object existed before `loadjava` started, it will have been dropped.

### **publish**

`[-publish <package>]`

`[-pubmain <number>]`

The publishing options cause `loadjava` to create PL/SQL wrappers for methods contained in the processed classes. Typically, a user wants to publish wrappers for only a few classes in a JAR. These options are most useful when specified in an option file.

To be eligible for publication, the method must satisfy the following:

1. The method must be a member of a public class.
2. The method must itself be declared public and static.
3. The method signature must be "mapable", which is defined in the following rules:
  - Java arithmetic types (`byte`, `int`, `long`, `float`, `double`) as arguments and return types are mapped to NUMBER.
  - `char` as an argument and return type is mapped to VARCHAR.
  - `java.lang.String` as an argument and return type is mapped to VARCHAR.
  - If the only argument of the method has type `java.lang.String`, special rules apply, as listed in the `-pubstring` option description.
  - If the return type is void, then a procedure is created.
  - If the return type is arithmetic, `char`, or `java.lang.String`, then a function is created and its return type is as specified in an earlier rule.

Methods that take arguments or return types that are not covered by the above rules are not eligible. No provision is made for OUT, IN-OUT SQL arguments, OBJECT types, or for many other SQL features.

**resolve**

```
{-resolve | -r}
```

Use `-resolve` to force `loadjava` to compile (if necessary) and resolve a class that has previously been loaded. It is not necessary to specify `-force`, because resolution is performed after, and independently of, loading.

**resolver**

```
{-resolver | -R} "resolver spec"
```

This option associates an explicit resolver spec with the class schema objects that `loadjava` creates or replaces.

A resolver spec consists of one or more items, each of which consists of a *name spec* and a *schema spec* expressed in the following syntax:

```
"((name_spec schema_spec) [(name_spec schema_spec)] ...)"
```

- A name spec is similar to a name in a Java `import` statement. It can be a fully qualified Java class name, or a package name whose final element is the wildcard character `"*"`, or (unlike an imported package name) simply the wildcard character `"*"`; however, the elements of a name spec must be separated by `"/"` characters, not periods. For example, the name spec `a/b/*` matches all classes whose names begin with `a.b`. The special name `*` matches all class names.
- A schema spec can be a schema name or the wildcard character `"-"`. The wildcard does not identify a schema but directs the resolve operation to not mark a class invalid because a reference to a matching name cannot be resolved. (Without a `"-"` wildcard in a resolver spec, an unresolved reference in the class makes the class invalid and produces an error message.) Use a `"-"` wildcard when you must test a class that refers to a class you cannot or do not want to load; for example, GUI classes that a class refers to but does not call because when run in the server there is no GUI.

The resolution operation interprets a resolver spec item as follows:

When looking for a schema object whose name matches the name spec, look in the schema named by the partner schema spec.

The resolution operation searches schemas in the order in which the resolver spec lists them. For example,

```
-resolver '(( * SCOTT) (* PUBLIC))'
```

means the following:

Search for any reference first in SCOTT and then in PUBLIC. If a reference is not resolved, then mark the referring class invalid and display an error message; in other words, call attention to missing classes.

The following example:

```
-resolver "(( * SCOTT) (* PUBLIC) (my/gui/* -))"
```

means the following:

Search for any reference first in SCOTT and then in PUBLIC. If the reference is not found, and is to a class in the package my.gui then mark the referring class valid, and do not display an error; in other words, ignore missing classes in this package. If the reference is not found and is not to a class in my.gui, then mark the referring class invalid and produce an error message.

#### **user**

```
{-user | -u} <user>/<password>[@<database>]
```

By default, loadjava loads into the login schema specified by the -user option. Use the -schema option to specify a different schema to load into. This does not involve a login into that schema, but does require that you have sufficient permissions to alter it.

The permissible forms of @<database> depend on whether you specify -oci or -thin; -oci is the default.

- -oci: @<database> is optional; if you do not specify, loadjava uses the user's default database. If specified, <database> can be a TNS name or a Oracle Net Services name-value list.
- -thin: @<database> is required. The format is <host>:<lport>:<SID>.
  - <host> is the name of the machine running the database.
  - <lport> is the listener port that has been configured to listen for Oracle Net Services connections; in a default installation, it is 5521.
  - <SID> is the database instance identifier; in a default installation it is ORCL.

Here are examples of loadjava commands:

- Connect to the default database with the default OCI driver, load the files in a JAR into the TEST schema, then resolve them.

```
loadjava -u joe/shmoe -resolve -schema TEST ServerObjects.jar
```

- Connect with the thin driver, load a class and a resource file, and resolve each class:

```
loadjava -thin -u SCOTT/TIGER@dbhost:5521:orcl \  
-resolve alpha.class beta.props
```

- Add Betty and Bob to the users who can execute `alpha.class`:

```
loadjava -thin -schema test -u SCOTT/TIGER@localhost:5521:orcl \  
-grant BETTY,BOB alpha.class
```

## dropjava

The `dropjava` tool is the converse of `loadjava`. It transforms command-line file names and JAR or ZIP file contents to schema object names, then drops the schema objects and deletes their corresponding digest table rows. You can enter `.java`, `.class`, `.sqlj`, `.ser`, `.zip`, `.jar`, and resource file names on the command line in any order.

Alternatively, you can specify a schema object name (full name, not short name) directly to `dropjava`. A command-line argument that does not end in `.jar`, `.zip`, `.class`, `.java`, or `.sqlj` is presumed to be a schema object name. If you specify a schema object name that applies to multiple schema objects (such as a source schema object `FOO` and a class schema object `FOO`), all will be removed.

Dropping a class invalidates classes that depend on it, recursively cascading upwards. Dropping a source drops classes derived from it.

