HP JFS 3.3 and HP OnLineJFS 3.3 VERITAS File System 3.3 System Administrator's Guide

for HP-UX 11.00 and HP-UX 11i

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Preface

Introduction

The *VERITAS© File System System Administrator's Guide* provides information on the most important aspects of administering a VERITAS File System™ (VxFS©).The VERITAS File System is also known as the Journaled File System, or JFS. This guide also provides information on administering the HP OnLineJFS product, an optional add-on product for HP-UX systems. This document describes JFS 3.3 and OnLineJFS 3.3.

This guide is for system administrators who configure and maintain HP-UX 11.x systems with JFS 3.3, and assumes that you have:

- An understanding of system administration.
- A working knowledge of the HP-UX operating system.
- A general understanding of file systems.

Organization

- Chapter 1, The VxFS File System,, introduces the features and characteristics of this product.
- Chapter 2, Disk Layout, describes and illustrates the major components of VxFS disk layouts.
- Chapter 3, Extent Attributes, describes the policies associated with allocation of disk space.
- Chapter 4, Online Backup, describes the snapshot backup feature of VxFS.
- Chapter 5, Performance and Tuning, describes VxFS tools that optimize system performance. This section includes information on mount options.
- Chapter 6, Application Interface, describes ways to optimize an application for use with VxFS. This chapter includes details on cache advisories, extent sizes, and reservation of file space.
- Chapter 7, Quotas, describes VxFS methods to limit user access to file and data resources.
- Appendix A, Kernel Messages, lists VxFS kernel error messages in numerical order and provides explanations and suggestions for dealing with these problems.
- The "Glossary" contains a list of terms and definitions relevant to VxFS.

Related Documents

To install JFS 3.3 and OnLineJFS 3.3, and for more information about these products, see the following documents:

- For HP-UX 11.00 systems: *HP JFS 3.3 and HP OnLineJFS 3.3 Release Notes*
- For HP-UX 11.10 systems: *Release Notes for HP-UX Release 11.10 and HP-UX 11.10 Installation and Configuration Notes*
- For HP-UX 11i systems: *HP-UX 11i Release Notes* and *HP OnLineJFS 3.3 Release Notes for HP-UX 11i*

The online manual pages provide additional details on VxFS commands and utilities.

Conventions

Typeface	Usage	Examples
monospace	computer output, files, directories, software elements such as command options, function names, and parameters	Read tuneables from the `/etc/vx/tunefstab` file. See the `ls`(1) manual page for more information.
monospace (**bold**)	user input	# **`mount -F vxfs /h/filesys`**
italic	new terms, book titles, emphasis, variables replaced with a name or value	See the *User's Guide* for details. The variable *ncsize* determines the value of...

Symbol	Usage	Examples
%	C shell prompt	
$	Bourne/Korn shell prompt	
#	superuser prompt (all shells)	
\	continued input on the following line; you do not type this character	# **`mount -F vxfs \ /h/filesys`**
[ ]	in a command synopsis, brackets indicates an optional argument	`ls [ -a ]`
|	in a command synopsis, a vertical bar separates mutually exclusive arguments	`mount [ suid | nosuid ]`

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For technical support, if you have a support contract, call the HP Response Center at 1-800-633-3600.

For additional information about HP OnLineJFS and other HP high availability products, visit the Web site at:

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1 The VxFS File System

Introduction

VxFS is an extent based, intent logging file system. VxFS is particularly geared toward UNIX environments that require high performance and availability and deal with large volumes of data.

This chapter provides an overview of major VxFS features that are described in detail in later chapters.The following topics are covered in this chapter:

- “JFS and OnLineJFS Feature Comparison”
- “Disk Layout Options”
- “File System Performance Enhancements”
- “Extent-Based Allocation”
- “Extent Attributes”
- “Fast File System Recovery”
- “Online System Administration”
- “Online Backup”
- “Application Interface”
- “Extended mount Options”
- “Enhanced I/O Performance”
- “Quotas”
- “Access Control Lists”
- “Support for Large Files”

JFS 3.3 and OnLineJFS 3.3 Product Availability

HP JFS 3.3 and HP OnLineJFS 3.3 are available for HP-UX 11.00 and later systems. You can download JFS 3.3 for HP-UX 11.00 for free from the HP Software Depot (http://www.software.hp.com), or you can request a free JFS 3.3 CD from the Software Depot. You can purchase HP OnLineJFS 3.3 (product number B3929CA for servers and product number B5118CA for workstations) for HP-UX 11.0 or HP-UX 11i from your HP sales representative. JFS 3.3 is included with HP-UX 11i systems.

JFS and OnLineJFS Feature Comparison

HP-UX supports two separate Journaled File System products: the basic product, JFS, which is built into the HP-UX operating system, and the optional, advanced product, OnLineJFS, which is purchased separately. The following table lists VxFS file system features supported in JFS 3.3 and OnLineJFS 3.3.

Table 1-1 VxFS File System Feature Comparison

Feature	JFS 3.3	OnLineJFS 3.3
extent-based allocation	*	*
extent attributes	*	*
fast file system recovery	*	*
access control list (ACL) support	*	*
enhanced application interface	*	*
enhanced mount options	*	*
improved synchronous write performance	*	*
support for large files (up to one terabyte)	*	*
support for large file systems (up to one terabyte)	*	*
enhanced I/O performance	*	*
support for BSD-style quotas	*	*
unlimited number of inodes	*	*
file system tuning [`vxtunefs`(1M)]	*	*
online administration		*
ability to reserve space for a file and set fixed extent sizes and allocation flags		*
online snapshot file system for backup		*
direct I/O, supporting improved database performance		*
data synchronous I/O		*
DMAPI		*

VxFS supports all UFS file system features and facilities except for the linking, removing, or renaming of "." and ".." directory entries. Such operations may disrupt file system sanity.

Disk Layout Options

Three disk layout formats are available with VxFS:

Version 2

The Version 2 disk layout supports such features as:

- filesets
- dynamic inode allocation

  The Version 2 layout is available with optional support for quotas.

Version 3

The Version 3 disk layout offers additional support for:

- files up to one terabyte
- file systems up to one terabyte

Version 4

Version 4 is the latest disk layout with the following additional feature:

- Access Control Lists

  See Chapter 2 , “Disk Layout” for a description of the disk layouts.

  The following table lists HP-UX Releases with the VxFS versions and disk layouts they support:

Table 1-2 Supported and Default Disk Layouts on HP-UX Releases

HP-UX Release	VxFS Version	Supported Disk Layouts	Default Disk Layout
10.10	2.3	2	2
10.20	3.0	2, 3	3
11.00 with JFS 3.1	3.1	2, 3	3
11.00 with JFS 3.3	3.3	2, 3, 4	3
11i	3.3	2, 3, 4	4

File System Performance Enhancements

The HFS file system uses block based allocation schemes which provide adequate random access and latency for small files but limit throughput for larger files. As a result, the HFS file system is less than optimal for commercial environments.

VxFS addresses this file system performance issue through an alternative allocation scheme and increased user control over allocation, I/O, and caching policies. An overview of the VxFS allocation scheme is covered in the section “Extent-Based Allocation”.

VxFs provides the following performance enhancements:

- extent based allocation
- enhanced mount options
- data synchronous I/O
- direct I/O and discovered direct I/O
- caching advisories
- enhanced directory features
- explicit file alignment, extent size, and preallocation controls
- tuneable I/O parameters
- tuneable indirect data extent size

The rest of this chapter along with Chapter 5 , “Performance and Tuning” and Chapter 6 , “Application Interface” provide more details on some of these features.

Extent-Based Allocation

Disk space is allocated in 1024-byte sectors to form logical blocks. VxFS supports logical block sizes of 1024, 2048, 4096, and 8192 bytes. The default block size is 1K for file systems up to 8 GB, 2K for file systems up to 16 GB, 4K for file systems up to 32 GB, and 8K for file systems beyond this size.