---



---

**Note:** You must remove Java schema objects in the same way that you first loaded them. If you load a `.sqlj` source file and translate it in the server, you must run `dropjava` on the same source file. If you translate on a client and load classes and resources directly, run `dropjava` on the same classes and resources.

---



---

You can execute the `dropjava` tool either through the command line (as described below) or through the `dropjava` method contained within the `DBMS_JAVA` class. To execute within your Java application, do the following:

```
call dbms_java.dropjava('... options...');
```

where the options are the same as specified below. Separate each option with a blank. Do not separate the options with a comma. The only exception for this is the

`-user` option. The connection is always made to the current session, so you cannot specify another username through the `-user` option.

For `-resolver`, you should specify all other options first, a comma, then the `-resolver` option with its definition. Do not specify the following options, because they relate to the database connection for the `loadjava` command-line tool: `-thin`, `-oci`, `-user`, `-password`. The output is directed to `stderr`. Set `serveroutput` on and call `dbms_java.set_output` as appropriate.

## Syntax

```
dropjava [options] {<file>.java | <file>.class | file.sqlj |
<file>.jar | <file.zip> | <resourcefile>} ...
  -u | -user <user>/<password>[@<database>]
  [-genmissingjar <JARfile>]
  [-jarasresource]
  [-noserverside]
  [-o | -oci | -oci8]
  [-optionfile <file>]
  [-optiontable <table_name>]
  [-S | -schema <schema>]
  [-stdout ]
  [-s | -synonym]
  [-t | -thin]
  [-time]
  [-v | -verbose]
```

## Argument Summary

[Table 7-3](#) summarizes the `dropjava` arguments.

**Table 7-3** *dropjava Argument Summary*

Argument	Description
<code>-user</code>	Specifies a user, password, and optional database connect string; the files will be dropped from this database instance.
<code>&lt;filenames&gt;</code>	You can specify any number and combination of <code>.java</code> , <code>.class</code> , <code>.sqlj</code> , <code>.ser</code> , <code>.jar</code> , <code>.zip</code> , and resource file names, in any order.
<code>-genmissingjar</code> <code>&lt;file&gt;</code>	<code>dropjava</code> treats the operand of this option as a file to be processed.
<code>-jarasresource</code>	Drops the whole JAR file, which was previously loaded as a resource.



**Table 7–3 dropjava Argument Summary (Cont.)**

Argument	Description
<code>-noserverside</code>	Changes the behavior of the server-side <code>dropjava</code> tool to use a JDBC driver to access shemas. Normally, server-side <code>dropjava</code> has a performance enhancement that it will modify the schema directly—without using a JDBC driver to access the schemas. However, if you want the server-side to use a JDBC driver, use this option.
<code>-oci</code>   <code>-oci8</code>	Directs <code>dropjava</code> to connect with the database using the OCI JDBC driver. <code>-oci</code> and <code>-thin</code> are mutually exclusive; if neither is specified, then <code>-oci</code> is used by default. Choosing <code>-oci</code> implies the form of the <code>-user</code> value.
<code>-optionfile &lt;file&gt;</code>	This has the same usage as for <code>loadjava</code> .
<code>-optiontable &lt;table&gt;</code>	This has the same usage as for <code>loadjava</code> .
<code>-schema</code>	Designates the schema from which schema objects are dropped. If not specified, the <code>logon</code> schema is used. To drop a schema object from a schema that is not your own, you need the <code>DROP ANY PROCEDURE</code> and <code>UPDATE ANY TABLE</code> privileges.
<code>-stdout</code>	Causes the output to be directed to <code>stdout</code> , rather than to <code>stderr</code> .
<code>-synonym</code>	Drops a <code>PUBLIC</code> synonym that was created with <code>loadjava</code> .
<code>-thin</code>	Directs <code>dropjava</code> to communicate with the database using the <code>thin</code> JDBC driver. <code>-oci</code> and <code>-thin</code> are mutually exclusive; if neither is specified, then <code>-oci</code> is used by default. Choosing <code>-thin</code> implies the form of the <code>-user</code> value.
<code>-time</code>	Prints a timestamp on every message.
<code>-verbose</code>	Directs <code>dropjava</code> to emit detailed status messages while running.

## Argument Details

### File Names

`dropjava` interprets most file names as `loadjava` does:

- `.class` files: `dropjava` finds the class name in the file and drops the corresponding schema object.
- `.java` and `.sqlj` files: `dropjava` finds the first class name in the file and drops the corresponding schema object.

- `.jar` and `.zip` files: `dropjava` processes the archived file names as if they had been entered on the command line.

If a file name has another extension or no extension, then `dropjava` interprets the file name as a schema object name and drops all source, class, and resource objects that match the name. For example, the hypothetical file name `alpha` drops whichever of the following exists: the source schema object named `alpha`, the class schema object named `alpha`, and the resource schema object named `alpha`. If the file name begins with the `/` character, then `dropjava` prepends `ROOT` to the schema object name.

If `dropjava` encounters a file name that does not match a schema object, it displays a message and processes the remaining file names.

#### **user**

```
{-user | -u} <user>/<password>[@<database>]
```

The permissible forms of `@<database>` depend on whether you specify `-oci` or `-thin`; `-oci` is the default.

- `-oci:@<database>` is optional; if you do not specify, then `dropjava` uses the user's default database. If specified, then `<database>` can be a TNS name or a Oracle Net Services name-value list.
- `-thin:@<database>` is required. The format is `<host>:<listener>:<SID>`.
  - `<host>` is the name of the machine running the database.
  - `<listener>` is the listener port that has been configured to listen for Oracle Net Services connections; in a default installation, it is 5521.
  - `<SID>` is the database instance identifier; in a default installation, it is `ORCL`.

Here are some `dropjava` examples.

- Drop all schema objects in schema `TEST` in the default database that were loaded from `ServerObjects.jar`:

```
dropjava -u SCOTT/TIGER -schema TEST ServerObjects.jar
```
- Connect with the thin driver, then drop a class and a resource file from the user's schema:

```
dropjava -thin -u SCOTT/TIGER@dbhost:5521:orcl alpha.class beta.props
```

## Dropping Resources

Care must be taken if you are removing a resource that was loaded directly into the server. This includes profiles if you translated on the client without using the `-ser2class` option. When dropping source or class schema objects, or resource schema objects that were generated by the server-side SQLJ translator, the schema objects will be found according to the package specification in the applicable `.sqlj` source file. However, the fully qualified schema object name of a resource that was generated on the client and loaded directly into the server depends on path information in the `.jar` file or on the command line at the time you loaded it. If you use a `.jar` file to load resources and use the same `.jar` file to remove resources, there will be no problem. If, however, you use the command line to load resources, then you must be careful to specify the same path information when you run `dropjava` to remove the resources.

## ojvmjava

The `ojvmjava` tool is an interactive interface to a database instance's session namespace. You specify database connection arguments when you start `ojvmjava`. It then presents you with a prompt to indicate that it is ready for commands.

The shell can launch an executable, that is, a class with a static `main()` method. Executables must have been loaded with `loadjava`.

## Syntax

```
ojvmjava {-user <user>[/<password>@database] [options]
  [@<filename>]
  [-batch]
  [-c | -command <command> <args>]
  [-debug]
  [-d | -database <conn_string>]
  [-fileout <filename>]
  [-o | -oci | -oci8]
  [-oschema <schema>]
  [-t | -thin]
  [-version | -v]
```

## Argument Summary

[Table 7-4](#) summarizes the `ojvmjava` command-line arguments.

**Table 7-4** *ojvmjava Argument Summary*

Option	Description
-user   -u	Specifies user's name for connecting to the database. This name is case insensitive; the name will always be uppercased. If you provide the database information, the default syntax used is OCI. You can also specify the default database by the following option: -user <user>/<password>@
-password   -p	Specifies user's password for connecting to the database. This name case insensitive; the name will always be uppercased.
@<filename>	Specifies a script file that contains <code>ojvmjava</code> commands to be executed. See <a href="#">"Scripting ojvmjava Commands in the @&lt;filename&gt; Option"</a> on page 7-29 for structure of the indicated file.
-batch	Disables all messages printed to the screen. No help messages or prompts will be printed. Only responses to entered commands are printed.
-command	Executes the desired command. If you do not want to run <code>ojvmjava</code> in interpretive mode, but only want to execute a single command, execute <code>ojvmjava</code> with the <code>-command</code> option followed by a string that contains the command and the arguments. Once the command executes, <code>ojvmjava</code> exits. The following executes the "ls -lR" command on the designated host: <pre>ojvmjava -user/TIGER -command "java foo"</pre>
-debug	Prints debugging information.
-d   -database <conn_string>	Provide a database connection string.
-fileout <file>	Redirect output to the provided file.
-o   -oci   -oci8	Use the JDBC OCI driver. The OCI driver is the default. This flag specifies the syntax used in either the <code>@database</code> or <code>-database</code> option.
-oschema <schema>	Use this schema for class lookup.
-t   -thin	Specifies that the database syntax used is for the JDBC Thin driver. The database connection string must be of the form <host>:<port>:<SID> or an Oracle Net Services Name-Value list.
-verbose	Print the connection information.
-version	Shows the version.

**Example** Here is a `ojvmjava` example.

Open a shell on the session namespace of the database `orcl` on listener port 2481 on host `dbserver`.

```
ojvmjava -thin -user SCOTT/TIGER@dbserver:2481:orcl
```

The `ojvmjava` commands span several different types of functionality, which are grouped as follows:

- [ojvmjava Options](#)—Describes the options for the `ojvmjava` command-line tool
- [Shell Commands](#)—Describes the commands that are used for manipulating and viewing contexts and objects in the namespace.

### ojvmjava Options

- [ojvmjava Tool Output Redirection](#)
- [Scripting ojvmjava Commands in the @<filename> Option](#)

**ojvmjava Tool Output Redirection** You can specify that any output generated by the `ojvmjava` tool is put into a file by appending the `"&><filename>"` at the end of the command options. The following pipes all output to the `listDir` file:

```
ls -lR &>/tmp/listDir
```

**Scripting ojvmjava Commands in the @<filename> Option** This option designates a script file that contains one or more `ojvmjava` commands. The script file specified is located on the client. The `ojvmjava` tool reads in the file and then executes all commands on the designated server. Also, because the script file is executed on the server, any interaction with the operating system in the script file—such as redirecting output to a file or executing another script—will occur on the server. If you direct `ojvmjava` to execute another script file, this file must exist within `$ORACLE_HOME` directory on the server.

Type in the `ojvmjava` command followed by any options and any expected input arguments.

The script file contains any `ojvmjava` command followed by options and input parameters. The input parameters can be passed in on the `ojvmjava` command-line. The `ojvmjava` command processes all known `ojvmjava` options and then passes on any other options and arguments to the script file.

To access arguments within the commands in the script file, place `&1...&n` to denote the arguments. If all input parameters are passed into a single command, you can supply a the string `"&*"` to denote that all input parameters are to be passed to this command.

The following shows the contents of the script file, `execShell`:

```
chmod +x SCOTT nancy /alpha/beta/gamma
chown SCOTT /alpha/beta/gamma
java testhello &*
```

Because only two input arguments are expected, you can implement the `java` command input parameters as follows:

```
java testhello &1 &2
```

---

---

**Note:** You can also supply arguments to the `-command` option in the same manner. The following shows an example:

```
ojvmjava ... -command "cd &1" contexts
```

After processing all other options, the `ojvmjava` tool passes "contexts" in as the argument to the "cd" command.