An *extent* is defined as one or more adjacent blocks of data within the file system. An extent is presented as an *address-length* pair, which identifies the starting block address and the length of the extent (in file system or logical blocks). VxFS allocates storage in groups of extents rather than a block at a time (as seen in the HFS file system).

Extents allow disk I/O to take place in units of multiple blocks if storage is allocated in consecutive blocks. For sequential I/O, multiple block operations are considerably faster than block-at-a-time operations; almost all disk drives accept I/O operations of multiple blocks.

The Extent allocation only slightly alters the interpretation of addressed blocks from the inode structure compared to block based inodes. HFS file system inode structure contains the addresses of 12 direct blocks, one indirect block, and one double indirect block. An indirect block contains the addresses of other blocks. The HFS indirect block size is 8K and each address is 4 bytes long. HFS inodes therefore can address 12 blocks directly and up to 2048 more blocks through one indirect address.

A VxFS inode is similar to the HFS inode and references 10 direct extents, each of which are pairs of starting block addresses and lengths in blocks. The VxFS inode also points to two indirect address extents, which contain the addresses of other extents:

- The first indirect address extent is used for single indirection; each entry in the extent indicates the starting block number of an indirect data extent.
- The second indirect address extent is used for double indirection; each entry in the extent indicates the starting block number of a single indirect address extent.

Each indirect address extent is 8K long and contains 2048 entries. All indirect data extents for a file must be the same size; this size is set when the first indirect data extent is allocated and stored in the inode. Directory inodes always use an 8K indirect data extent size. Regular file

inodes also use an 8K default indirect data extent size but allocate the indirect data extents in clusters to simulate larger extents.

Typed Extents

NOTE The information in this section applies to the VxFS Version 3 and 4 disk layout.

In Version 3 and 4, VxFS introduced a new inode block map organization for indirect extents known as *typed extents*. Each entry in the block map has a typed descriptor record containing a type, offset, starting block, and number of blocks.

Indirect and data extents use this format to identify logical file offsets and physical disk locations of any given extent. The extent descriptor fields are defined as follows:

type	Uniquely identifies an extent descriptor record and defines the record's length and format.
offset	Represents the logical file offset in blocks for a given descriptor. Used to optimize lookups and eliminate hole descriptor entries.
starting block	The starting file system block of the extent.
number of blocks	The number of contiguous blocks in the extent.

- Indirect address blocks are fully typed and may have variable lengths up to a maximum and optimum size of 8K. On a fragmented file system, indirect extents may be smaller than 8K depending on space availability. VxFS always tries to obtain 8K indirect extents but resorts to smaller indirects if necessary.
- Indirect Data extents are variable in size to allow files to allocate large, contiguous extents and take full advantage of VxFS's optimized I/O.
- Holes in sparse files require no storage and are eliminated by typed records. A hole is determined by adding the offset and length of a descriptor and comparing the result with the offset of the next record.
- While there are no limits on the levels of indirection, lower levels are expected in this format since data extents have variable lengths.
- This format uses a type indicator that determines its record format and content and accommodates new requirements and functionality

for future types.

The current typed format is used on regular files only when indirection is needed. Typed records are longer than the previous format and require less direct entries in the inode. Newly created files start out using the old format which allows for ten direct extents in the inode. The inode's block map is converted to the typed format when indirection is needed to offer the advantages of both formats.

Extent Attributes

VxFS allocates disk space to files in groups of one or more extents. HP OnLineJFS also allows applications to control some aspects of the extent allocation. *Extent attributes* are the extent allocation policies associated with a file.

The `setext` and `getext` commands allow the administrator to set or view extent attributes associated with a file, as well as to preallocate space for a file. Refer to Chapter 3 , “Extent Attributes,” Chapter 6 , “Application Interface,” `setext`(1M), and `getext`(1M) for discussions on how to use extent attributes.

The `vxtunefs` command allows the administrator to set or view the default indirect data extent size. Refer to Chapter 5 , “Performance and Tuning” and `vxtunefs`(1M) for discussions on how to use the indirect data extent size feature.

NOTE `setext` functionality is available only with the optional HP OnLineJFS product.

Fast File System Recovery

The HFS file system relies on full structural verification by the `fsck` utility as the only means to recover from a system failure. For large disk configurations, this utility involves a time consuming process of checking the entire structure, verifying that the file system is intact, and correcting any inconsistencies.

VxFS provides recovery only seconds after a system failure by utilizing a tracking feature called *`intent logging`*. This feature records pending changes to the file system structure in a circular *`intent log.`* During system failure recovery, the VxFS `fsck` utility performs an intent log replay, which scans the intent log and nullifies or completes file system operations that were active when the system failed. The file system can then be mounted without completing a full structural check of the entire file system. The intent log recovery feature is not readily apparent to the user or the system administrator except during a system failure.

Replaying the intent log may not completely recover the damaged file system structure if the disk suffers a hardware failure; such situations may require a complete system check using the `fsck` utility provided with VxFS.

Online System Administration

With the HP OnLineJFS product, a VxFS file system can be defragmented and resized while it remains online and accessible to users. The following sections contain detailed information about these features.

NOTE The online administration features, defragmentation, resizing, and online backup, are available only with the optional HP OnLineJFS product.

Defragmentation

Free resources are initially aligned and allocated to files in the most efficient order possible to provide optimal performance. On an active file system, the original order of free resources is lost over time as files are created, removed, and resized. The file system is spread further and further along the disk, leaving unused gaps or *fragments* between areas that are in use. This process is also known as *fragmentation* and leads to degraded performance because the file system has fewer options when assigning a file to an extent (a group of contiguous data blocks).

The HFS file system uses the concept of *cylinder groups* to limit fragmentation. Cylinder groups are self-contained sections of a file system that indicate free inodes and data blocks. Allocation strategies in HFS attempt to place inodes and data blocks in close proximity. This reduces fragmentation but does not eliminate it.

HP OnLineJFS provides the online administration utility `fsadm` to resolve the problem of fragmentation. The `fsadm` utility defragments a mounted file system by:

- removing unused space from directories
- making all small files contiguous
- consolidating free blocks for file system use

This utility can run on demand and should be scheduled regularly as a `cron` job.

Resizing

A file system is assigned a specific size as soon as it is created; the file system may become too small or too large as changes in file system usage take place over time.

The HFS file system traditionally offers four solutions to address an inadequate small file system:

- Move some users to a different file system.
- Move a subdirectory of the file system to a new file system.
- Copy the entire file system to a larger file system.
- Unmount the file system (offline), extend the volume, extend the file system, then remount the file system.

Most large file systems with too much space try to reclaim the unused space by off-loading the contents of the file system and rebuilding it to a preferable size. The HFS file system requires unmounting the file system and blocking user access during the modification.

When the HP OnLineJFS product is installed, the VxFS utility `fsadm` can expand or shrink a file system without unmounting the file system or interrupting user productivity. However, to expand a file system, the underlying device on which it is mounted must be expandable. LVM facilitates expansion using virtual disks that can be increased in size while in use. The VxFS and LVM packages complement each other to provide online expansion capability.

NOTE You can only shrink a file system that uses the version 4 disk layout. However, even with the version 4 disk layout, it is sometimes not possible to shrink a file system. When shrinking a version 4 file system, JFS attempts to move extents off the area of the file system being reduced. However, if JFS cannot move extents off the area of the file system being reduced, the shrink will fail.

Online Backup

The HP OnLineJFS product provides a method of online backup of data using the *snapshot* feature. An image of a mounted file system instantly becomes an exact read-only copy of the file system at a certain point in time. The original file system is *snapped* while the copy is called the *snapshot*.

When changes are made to the snapped file system, the old data is first copied to the snapshot. When the snapshot is read, data that has not changed is read from the snapped file system. Changed data is read directly from the snapshot.

Backups require one of the following methods:

- copying selected files from the snapshot file system (using `find` and `cpio`)
- backing up the entire file system (using `fscat`)
- initiating a full or incremental backup (using `vxdump`)

For detailed information about performing online backups, see Chapter 4 , “Online Backup.”