---

---

To execute this file, do the following:

```
ojvmjava -user SCOTT -password TIGER -thin -database dbserver:2481:orcl \
@execShell alpha beta
```

The `ojvmjava` processes all options that it knows about and passes along any other input parameters to be used by the commands that exist within the script file. In this example, the parameters, `alpha` and `beta`, are passed to the `java` command in the script file. Thus, the actual command executed is as follows:

```
java testhello alpha beta
```

You can add any comments in your script file with the hash symbol (`#`). The `"#"` symbol makes anything to the end of the line a comment, which is ignored by `ojvmjava`. For example:

```
#this whole line is ignored by ojvmjava
```

## Shell Commands

The following shell commands behave similarly to their UNIX counterparts:

- `echo`
- `java`
- `exit`
- `version`
- `help`
- `whoami`

Each of these shell commands contains the following common options:

**Table 7–5** *ojvmjava Command Common Options*

Option	Description
<code>-describe   -d</code>	Summarizes the tool's operation.
<code>-help   -h</code>	Summarizes the tool's syntax.
<code>-version</code>	Shows the version.

### echo

Prints to stdout exactly what is indicated. This is used mostly in script files.

The syntax is as follows:

```
echo [<echo_string>] [<args>]
```

where *<echo\_string>* is a string that contains the text you want written to the screen during the shell script invocation and *<args>* are input arguments from the user. For example, the following prints out a notification:

```
echo "Adding an owner to the schema" &1
```

If the input argument is "SCOTT", the output would be "Adding an owner to the schema SCOTT"

### exit

The `exit` command terminates `ojvmjava`.

### Syntax

```
exit
```

Here is an example:

Leave the shell:

```
$ exit
%
```

## help

The `help` command summarizes the syntax of the shell commands. You can also use the `help` command to summarize the options for a particular command.

## Syntax

```
help [<command>]
```

## java

The `java` command is analogous to the JDK `java` command; it invokes a class's static `main()` method. The class must have been loaded with `loadjava`. (There is no point to publishing a class that will be invoked with the `java` command.) The `java` command provides a convenient way to test Java code that runs in the database. In particular, the command catches exceptions and redirects the class's standard output and standard error to the shell, which displays them as with any other command output. (The usual destination of standard out and standard error for Java classes executed in the database is one or more database server process trace files, which are inconvenient and may require DBA privileges to read.)

## Syntax

```
java [-schema <schema>] <class> [arg1 ... argn]
```

## Argument Summary

[Table 7-6](#) summarizes the `java` arguments.

**Table 7-6** *java Argument Summary*

Option	Description
<code>class</code>	Names the Java class schema object that is to be executed.
<code>-schema</code>	Names the schema containing the class to be executed; the default is the invoker's schema. The schema name is case sensitive.
<code>arg1 ... argn</code>	Arguments to the class's <code>main()</code> method.

Here is a `java` command example.

Say hello and display arguments:



```

package hello;
public class World {
    public World() {
        super();
    }
    public static void main(String[] argv) {
        System.out.println("Hello from the Oracle9i ORB");
        if (argv.length != 0)
            System.out.println("You supplied " + argv.length + " arguments: ");
        for (int i = 0; i < argv.length; i++)
            System.out.println(" arg[" + i + "] : " + argv[i]);
    }
}

```

Compile, load, publish, and run the executable as follows, substituting your userid, host, and port information as appropriate:

```

% javac hello/World.java
% loadjava -r -user SCOTT/TIGER@localhost:2481:orcl hello/World.class
% ojvmjava -user SCOTT -password TIGER -database localhost:2481:orcl
$ java testhello alpha beta
Hello from the Oracle9i ORB
You supplied 2 arguments:
arg[0] : alpha
arg[1] : beta

```

## version

The `version` command shows the version of the `ojvmjava` tool. You can also show the version of a specified command.

## Syntax

```
version [options] [<command>]
```

Here is an example of the `version` command.

Display the shell's version:

```

$ version
1.0

```

## whoami

Prints out the current user that logged into this session.



---

---

# Glossary

## **API**

API stands for Application Programming Interface. As applied to Java, an API is a well-defined set of classes and methods that furnish a specific set of functionality to the Java programmer. JDBC and SQLJ are APIs for accessing SQL data.

## **Bytecodes**

The set of single-byte, machine-independent instructions to which Java source code is compiled using the Java compiler.

## **Call Memory**

The memory that the memory manager uses to allocate new objects.

## **CLASSPATH**

The environment variable (or command line argument) that the JDK or JRE uses to specify the set of directory tree roots in which Java source, classes, and resources are located.

## **Context Switch**

In a uniprocessor system, the current thread is interrupted by a higher priority thread or by some external event, and the system switches to a different thread. The choice of which thread to dispatch is usually made on a priority basis or based on how long a thread has been waiting.

## **Cooperative Multitasking**

The programmer places calls to the `Thread.yield()` method in locations in the code where it is appropriate to suspend execution so that other threads can run.

This is quite error-prone because it is often difficult to assess the concurrent behavior of a program as it is being written.

### **Core Class Libraries**

Generally, the Java packages delivered with the Sun Microsystems JDK, `java.*`. We also use this term to denote some `sun.*` packages.

### **Deadlock**

The conflict state where two or more synchronized Java objects depend on locking each other, but cannot, because they themselves are locked by the dependent object. For example, object A tries to lock object B while object B is trying to lock object A. This situation is difficult to debug, because a preemptive Java virtual machine can neither detect nor prevent deadlock. Without deadlock detection, a deadlocked program simply hangs.

### **Dispatch**

The system saves the state of the currently executing thread, restores the state of the thread to be executed, and branches to the stored program counter for the new thread, effectively continuing the new thread as if it had not been interrupted.

### **Driver**

As used with JDBC, a layer of code that determines the low-level libraries employed to access SQL data and/or communicate across a network. The three JDBC drivers supported in Oracle9i JVM are: Thin, OCI, and KPRB.

### **End-of-Call**

Within your session, you may invoke Java many times. Each time you do this, end-of-call occurs at the point at which Java code execution completes. The memory manager migrates static variables to session space at end-of-call.

### **Garbage Collection**

The popular name for the automatic storage reclamation facility provided by the Java virtual machine.

### **IDE**

Integrated Development Environment. A Java IDE runs on a client workstation, providing a graphical user interface for access to the Java class library and development tools.

**Java Schema Object**

The term that Oracle9i uses to denote either Java source, binary, or resources when stored in the database. These three Java schema objects correspond to files under the JDK—`.java`, `.class`, or other files (such as `.properties` files) used in the JDK CLASSPATH.

**JCK**

Java Compatibility Kit. The set of Java classes that test a Java virtual machine and Java compiler's compliance with the Java standard. JCK releases correspond to the Sun Microsystems JDK releases, although in the case of Oracle9i, only the Java classes and not the virtual machine, are identical to the Sun Microsystems JDK.

**JDBC**

Java Database Connectivity. The standard Java classes that provide vendor-independent access to databases.

**JDBC Driver**

The vendor-specific layer of JDBC that provides access to a particular database. Oracle provides three JDBC drivers—Thin, OCI, and KPRB.

**JDK**

Java Development Kit. The Java virtual machine, together with the set of Java classes and tools that Sun Microsystems furnishes to support Java application and applet development. The JDK includes a Java compiler; the JRE does not.

**JLS**

Java Language Specification. This specification defines the syntax and semantics of the Java language.

**JRE**

Java Runtime Environment. The set of Java classes supporting a Java application or applet at runtime. The JRE classes are a subset of the JDK classes.

**Lazy Initialization**

A technique for initializing data, typically used in accessor methods. The technique checks to see if a field has been initialized (is non-null) before returning the initialized object to it. The overhead associated with the check is often small, especially in comparison to initializing a data structure that may never be accessed. You can employ this technique in conjunction with end-of-call processing to minimize session space overhead.

**Object Graph**

An object is said to reference the objects held in its fields. This collection of objects forms an object graph. The memory manager actually migrates the object graphs held in static variables; that is, it migrates not only the objects held in static fields, but the objects that those objects reference, and so on.

**Oracle9i JVM**

Oracle's scalable Java server platform, composed of the Java virtual machine running within the Oracle9i database server, the Java runtime environment and Oracle extensions.

**Preemptive Multitasking**

The operating system preempts, or takes control away from a thread, under certain conditions, such as when another thread of higher priority is ready to run, or when an external interrupt occurs, or when the current thread waits on an I/O operation, such as a socket accept or a file read. Some Java virtual machines implement a type of round-robin preemption by preempting the current thread on certain virtual machine instructions, such as backward branches, method calls, or other changes in control flow. For a Java virtual machine that maps Java threads to actual operating system threads, the preemption takes place in the operating system kernel, outside the control of the virtual machine. Although this yields decent parallelism, it complicates garbage collection and other virtual machine activities.

**Process**

An address space and one or more threads.

**Session Memory**

The memory that the memory manager uses to hold objects that survive past the end-of-call—those objects reachable from Java static variables within your session.

**SQLJ**

Embedded SQL in Java. The standard that defines how SQL statements can be embedded in Java programs to access SQL data. A translator transforms the SQLJ programs to standard JDBC programs.

**Strong Typing**

In Java, the requirement that the class of each field and variable, and the return type of each method be explicitly declared.

**Symmetric Multiprocessing (SMP)**

The hardware has multiple processors, and the operating system maps threads to different processors, depending on their load and availability. This assumes that the Java virtual machine maps OS threads to Java threads. This mechanism provides true concurrency among the threads, but can lead to subtle programming errors and deadlock conflicts on synchronized objects.

**System**

Often used in discussion as the combination of the hardware, the operating system, and the Java virtual machine.

**Thread**

An execution context consisting of a set of registers, a program counter, and a stack.

**Virtual Machine**

A program that emulates the functionality of a traditional processor. A Java virtual machine must conform to the requirements of the Java Virtual Machine Specification.





## Symbols

---

#sql, 3-8, 3-9

## A

---

### Accelerator

- deploync tool, 6-16
- for user applications, 6-5
- installation requirements, 6-5
- ncomp tool, 6-7
- overview, 6-2, 6-3
- statusnc tool, 6-17

act method, 6-26

ALREADY\_NCOMPED status, 6-17

### application

- compiling, 2-8
- development, 2-3
- executing in a session, 2-3
- execution control, 2-6
- execution rights, 2-20
- invoking, 3-3, 3-20
- threading, 2-38

### attributes

- definition, 1-5
- types of, 1-6

authentication, 5-2

## B

---

BasicPermission, 5-14

### bytecode

- defined, 1-10
- verification, 2-15

## C

---

### call

- definition, 2-2
- managing resources across calls, 2-35
- static fields, 2-5

call specification, 3-4, 3-5

### Callback class

- act method, 6-26

### class

- attributes, 1-5, 1-7
- definition, 1-5
- dynamic loading, 1-18
- execution, 2-2
- hierarchy, 1-7
- inheritance, 1-7, 1-8
- loading, 2-2, 2-6, 2-16, 3-2
- marking valid, 2-13
- methods, 1-5, 1-7
- name, 2-26
- protected, 5-26
- publish, 2-2, 2-25, 3-2
- resolving references, 2-12, 3-2
- schema object, 2-6, 2-13, 2-16, 2-17