Application Interface

The VxFS file system conforms to the System V Interface Definition (SVID) requirements and supports user access through the Network File System (NFS). Applications that require performance features not available with other file systems can take advantage of VxFS enhancements that are introduced in this section and covered in detail in Chapter 6 , “Application Interface.”

Application Transparency

In most cases, any application designed to run on the HFS file system should run transparently on the VxFS file system.

Expanded Application Facilities

The HP OnLineJFS product provides some facilities frequently associated with commercial applications that make it possible to:

- preallocate space for a file
- specify a fixed extent size for a file
- bypass the system buffer cache for file I/O
- specify the expected access pattern for a file

Since these facilities are provided using VxFS-specific ioctl system calls, most existing UNIX system applications do not use these facilities. The `cp`, `cpio`, and `mv` utilities use these facilities to preserve extent attributes and allocate space more efficiently. The current attributes of a file can be listed using the `getext` command or `ls` command. The facilities can also improve performance for custom applications. For portability reasons, these applications should check what file system type they are using before using these interfaces.

Extended mount Options

The VxFS file system supports extended `mount` options to specify:

- enhanced data integrity modes
- enhanced performance modes
- temporary file system modes
- improved synchronous writes

See Chapter 5 , “Performance and Tuning” and `mount_vxfs`(1M) for details on the VxFS `mount` options.

Enhanced Data Integrity Modes

NOTE Performance trade-offs are associated with these `mount` options.

The HFS file system is “buffered” in the sense that resources are allocated to files and data is written asynchronously to files. In general, the buffering schemes provide better performance without compromising data integrity.

If a system failure occurs during space allocation for a file, uninitialized data or data from another file may appear in the extended file after reboot. Data written shortly before the system failure may also be lost.

Using blkclear for Data Integrity

In environments where performance is more important than absolute data integrity, the preceding situation is not of great concern. However, VxFS supports environments that emphasize data integrity by providing the `mount -o blkclear` option that ensures uninitialized data does not appear in a file.

Using closesync for Data Integrity

VxFS provides the `mount -o mincache=closesync` option, which is useful in desktop environments with users who are likely to shut off the power on machines without halting them first. In `closesync` mode, only

files that are written during the system crash or shutdown can lose data. Any changes to a file are flushed to disk when the file is closed.

Enhanced Performance Mode

The HFS file system is asynchronous in the sense that structural changes to the file system are not immediately written to disk. File systems are designed this way to provide better performance. However, recent changes to the file system may be lost if a system failure occurs. More specifically, attribute changes to files and recently created files may disappear.

The default logging mode provided by VxFS (`mount -o log`) guarantees that all structural changes to the file system are logged to disk before the system call returns to the application. If a system failure occurs, `fsck` replays any recent changes to preserve all metadata. Recent file data may be lost unless a request was made to `sync` it to disk.

Using delaylog for Enhanced Performance

VxFS provides the `mount -o delaylog` option which increases performance by delaying the logging of some structural changes. However, recent changes may be lost during a system failure. This option provides at least the same level of data accuracy that traditional UNIX file systems provide for system failures, along with fast file system recovery.

Temporary File System Modes

On most UNIX systems, temporary file system directories (such as `/tmp` and `/usr/tmp`) often hold files that do not need to be retained when the system reboots. The underlying file system does not need to maintain a high degree of structural integrity for these temporary directories.

Using tmplog for Temporary File Systems

VxFS provides a `mount -o tmplog` option which allows the user to achieve higher performance on temporary file systems by delaying the logging of most operations.

Improved Synchronous Writes

HP OnLineJFS provides superior performance for synchronous write

applications.

The default `datainlog` option to `mount` greatly improves the performance of small synchronous writes.

The `convosync=dsync` option to `mount` improves the performance of applications that require synchronous data writes but not synchronous inode time updates.

NOTE The use of the `convosync=dsync` option violates POSIX semantics.

NOTE The `datainlog` and `convosync` options are available only with the optional HP OnLineJFS product.

Enhanced I/O Performance

VxFS provides enhanced I/O performance by applying an aggressive I/O clustering policy.

Enhanced I/O Clustering

I/O clustering is a technique of grouping multiple I/O operations together for improved performance. The VxFS I/O policies provide more aggressive clustering processes than other file systems and offer higher I/O throughput when using large files; the resulting performance is comparable to that provided by raw disk.

Application-Specific Parameters

System administrators can also set application specific parameters on a per-file system basis to improve I/O performance.

- Default Indirect Extent Size

  On disk layout Version 2, this value can be set up to apply to all the indirect extents, provided a fixed extent size is not already set and the file does not already have indirect extents. The Version 3 and 4 disk layout uses typed extents which have variable sized indirects.

- Discovered Direct I/O

  All sizes above this value would be performed as direct I/O.

NOTE The Discovered Direct I/O parameter is available only with the HP OnLineJFS product.

- Maximum Direct I/O Size

  This value defines the maximum size of a single direct I/O.

NOTE The Maximum Direct I/O Size parameter is available only with the HP OnLineJFS product.

For a discussion of performance benefits, refer to Chapter 5 , “Performance and Tuning”, Chapter 6 , “Application Interface”, `vxtunefs`(1M), and `tunefstab`(4).

Quotas

VxFS supports the Berkeley Software Distribution (BSD) style user quotas, which allocate per-user quotas and limit the use of two principal resources: files and data blocks. The system administrator can assign quotas for each of these resources. Each quota consists of two limits for each resource:

- The *hard limit* represents an absolute limit on data blocks or files. The user may never exceed the hard limit under any circumstances.
- The *soft limit* is lower than the hard limit and may be exceeded for a limited amount of time. This allows users to temporarily exceed limits as long as they fall under those limits before the allotted time expires.

The system administrator is responsible for assigning hard and soft limits to users. See “Quota Limits” for more information.

Access Control Lists

An Access Control List (ACL) stores a series of entries that identify specific users or groups and their access privileges for a directory or file. A file may have its own ACL or may share an ACL with other files. ACLs have the advantage of specifying detailed access permissions for multiple users and groups. Refer to getacl (1M) and `setacl`(1M) for information on viewing and setting ACLs.

NOTE Access control lists require a file system with the version 4 disk layout.

Support for Large Files

VxFS can, theoretically, support files up to two terabytes in size because file system structures are no longer in fixed locations (see Chapter 2 , “Disk Layout”). The maximum size tested and supported on HP-UX 11.x systems is one terabyte. Large files are files larger than two gigabytes in size.

NOTE Be careful when enabling large file capability. Applications and utilities such as backup may experience problems if they are not aware of large files.

Creating a File System with Large Files

You can create a file system with large file capability by entering the following command:

```
# mkfs -F vxfs -o largefiles special_device size
```

Specifying `largefiles` sets the `largefiles` flag, which allows the file system to hold files up to one terabyte in size. Conversely, the default `nolargefiles` option clears the flag and limits files being created to a size of two gigabytes or less:

```
# mkfs -F vxfs -o nolargefiles special_device size
```

NOTE The `largefiles` flag is persistent and stored on disk.

Mounting a File System with Large Files

If a mount succeeds and `nolargefiles` is specified, the file system cannot contain or create any large files. If a mount succeeds and `largefiles` is specified, the file system may contain and create large files.

The `mount` command fails if the specified `largefiles|nolargefiles` option does not match the on-disk flag.

The mount command defaults to match the current setting of the on-disk flag if specified without the largefiles or nolargefiles option, so it's best not to specify either option. After a file system is mounted, you can use the fsadm utility to change mount options.

Managing a File System with Large Files

You can determine the current status of the largefiles flag with any of the following commands:

```
# mount
# mkfs -F vxfs -m  special_device
# fsadm -F vxfs  mount_point
```

You can switch capabilities on a mounted file system with the fsadm command:

```
# fsadm -F vxfs -o largefiles|nolargefiles mount_point
```

You cannot switch a file system to nolargefiles if it holds large files.

See mount_vxfs(1M), fsadm_vxfs(1M), and mkfs_vxfs(1M).

2 Disk Layout

Introduction

Three disk layouts are available with the VxFS file system:

Version 2	The Version 2 disk layout was designed to support features such as filesets, dynamic inode allocation, and enhanced security.
Version 3	The Version 3 disk layout encompasses all file system structural information in files, rather than at fixed locations on disk, allowing for greater scalability. Version 3 supports files and file systems up to one terabyte in size.
Version 4	The Version 4 disk layout supports access control lists (ACLs).

NOTE The Version 1 disk layout is not supported on HP-UX.

The following topics are covered in this chapter:

- "Disk Space Allocation"
- "The VxFS Version 1 Disk Layout"
- "Overview"
- "Super-Block"
- "Intent Log"
- "Allocation Unit"
- "The VxFS Version 2 Disk Layout"
  - "Overview"
  - "Basic Layout"
  - "Filesets and Structural Files"
  - "Locating Dynamic Structures"
- "The VxFS Version 3 Disk Layout"
- "The VxFS Version 4 Disk Layout"

When HP-UX 11.1x is installed on a system, new VxFS file systems are created with the Version 4 layout by default. When JFS 3.3 is installed on an HP-UX 11.00 system, new file systems are created with the Version 3 layout by default. Although `mkfs` allows the user to specify

other disk layouts, it is generally preferable to use the Version 4 layout for new file systems.

The vxupgrade command can upgrade an existing Version 3 VxFS file system to the Version 4 layout while the file system remains online. vxupgrade can also upgrade a Version 2 file system to the Version 3 layout. See vxupgrade(1M) for details on upgrading VxFS file systems.You cannot downgrade a file system that has been upgraded.

NOTE

You cannot upgrade the root (/) or /usr file systems to Version 4 on an 11.00 system running JFS 3.3. Additionally, we do not advise upgrading the /var or /opt file systems to Version 4 on an 11.00 system. These core file systems are crucial for system recovery. The HP-UX 11.00 kernel and emergency recovery media were built with an older version of JFS that does not recognize the Version 4 disk layout. If these file systems were upgraded to Version 4, your system might have errors booting with the 11.00 kernel as delivered, or booting with the emergency recovery media.

Disk Space Allocation

Disk space is allocated by the system in 1024-byte sectors. An integral number of sectors are grouped together to form a logical block. VxFS supports logical block sizes of 1024, 2048, 4096, and 8192 bytes. The default block size is 1024 bytes for file systems less than 3 gigabytes; 2048 bytes for file systems less than 16 gigabytes; 4096 bytes for file systems less than 32 gigabytes; and 8192 bytes for file systems 32 gigabytes or larger. The block size may be specified as an argument to the `mkfs` utility and may vary between VxFS file systems mounted on the same system. VxFS allocates disk space to files in extents. An extent is a set of contiguous blocks.

The VxFS Version 1 Disk Layout

This section describes the VxFS Version 1 disk layout.

NOTE The Version 1 disk layout is not supported on HP-UX.

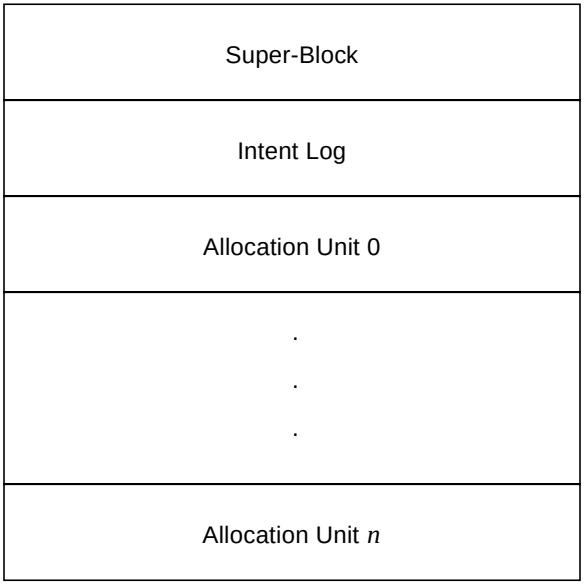
Overview

The VxFS Version 1 disk layout, as shown in Figure 2-1, “VxFS Version 1 Disk Layout” includes:

- the super-block
- the intent log
- one or more allocation units

These elements are discussed in detail in the sections that follow.

Figure 2-1 VxFS Version 1 Disk Layout



Super-Block

The super-block contains important information about the file system, such as:

- the file system type
- creation and modification dates
- label information
- information about the size and layout of the file system
- the count of available resources
- the file system disk layout version number

The super-block is always in a fixed location, offset from the start of the file system by 8192 bytes. This fixed location enables utilities to easily locate the super-block when necessary. The super-block is 1024 bytes long.

Copies of the super-block are kept in allocation unit headers: these copies can be used for recovery purposes if the super-block is corrupted or destroyed (see `fsck_vxfs`(1M) for more details).

Intent Log

In the event of system failure, the VxFS file system uses intent logging to guarantee file system integrity.

The *`intent log`* is a circular activity log with a default size of 1024 blocks. If the file system is smaller than 4 MB, the default log size is reduced (by `mkfs_vxfs(1M)`) to avoid wasting space. The intent log contains records of the intention of the system to update a file system structure. An update to the file system structure (a *`transaction`*) is divided into separate sub-functions for each data structure that needs to be updated. A composite log record of the transaction is created, containing the sub-functions constituting the transaction.

For example, the creation of a file that would expand the directory in which the file is contained would produce a transaction consisting of the following sub-functions:

- a free extent map update for the allocation of the new directory block
- a directory block update

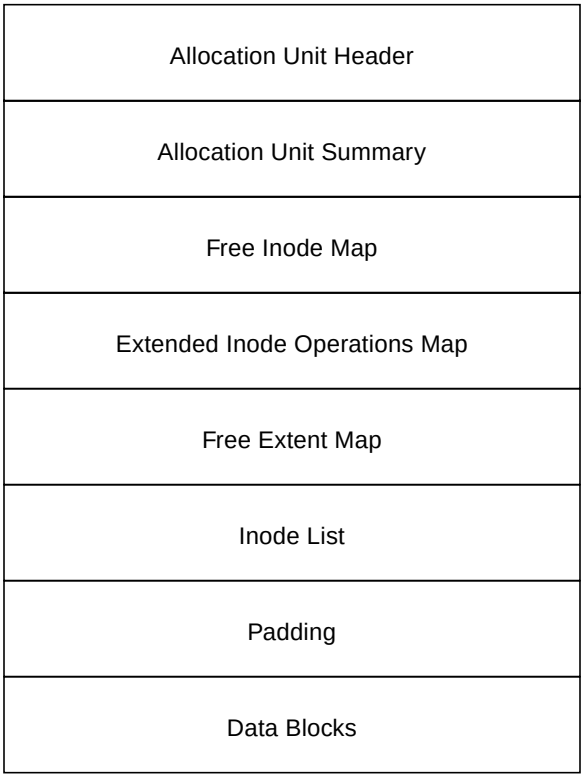
- an inode modification for the directory size change
- an inode modification for the new file
- a free inode map update for the allocation of the new file

VxFS maintains log records in the intent log for all pending changes to the file system structure and ensures that the log records are written to disk in *advance* of the changes to the file system. Once the intent log has been written, the transaction's other updates to the file system can be written in any order. In the event of a system failure, the pending changes to the file system are either nullified or completed by the `fsck` utility. The VxFS intent log generally only records changes to the file system structure. File data changes are not normally logged.

Allocation Unit

An allocation unit is a group of consecutive blocks in a file system that contain a resource summary, free resource maps, inodes, data blocks, and a copy of the super-block. An allocation unit in the VxFS file system is similar in concept to the HFS "cylinder group." Each component of an allocation unit begins on a block boundary. The VxFS Version 1 allocation unit is shown in Figure 2-2, "Allocation Unit Structure."

Figure 2-2 Allocation Unit Structure



One or more allocation units exist per file system. Allocation units are located immediately after the intent log. The number and size of allocation units can be specified when the file system is made. All of the allocation units, except possibly the last one, are of equal size. If space is limited, the last allocation unit can have a partial set of data blocks to allow use of all remaining blocks.