.class files, 2-7, 2-16, 2-17

### Class interface

- forName method, 2-27

class schema object, 7-2, 7-3

### ClassForName class

- lookupClass method, 2-30

classForNameAndSchema method, 2-29

ClassNotFoundException, 2-27

CLASSPATH, 2-6, 2-27

### client

- setup, 4-6
- code
  - native compilation, 6-2
- CodeSource class, 5-5
  - equals method, 5-5
  - implies method, 5-5
- compiling, 2-8
  - error messages, 2-9, 7-5
  - memory problems, 6-24
  - options, 2-9, 7-5
  - runtime, 2-8
  - setting options, 3-15
- configuration, 4-1
  - JVM, 4-2 to ??
  - performance, 6-19
- connection
  - configuration, 4-3
  - security, 5-2

## D

---

- data confidentiality, 5-2
- database
  - configuration, 4-2
  - privileges, 5-2
- DBA\_JAVA\_POLICY view, 5-6, 5-18, 5-20
- DBMS\_JAVA package, 3-17, 4-3
  - defined, 5-5
  - delete\_permission method, 4-5, 5-19
  - disable\_permission method, 4-5, 5-18
  - dropjava method, 4-4
  - enable\_permission method, 4-5, 5-18
  - get\_compiler\_option method, 4-4
  - grant\_permission method, 4-5, 5-8, 5-10
  - grant\_policy\_permission method, 4-5, 5-12, 5-20
  - loadjava method, 4-4
  - longname method, 2-23, 2-26, 4-3
  - modifying permissions, 5-19
  - modifying PolicyTable permissions, 5-10, 5-12
  - reset\_compiler\_option method, 4-4
  - restart\_debugging method, 3-17, 4-5
  - restrict\_permission method, 4-5, 5-9, 5-10
  - revoke\_permission method, 4-5, 5-18
  - set\_compiler\_option method, 3-15, 4-4
  - set\_output method, 3-20, 4-4

- setting permissions, 5-5
- shortname method, 2-24, 2-26, 4-3
- start\_debugging method, 3-17, 4-5
- stop\_debugging method, 4-5
- DBMS\_OUTPUT package, 4-4
- DbmsJava class, see DBMS\_JAVA package
- DbmsObjectInputStream class, 2-30
- DbmsObjectOutputStream class, 2-30
- deadlock, 2-39
- DeadlockError exception, 2-39
- debug
  - compiler option, 2-10, 7-6
- DebugAgent class, 3-14
- debugging, 4-5, 5-25
  - agent, 3-14, 3-16, 3-17
  - connecting a debugger, 3-18
  - Java applications, 1-4, 3-13
  - necessary permissions, 5-25
  - setting compiler options, 3-15
  - starting Debug Agent, 3-16
  - starting proxy, 3-15
  - using OracleAgent class, 3-17
- DebugProxy class, 3-14, 3-15
- definer rights, 2-21
- delete method, 5-19
- delete\_permission method, 4-5, 5-19
- deploync tool, 6-16
- digest table, 7-4, 7-5
- disable method, 5-18
- disable\_permission method, 4-5, 5-18
- dropjava
  - method, 4-4
  - tool, 2-18
- dropjava tool, 7-23

## E

---

- enable method, 5-19
- enable\_permission method, 4-5, 5-18
- encoding
  - compiler option, 2-9, 7-6
- end-of-call migration, 6-25
- EndOfCallRegistry class, 6-25
  - registerCallback method, 6-26
- endSession method, 2-40

- equals method, 5-5
- errors
  - compilation, 2-9
- exception
  - ClassNotFoundException, 2-27
  - DeadlockError, 2-39
  - IOException, 2-33
  - LimboError, 2-39
  - ThreadDeathException, 2-40
- execution rights, 2-20
- exit command, 7-31
- exitCall method, 2-40

## F

---

- file names
  - dropjava, 7-25
  - loadjava, 7-16
- FilePermission, 5-7, 5-19, 5-21, 5-23, 6-6
- files, 2-32
  - across calls, 2-35
  - lifetime, 2-33
  - relative path names, 2-34
- finalizers, 2-35
- footprint, 1-16, 2-4
- forName method, 2-27

## G

---

- garbage collection, 1-14, 1-15, 2-5
  - managing resources, 2-32
  - misuse, 2-34
  - purpose, 2-34
- get\_compiler\_option method, 2-10, 4-4, 7-6
- getCallerClass method, 2-28
- getClassLoader method, 2-28
- getProperty method, 3-20
- grant method, 5-8
- grant\_permission method, 4-5, 5-8, 5-10
- grant\_policy\_permission method, 4-5, 5-12, 5-20
- granting permission, 5-5
- grantPolicyPermission method, 5-13
- GUI, 2-25

## H

---

- help command, 7-32

## I

---

- implies method, 5-5
- inheritance, 1-7, 1-8
- installation, 4-1, 4-2
- integrity, 5-2
- interfaces
  - defined, 1-8
  - user, 2-25
- internet newsgroups, xv
- INVALID status, 6-17
- invoker rights, 2-21
  - advantages, 2-21
- IOException, 2-33

## J

---

- Java
  - applications, 2-1, 2-8
    - loading, 2-16
  - attributes, 1-5
  - class, 1-5
  - client
    - setup, 4-6
  - compiling, 2-8
  - development environment, 2-6
  - differences from Sun JDK, 2-3
  - documentation, xiv, 1-2, 1-22
  - execution control, 2-6
  - execution rights, 2-20
  - features, 1-13
  - in the database, 1-2, 1-14, 2-1, 2-2
  - interpreter, 2-2
  - introduction, xiii
  - invoking, 2-2, 3-3
  - loading classes, 2-6, 3-2
    - checking results, 2-23
  - methods, 1-5
  - natively compiling, 6-2
  - overview, 1-2, 1-5
  - permissions, 4-5
  - polymorphism, 1-8