Allocation Unit Header

The allocation unit header contains a copy of the file system's super-block that is used to verify that the allocation unit matches the super-block of the file system. The super-block copies contained in allocation unit headers can also be used for recovery purposes if the super-block is corrupted or destroyed. The allocation unit header occupies the first block of each allocation unit.

Allocation Unit Summary

The allocation unit summary contains the number of inodes with extended operations pending, the number of free inodes, and the number of free extents in the allocation unit.

Free Inode Map The free inode map is a bitmap that indicates which inodes are free and which are allocated. A free inode is indicated by the bit being on. Inodes zero and one are reserved by the file system; inode two is the inode for the root directory; inode three is the inode for the `lost+found` directory.

Extended Inode Operations Map The extended inode operations map keeps track of inodes on which operations would remain pending for too long to reside in the intent log. The extended inode operations map is in the same format as the free inode map. To prevent the intent log from wrapping and the transaction from getting overwritten, the required operations are stored in the affected inode (if the transaction has not completed, it does not get overwritten, the new log waits and the file system is frozen). This map is then updated to identify the inodes that have extended operations that need to be completed.

Free Extent Map The free extent map is a series of independent 512-byte bitmaps that are each referred to as a free extent map section. Each section is broken down into multiple regions. The first region, of 2048 bits, represents a section of 2048 one-block extents. The second region, of 1024 bits, represents a section of 1024 two-block extents. This regioning continues for all powers of 2 up to the single bit that represents one 2048 block extent.

The file system uses this bitmapping scheme to find an available extent closest in size to the space required. This keeps files as contiguous as possible for faster performance.

Inode List An inode is a data structure that contains information about a file. The VxFS inode size is 256 bytes. Each inode stores information about a particular file such as:

- file length
- link count
- owner and group IDs
- access privileges

- time of last access
- time of last modification
- pointers to the extents that contain the file's data

There are up to ten direct extent address size pairs per inode. Each direct extent address indicates the starting block number of a direct extent; direct extent sizes can vary. If all of the direct extents are used, two indirect address extents are available for use in each inode:

- The first indirect address extent is used for single indirection, where each entry in the extent indicates the starting block number of an indirect data extent.
- The second indirect address extent is used for double indirection, where each entry in the extent indicates the starting block number of a single indirect address extent.

Each indirect address extent is 8K long and contains 2048 entries. All indirect data extents for a given file have the same size, which is determined when the file's first indirect data extent is allocated.

The inode list is a series of inodes. There is one inode in the list for every file in the file system.

Padding It may be desirable to align data blocks to a physical boundary. To facilitate this, the system administrator may specify that a gap be left between the end of the inode list and the first data block.

Data Blocks The balance of the allocation unit is occupied by data blocks. Data blocks contain the actual data stored in files and directories.

The VxFS Version 2 Disk Layout

This section describes the VxFS Version 2 disk layout.

Due to the relatively complex nature of the Version 2 layout, the sections that follow are arranged to cover the following general areas:

- Structural elements of the file system that exist in fixed locations. These elements are discussed in “Basic Layout”.
- Structural elements of the file system that do not exist in fixed locations. These elements are discussed in “Filesets and Structural Files”.
- The location and use of the various structural elements when the file system is mounted. This is discussed in “Locating Dynamic Structures”.

Overview

Many aspects of the Version 1 disk layout are preserved in the Version 2 disk layout. However, the Version 2 layout differs from the Version 1 layout in that it includes support for the following features:

- filesets (sets of files within a file system)
- dynamic inode allocation (allocation of inodes on an as-needed basis)
- enhanced security

The addition of filesets and dynamic allocation of inodes has affected the disk layout in various ways. In particular, many of the file system structures are now located in files (referred to as *structural files*) rather than in fixed disk areas. This provides a simple mechanism for dynamic growth of structures. For example, inodes are now stored in structural files and allocated as needed. In general, file system structures that deal with space allocation are still in fixed disk locations, while most other structures are dynamically allocated and have become clients of the file system’s disk space allocation scheme.

The Version 2 disk layout adds BSD-style quota support. The differences include the fileset header structure modification to store a quota inode and preallocation of an internal quotas file.

Basic Layout

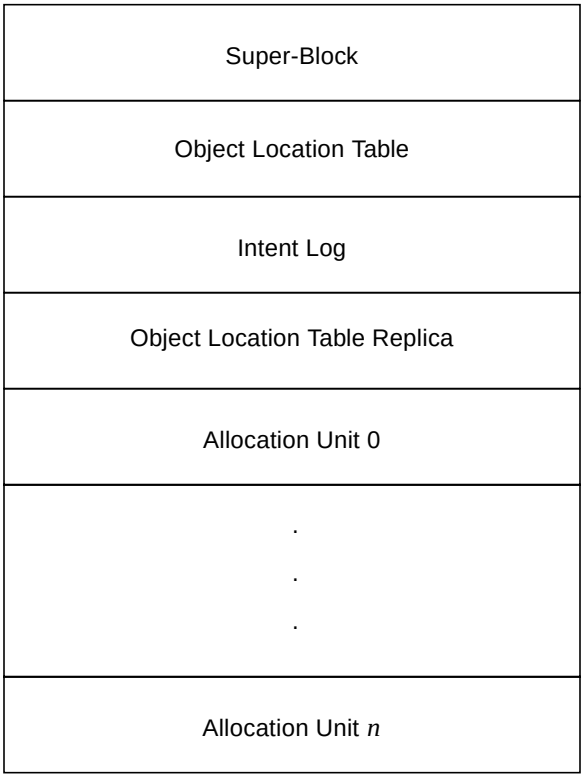
This section describes the structural elements of the file system that exist in fixed locations on the disk.

The VxFS Version 2 disk layout is illustrated in Figure 2-3, “VxFS Version 2 Disk Layout” and is composed of:

- the super-block
- the object location table
- the intent log
- a replica of the object location table
- one or more allocation units

These and other elements are discussed in detail in the sections that follow.

Figure 2-3 VxFS Version 2 Disk Layout



Super-Block

The super-block contains important information about the file system, such as

- the file system type
- creation and modification dates
- label information
- information about the size and layout of the file system
- the count of available resources
- the file system disk layout version number
- pointers to the object location table and its replica

The super-block is always in a fixed location, offset from the start of the file system by 8192 bytes. This fixed location enables utilities to easily locate the super-block when necessary. The super-block is 1024 bytes long.

Copies of the super-block are kept in allocation unit headers: these copies can be used for recovery purposes if the super-block is corrupted or destroyed (see `fsck_vxfs`(1M)).

Object Location Table

The object location table (OLT) can be considered an extension of the super-block. The OLT contains information used at mount time to locate file system structures that are not in fixed locations. The OLT is typically located immediately after the super-block and is 8K long. However, if a Version 1 file system is upgraded to Version 2, the placement of the OLT depends on the availability of space.

The OLT is replicated and its replica is located immediately after the intent log. The OLT and its replica are separated in order to minimize the potential for losing both copies of the vital OLT information in the event of localized disk damage.

The contents and use of the OLT are described in “Locating Dynamic Structures”.

Intent Log

The VxFS file system uses intent logging to guarantee file system integrity in the event of system failure

The *`intent log`* is a circular activity log with a default size of 512 blocks. If the file system is less than 4 MB, the log size will be reduced to avoid wasting space. The intent log contains records of the intention of the system to update a file system structure. An update to the file system structure (a *`transaction`*) is divided into separate sub-functions for each data structure that needs to be updated. A composite log record of the transaction is created that contains the subventions that constitute the transaction.

For example, the creation of a file that would expand the directory in which the file is contained will produce a transaction consisting of the following subventions:

- a free extent map update for the allocation of the new directory block

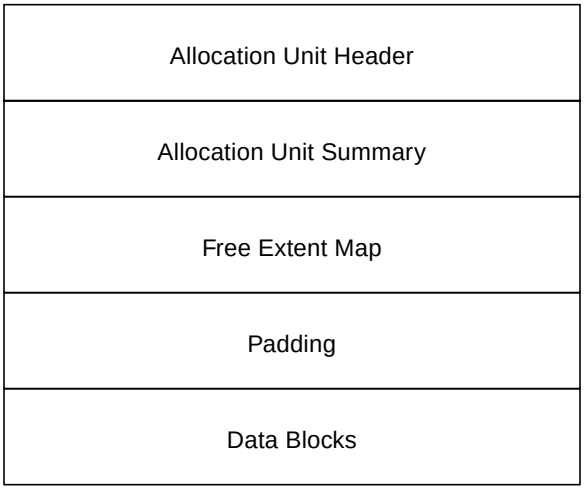
- a directory block update
- an inode modification for the directory size change
- an inode modification for the new file
- a free inode map update for the allocation of the new file

VxFS maintains log records in the intent log for all pending changes to the file system structure, and ensures that the log records are written to disk in *advance* of the changes to the file system. Once the intent log has been written, the transaction's other updates to the file system can be written in any order. In the event of a system failure, the pending changes to the file system are either nullified or completed by the `fsck` utility. The VxFS intent log generally only records changes to the file system structure. File data changes are not normally logged.

Allocation Unit

An allocation unit is a group of consecutive blocks in a file system that contain a resource summary, a free resource map, data blocks, and a copy of the super-block. An allocation unit in the VxFS file system is similar in concept to the HFS "cylinder group." Each component of an allocation unit begins on a block boundary. All of the Version 2 allocation unit components deal with the allocation of disk space. Those components of the Version 1 allocation unit that deal with inode allocation have been relocated elsewhere for Version 2. In particular, the inode list now resides in an inode list file and the inode allocation information now resides in an inode allocation unit (described later). The VxFS Version 2 allocation unit is depicted in Figure 2-4, "Allocation Unit Structure."

Figure 2-4 Allocation Unit Structure



One or more allocation units exist per file system. Allocation units are located after the OLT replica. The number and size of allocation units can be specified when the file system is made. All of the allocation units, except possibly the last one, are of equal size. If space is limited, the last allocation unit can have a partial set of data blocks to allow use of all remaining blocks.

Allocation Unit Header The allocation unit header contains a copy of the file system's super-block that is used to verify that the allocation unit matches the super-block of the file system. The super-block copies contained in allocation unit headers can also be used for recovery purposes if the super-block is corrupted or destroyed. The allocation unit header occupies the first block of each allocation unit.

Allocation Unit Summary The allocation unit summary summarizes the resources (data blocks) used in the allocation unit. This includes information such as the number of free extents of each size in the allocation unit.

Free Extent Map The free extent map is a series of independent 512-byte bitmaps that are each referred to as a free extent map section. Each section is broken down into multiple regions. The first region of 2048 bits represents a section of 2048 one-block extents. The second region of 1024 bits represent a section of 1024 two-block extents. This regioning continues for all powers of 2 up to the single bit that represents

one 2048 block extent.

The file system uses this bitmapping scheme to find an available extent closest in size to the space required. This keeps files as contiguous as possible for faster performance.

Padding It may be desirable to align data blocks to a physical boundary. To facilitate this, the system administrator may specify that a gap be left between the end of the free extent map and the first data block. See Chapter 6 , “Application Interface,” for additional information on alignment.

Data Blocks The balance of the allocation unit is occupied by data blocks. Data blocks contain the actual data stored in files and directories.

Filesets and Structural Files

This section describes the structural elements of the file system that are not necessarily in fixed locations on the disk.

With the Version 2 layout, many structural elements of the file system are encapsulated in files to allow dynamic allocation of the file system structure. Files that store this file system structural data are referred to as *structural files*. As the file system grows, more space is allocated to the structural files. Structural files are intended for file system use only and are not generally visible to users.

The Version 2 layout supports *filesets*, which are collections of files that exist within a file system. In the current release, each file system contains two filesets:

attribute fileset	A special fileset that stores the structural elements of the file system in the form of structural files. These files are a property of the file system and are not normally visible to the user.
primary fileset	A fileset that contains files that are visible to and accessible by users.

Structural files exist in the attribute fileset only and include thefollowing:

fileset header file	A file that contains a series of fileset headers.
inode list file	A file that contains a series of inodes.

inode allocation unit (IAU) file	A file that contains a series of inode allocation units.
current usage table (CUT) file	A file that contains a series of fileset usage entries.
link count table file	A file that contains a link count for each inode in the attribute fileset.
quotas file	A file containing user quota information (for the primary fileset only).

Structural files and their components are discussed in the sections that follow.

Although structural files are contained in the structural fileset, they can "belong" to another fileset. For example, the inode list file for the primary fileset is in the structural fileset, but the structural details that it contains are only applicable to the primary fileset.

Each fileset is defined by structural files as follows:

- an inode list file, which contains the inodes belonging to the fileset
- an inode allocation unit file, which contains a series of inode allocation units
- an entry in the fileset header file, which contains one fileset header per fileset
- an entry in the current usage table file, which contains usage information for each fileset

In addition, the primary fileset has a user quotas file and the structural fileset has a link count table file.

Fileset metadata that cannot be reconstructed using the inode list is replicated to help `fsck` reconstruct the file system in the event of disk damage.

Figure 2-5, "Filesets and Structural Files" shows a fileset and the structural files by which it is defined.

Fileset Header

Each fileset has a header containing information about the fileset's contents and characteristic. All fileset headers are stored in a single fileset header file in the attribute fileset. The fileset header file contains

one fileset header per fileset (see Figure 2-6, “Fileset Header File”). Each fileset header entry is one block long. The fileset header file is replicated because fileset headers cannot be rebuilt from other data structures.

Figure 2-5 Filesets and Structural Files

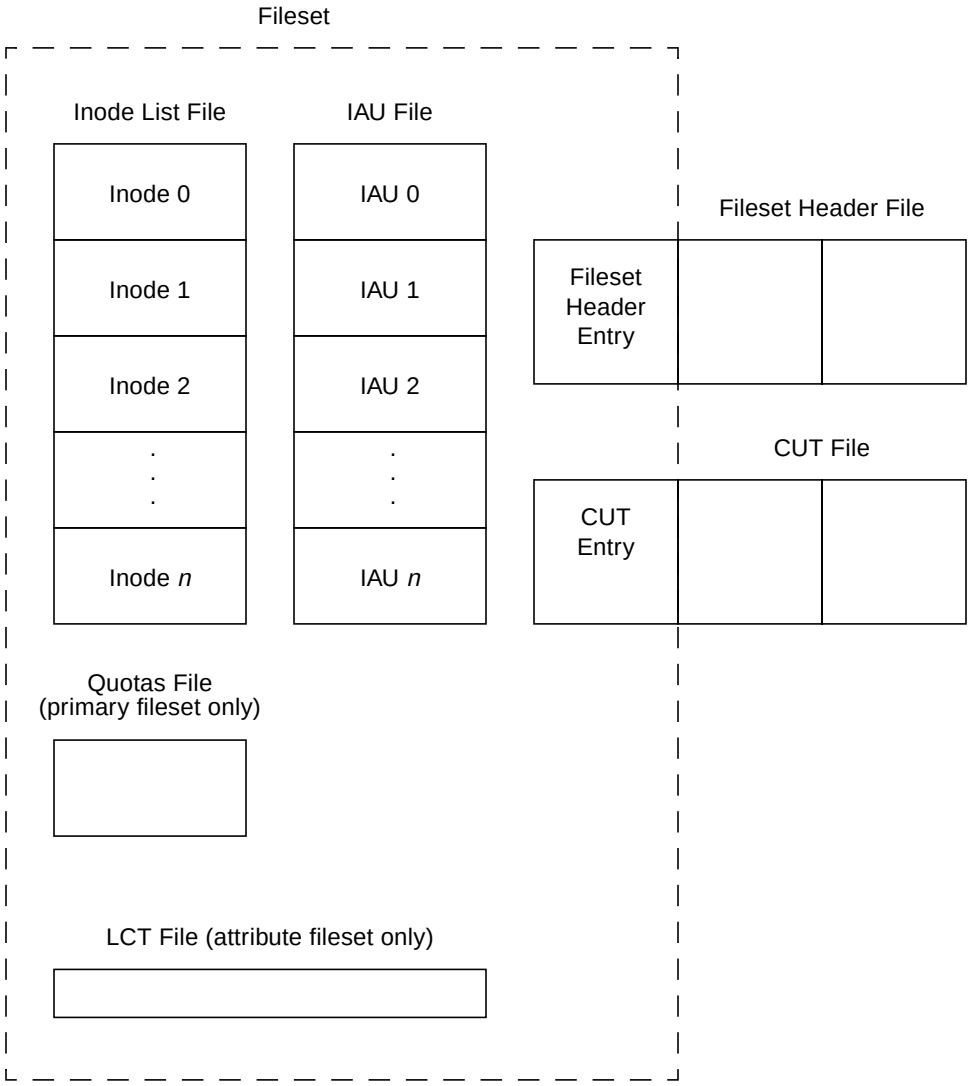
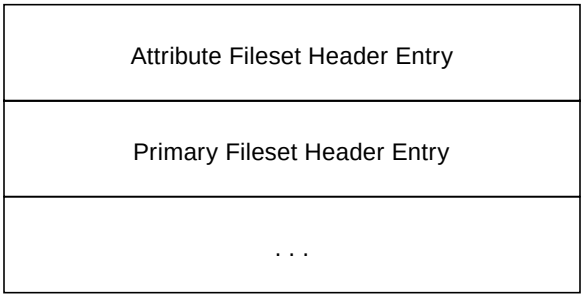