- programming models, xiv
- publishing, 2-6
- resolving classes, 2-12
- resources, 1-5
- stored procedures, see Java stored procedures
- Java 2
  - migrating from JDK 1.1, 1-2
  - security, 5-2
- java command, 7-32
- Java Compatibility Kit, see JCK
- .java files, 2-7, 2-16, 2-17
- java interpreter, 2-2, 2-6
- Java language specification, see JLS
- Java Native Interface, see JNI
- Java Remote Method Invocation, see RMI
- Java stored procedures, xiv, 2-5
  - defined, 1-19, 3-3
  - documentation, 1-22
  - invoking, 3-2
  - publishing, 2-25
- Java virtual machine, see JVM
- JAVASOFTWARE table, 2-9, 7-5
- JAVA\_ADMIN role
  - assigned permissions, 5-21
  - example, 5-14
  - granting permission, 5-3, 5-5, 5-12, 5-20
- JAVA\_DEPLOY role, 6-6
- JAVA\_MAX\_SESSIONSPACE\_SIZE
  - parameter, 6-20
- JAVA\_POOL\_SIZE parameter
  - default, 4-2
  - defined, 6-19, 6-21
  - errors, 6-24
- JAVA\_SOFT\_SESSIONSPACE\_LIMIT
  - parameter, 6-20
- JAVADEBUGPRIV role, 5-24, 5-25
- JAVASYSPRIV role, 5-3, 5-23, 5-24
- JAVAUSERPRIV role, 5-3, 5-23, 5-24
- JCK, 1-12
- jdb debugging tool, 3-13, 3-18
- JDBC
  - accessing SQL, 1-20
  - defined, 1-19, 3-2, 3-6
  - documentation, 1-22
  - driver types, 1-20, 3-6

- example, 3-7
- interacting with SQL, 3-12
- security, 5-2
- JDeveloper
  - development environment, 1-22, 3-11, 4-8
- JDK
  - web location, xiv
- JLS
  - specification, 1-12
  - web information, xiv
- JNI support, 3-5
- JPublisher
  - documentation, 1-22
- JServerPermission, 5-8, 5-19, 5-20, 5-21, 5-22, 5-23, 5-24
  - defined, 5-20
- JVM
  - bytecodes, 1-10
  - configure, 4-1
  - defined, 1-5, 1-10
  - garbage collection, 1-14, 1-15
  - install, 4-1, 4-2
  - multithreading, 1-14
  - responsibilities, 2-4
  - security, 4-5
  - specification, 1-12
  - web information, xiv

## L

---

- LimboError exception, 2-39
- loading, 2-16 to 2-25
  - checking results, 2-18, 2-23
  - class, 1-18, 2-6, 2-8
  - compilation option, 2-8
  - granting execution, 2-20
  - JAR or ZIP files, 2-19
  - necessary privileges and permissions, 2-19
  - reloading classes, 2-19
  - restrictions, 2-18
- loadjava method, 4-4
- loadjava tool, 2-17 to 2-19, 7-7 to 7-23
  - compiling source, 2-8, 6-24
  - example, 3-4
  - execution rights, 2-20, 5-3

- loading class, 2-16
- loading ZIP or JAR files, 2-19
- restrictions, 2-18
- using memory, 6-19
- logging, 2-9
- longname method, 2-23, 2-26, 4-3
- lookupClass method, 2-30

## M

---

- main method, 2-6
- memory
  - across calls, 2-34
  - call, 2-5
  - java pool, 6-22
  - leaks, 2-34
  - lifetime, 2-32, 2-33
  - manager, 2-7
  - performance configuration, 6-19
  - report allocation, 6-30
  - running out of, 6-24
  - session, 2-5, 6-26
- Memory Profiling Utility, see MemStat
- MemStat
  - analysis options, 6-31
  - class, 6-32
    - writeDump method, 6-32
    - writeDumpAtEOC method, 6-32
  - example, 6-33, 6-35
  - reporting, 6-34
  - security permissions, 6-33
  - using, 6-32
  - utility, 6-30
  - warning, 6-32
- methods, 1-5, 1-7
- multithreading, 1-14

## N

---

- namespace, 7-27
- native compilation, 1-17, 6-2
  - Accelerator, 6-3
  - classes loaded in database, 6-13
  - classes not loaded in database, 6-13
  - compile subset, 6-15

- deploync tool, 6-16
- designating build directory, 6-14
- errors, 6-11
- execution time, 6-8
- force recompile, 6-14
- ncomp tool, 6-7
  - scenarios, 6-13
  - statusnc tool, 6-17
- ncomp tool, 6-5, 6-7
  - executing, 6-7
  - security, 6-6
- NEED\_NCOMPING status, 6-17
- NEED\_NCOMPING status message, 6-12
- NetPermission, 5-7, 5-19, 5-21, 5-22
- networking
  - configuration, 4-3

## O

---

- object
  - full to short name conversion, 2-23
  - lifetime, 2-33
  - schema, 2-6
  - serialization, 2-30
  - short name, 2-23
- ObjectInputStream class, 2-30
- ObjectOutputStream class, 2-30
- ojvmjava tool, 7-27 to ??
- online
  - compiler option, 2-10, 7-6
- operating system
  - resources, 2-32
    - across calls, 2-35
    - lifetime, 2-33
    - performance, 6-19
- OracleAgent class
  - restart method, 3-17
  - start method, 3-17
  - stop method, 3-17
- OracleRuntime class
  - exitCall method, 2-40
  - getCallerClass method, 2-28
  - getClassLoader method, 2-28
- output
  - redirecting, 3-20