Figure 2-6 Fileset Header File



The fileset header for a given fileset includes information such as:

- the fileset index (1 for the attribute fileset and 999 for the primary fileset)
- the fileset name
- the inode numbers of the fileset's inode list file and its replica
- the total number of allocated inodes
- the maximum number of inodes allowed in the fileset
- the inode list extent size (in blocks)
- the inode number of the file containing the inode allocation units for the fileset
- the inode number of the fileset's link count table (attribute fileset only)
- the inode number of the fileset's quotas file (primary fileset only)

Inodes

An inode is a data structure that contains information about a file. The VxFS inode size is 256 bytes. Each inode stores information about a particular file such as:

- file length
- link count
- owner and group IDs
- access privileges

- time of last access
- time of last modification
- pointers to the extents that contain the file's data

There are up to ten direct extent address size pairs per inode. Each direct extent address indicates the starting block number of a direct extent; direct extent sizes can vary. If all of the direct extents are used, two indirect address extents are available for use in each inode. The first indirect address extent is used for single indirection, where each entry in the extent indicates the starting block number of an indirect data extent. The second indirect address extent is used for double indirection, where each entry in the extent indicates the starting block number of a single indirect address extent. Each indirect address extent is 8K long and contains 2048 entries. All indirect data extents for a given file have the same size, which is determined when the file's first indirect data extent is allocated.

Version 2 inodes differ from Version 1 inodes in that they are located in structural files to facilitate *dynamic inode allocation*, which is the allocation of inodes on an as-needed basis. Instead of allocating a fixed number of inodes into the file system, `mkfs` allocates a minimum number of inodes. Additional inodes are later allocated as the file system needs them.

The *inode list* is a series of inodes located in the inode list file. There is one inode in the list for every file in a given fileset. For recovery purposes, the inode list file is referenced by two inodes that point to the *same* set of data blocks. Although the inode addresses are replicated for recovery purposes, the inodes themselves are not.

An *inode extent* is an extent that contains inodes and is 8K long, by default. Inode extents are dynamically allocated to store inodes as they are needed.

Initial Inode List Extents The initial inode list extents contain the inodes first allocated by `mkfs_vxfs(1M)` for each fileset in a file system. During file system use, inodes are allocated as needed and are added into the inode list files for the filesets.

Figure 2-7, "Inode Lists" shows the initial inode list extents allocated for the primary and attribute filesets. Each of these extents contain 32 inodes and is 8K long.

The construction of the primary fileset's inode list resembles that of the

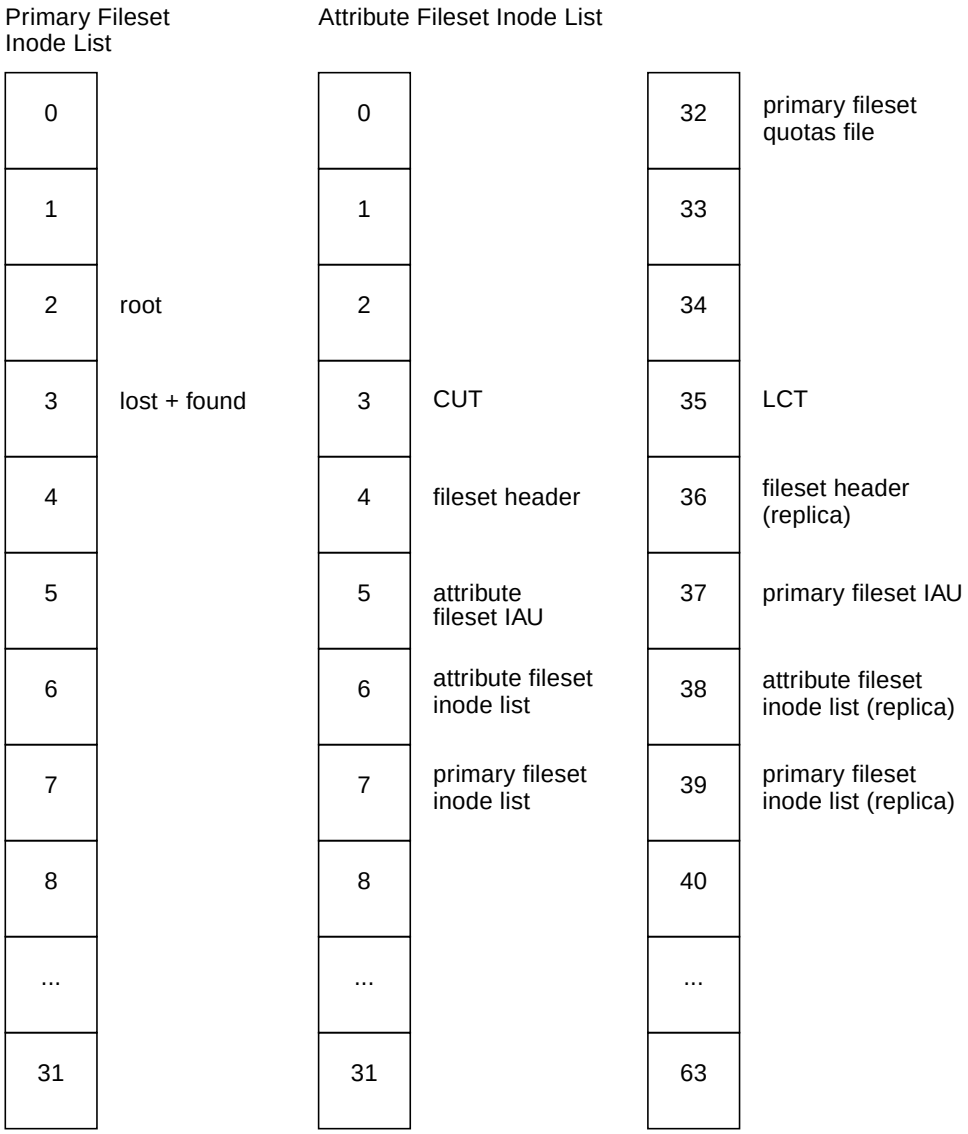
VxFS Version 1 file system layout, with the first two inodes reserved and inodes 2 and 3 pre-assigned to the `root` and `lost+found` directories. The structural fileset's inode list is similarly constructed, with certain inodes allocated for specific files and other inodes reserved or unallocated.