## P

---

### packages

- DBMS\_JAVA, 4-3
- protected, 5-26

### path

- relative path names, 2-34

### performance, 1-17, 6-1 to 6-30

### Permission class, 5-7, 5-13, 5-14, 5-19

### permissions, 4-5, 5-2 to 5-25

- administrating, 5-12
- assigning, 5-4, 5-5
- creating, 5-14
- deleting, 5-19
- disabling, 5-18
- enabling, 5-18
- FilePermission, 6-6
- granting, 5-5, 5-8, 5-10
- granting policy, 5-12
- grouped into roles, 5-24
- JAVA\_ADMIN role, 5-21
- JAVA\_DEPLOY role, 6-6
- JAVADEBUGPRIV role, 5-24
- JAVASYSPRIV role, 5-23
- JAVAUSERPRIV role, 5-23
- PUBLIC, 5-22
- restricting, 5-5, 5-9, 5-10
- specifying policy, 5-4
- SYS permissions, 5-22
- types, 5-7, 5-19

### policy table

- managing, 5-12
- modifying, 5-5
- setting permissions, 5-5
- viewing, 5-5

### PolicyTable class

- specifying policy, 5-4
- updating, 5-5, 5-15

### PolicyTableManager class

- delete method, 5-19
- disable method, 5-18
- enable method, 5-19
- revoke method, 5-18

### PolicyTablePermission, 5-8, 5-12, 5-19, 5-20, 5-21, 5-22

### polymorphism, 1-8

### privileges

- database, 5-2

### .properties files, 2-7, 2-16, 2-17

### PropertyPermission, 5-7, 5-19, 5-21, 5-22, 5-24

### PUBLIC permissions, 5-22

### publishing, 2-6, 2-8, 2-25, 3-2

- example, 3-4

## R

---

### ReflectPermission, 5-8, 5-19, 5-21, 5-22

### registerCallback method, 6-26

### reset\_compiler\_option method, 2-10, 4-4, 7-6

### resolver, 2-12 to ??, 7-3

- default, 2-13

- defined, 2-6, 2-8, 2-13, 2-27, 3-2

- example, 3-4

- ignoring non-existent references, 2-13, 2-15

### resource schema object, 2-6, 2-16, 2-17, 7-2

### restart method, 3-17

### restart\_debugging method, 3-17, 4-5

### restrict method, 5-9

### restrict\_permission method, 4-5, 5-9, 5-10

### revoke method, 5-18

### revoke\_permission method, 4-5, 5-18

### RMI

- support, 3-5

### RuntimePermission, 5-8, 5-19, 5-21, 5-22, 5-23, 5-24

## S

---

### schema object, 7-2

- defined, 2-16

- name, 2-26

- using, 2-6

### security, 5-1 to 5-26

- book recommendations, 5-4

- Java 2, 5-3

- JDBC, 5-2

- JVM, 4-5

- network, 5-2

### SecurityManager class, 5-4

### SecurityPermission, 5-8, 5-19, 5-21, 5-22

### .ser files, 2-7, 2-16, 2-17

- SerializablePermission, 5-7, 5-19, 5-21, 5-23
- serialization, 2-30
- ServerSocket class, 2-37
- sess\_sh
  - commands in a script file, 7-29
  - redirecting output, 7-29
- session
  - coordination with JVM, 2-4
  - definition, 2-2
  - footprint, 1-16
  - namespace, 7-27
  - role in Java execution, 2-3
- set\_compiler\_option method, 2-10, 3-14, 3-15, 4-4, 7-6
- set\_output method, 3-20, 4-4
- SHARED\_POOL\_SIZE parameter
  - default, 4-2
  - defined, 6-19
  - errors, 6-24
- shortname method, 2-24, 2-26, 4-3
- Socket class, 2-37
- SocketPermission, 5-8, 5-19, 5-21, 5-23, 5-24
- sockets
  - across calls, 2-32, 2-37
  - defined, 2-37
  - lifetime, 2-33, 2-37
- source schema object, 2-6, 2-16, 2-17, 7-2, 7-5
- SQL
  - query, 3-2, 3-6
- SQLJ
  - accessing SQL, 1-20
  - converting, 3-12
  - defined, xiv, 1-19, 1-21, 3-2, 3-6
  - documentation, 1-22
  - example, 3-8, 3-9
  - interoperates with PL/SQL, 3-12
  - running, 3-11
  - translating, 3-11
  - typing paradigm, 3-10
  - using JDBC, 1-21
- .sqlj files, 2-7, 2-16, 2-17
- sqlj utility, 3-11
- start method, 3-17
- start\_debugging method, 3-17, 4-5
- static variable, 2-5

- end of call migration, 6-25
- statusnc tool, 6-17
- stop method, 3-17
- stop\_debugging method, 3-17, 4-5
- SYS
  - assigned permissions, 5-22
  - security permissions, 5-20
- System class
  - getProperty method, 3-20

## T

---

- ThreadDeathException, 2-40
- threading, 2-32
  - applications, 2-38
  - lifecycle, 2-39
  - model, 1-14, 2-38
- trigger
  - using Java stored procedures, 3-3

## U

---

- user interface, 2-25
- USER\_ERRORS view, 2-9
- USER\_JAVA\_POLICY view, 5-6, 5-20
- USER\_OBJECTS view, 2-18, 2-23, 4-4

## V

---

- VSSGASTAT table, 6-22
- variables
  - static, 2-5
- version
  - retrieving, 3-20

## W

---

- web sites, xiv