There are two initial inode list extents for the attribute fileset. These contain the inodes for all structural files needed to find and set up the file system.

Some of the entries in the structural fileset's inode list are replicas of one another. For example, inodes 4 and 36 both reference copies of the fileset header file. The replicated inodes are used by `fsck_vxfs(1M)`to reconstruct the file system in the event of damage to either one of the replicas. Although the two initial inode list extents belonging to the attribute fileset are logically contiguous, they are physically separated. This helps to ensure the integrity of the replicated information and reduces the chance that localized disk damage might result in complete loss of the file system.

Note that inodes 6 and 38 in the attribute fileset reference the inode list file for the attribute fileset. In a newly created file system, this file contains the two inode extents pictured for the attribute fileset. Likewise, the attribute fileset inodes 7 and 39 reference the inode list file for the primary fileset. In a newly created file system, this file contains the single extent pictured for the primary fileset. All of the unused inodes in the initial extents of the structural inode list are reserved for future use.

Figure 2-7 Inode Lists



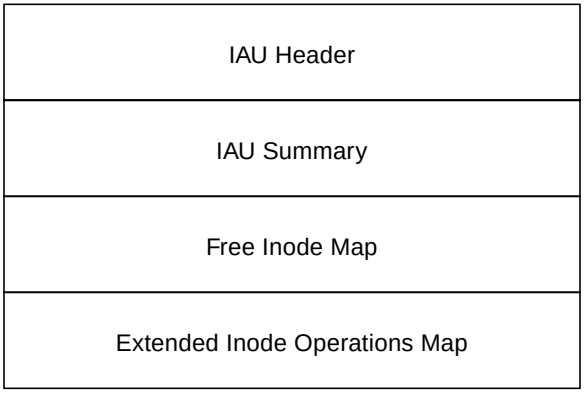
Inode Allocation Unit

An Inode Allocation Unit (IAU) contains inode allocation information for a given fileset. Each fileset contains one or more IAUs, each of which details allocation for a set number of inodes. The number of inodes per IAU varies, depending on the block size being used. One IAU exists for every 16,384 inodes in a fileset with the default block size (1024 bytes). If an IAU is damaged, the information that it contains can be reconstructed by examining the fileset's inode list.

The IAUs for a fileset are stored in sequential order in the fileset's IAU file. The fileset header identifies the attribute fileset inode associated with that fileset's IAU file.

Figure 2-8, "Inode Allocation Unit (IAU) Structure" shows the inode allocation unit structure. All IAU components begin on a block boundary.

Figure 2-8 Inode Allocation Unit (IAU) Structure



IAU Header The IAU header verifies that the inode allocation unit matches the fileset. The IAU header occupies the first block of each inode allocation unit. If damaged, the IAU can be reconstructed from inodes and other information.

IAU Summary The IAU summary summarizes the resources used in the IAU. It includes information on the number of free inodes in the IAU and the number of inodes with extended operation sets in the IAU. The IAU summary is 1 block long.

Free Inode Map The free inode map is a bitmap that indicates which inodes are free and which are allocated. A free inode is indicated by the

bit being on. The length of the free inode map is 2K for file systems with 1K or 2K block sizes and is equal to the block size for file systems with larger block sizes.

Extended Inode Operations Map The extended inode operations map keeps track of inodes on which operations would remain pending for too long to reside in the intent log. The extended inode operations map is in the same format as the free inode map. To prevent the intent log from wrapping and the transaction from getting overwritten, the required operations are stored in the affected inode. This map is then updated to identify the inodes that have extended operations that need to be completed. This map allows the `fsck` utility to quickly identify which inodes had extended operations pending at the time of a system failure. The length of the extended inode operations map is 2K for file systems with 1K or 2K block sizes and is equal to the block size for file systems with larger block sizes.

Link Count Table

The link count table (LCT) contains a reference count for each inode in the associated fileset. This reference count is identical to the conventional link field of an inode. Each LCT entry contains the actual reference count for the associated fileset inode. The link count field in an inode itself is set to either 0 or 1, and the actual number of links is stored in the LCT entry for the associated fileset inode.

The link count table can be reconstructed using the inode list, so it is not replicated.

The current layout only uses the LCT for inodes in the attribute fileset. The LCT supports quick updates of the link count for structural fileset inodes.

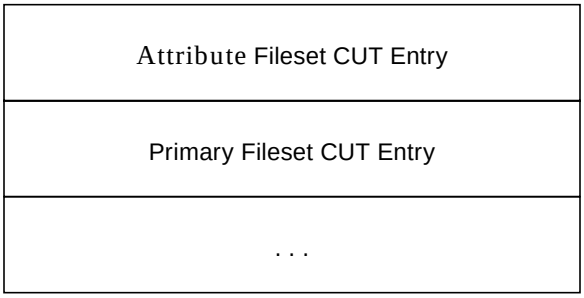
Current Usage Table

The current usage table (CUT) is a file that contains usage related information for each fileset. The information contained in the CUT changes frequently and is not replicated. The information in the CUT can, however, be reconstructed using the inode list if the CUT is damaged.

The CUT file contains one entry per fileset (see Figure 2-9, “Current Usage Table (CUT) File”). The CUT entry for a given fileset contains information such as the following:

- The number of blocks currently used by the fileset.
- The *fileset version number*, which is a 64-bit integer that is guaranteed to be at least as large as the largest inode version number. An *inode version number* is a 64-bit integer that is incremented every time its inode is modified or written to disk and can be used to indicate whether an inode has been modified in any way since the last time it was examined. It is possible to find out which inodes have been modified since a specific time by saving the fileset version number and then later looking for inodes with a larger version number.

Figure 2-9 Current Usage Table (CUT) File



Quotas File

VxFS supports BSD-style quotas for users. Quota information is stored in a quotas file. A user quotas file tracks the resources used by each user ID. The quotas file keeps track of soft limits, hard limits, block usage, and inode usage for users within a file system.

Because quotas apply to mountable filesets only, the attribute fileset does not have quotas. However, the primary fileset's quotas file exists as a structural file in the attribute fileset. The primary fileset's user quotas file is referenced by the structural fileset's initial inode list extent.

Locating Dynamic Structures

The existence of dynamic structures in the Version 2 disk layout makes the task of initially locating those structures difficult. The object location table (OLT) contains information needed to initially locate important file system structural elements. In particular, the OLT records the starting

block numbers of the initial inode list extents for the attribute fileset and indicates which inodes within those initial extents reference the fileset header file.

Object Location Table Contents

The OLT is composed of records for the following:

fileset header inodes	This record identifies the inode numbers of the fileset header file and its replica.
initial inode list extent addresses	This record identifies the addresses of the beginning of each of two 8K inode extents. These are the initial inode list extents for the attribute fileset, which contain the inodes for all structural files belonging to the attribute fileset.
current usage table inode	This record identifies the inode number of the file that contains the current usage table.

Mounting and the Object Location Table

At mount time, the object location table provides essential information about the location of key file system components. The super-block plays an important role in locating the OLT, in that it contains pointers to both the OLT and its replica.

Using the OLT, the process of mounting a VxFS Version 2 file system is:

Step 1. Read in the super-block. Validate the super-block and its replicas (located in the allocation unit headers).

Step 2. Read and validate the OLT and its replica at the locations recorded in the super-block.

Step 3. Obtain the addresses of the initial inode list extents for the attribute fileset from the OLT. Read in these initial inode extents.

Step 4. Find the fileset header file, based on the fileset header file inode number recorded in the OLT.

Step 5. Read the contents of the fileset header file. Each fileset header file entry represents a particular fileset and indicates the inode numbers of its inode list file and IAU file. The attribute fileset is set up first so that subsequent references to its inode list can be resolved.

The VxFS Version 3 Disk Layout

The Version 3 disk layout allows the file system to scale easily to accommodate large files and large file systems.

The Version 1 and 2 disk layouts divided up the file system space into allocation units. The first AU started part way into the file system which caused potential alignment problems depending on where the first AU started. Each allocation unit also had its own summary, bitmaps, and data blocks. Because this AU structural information was stored at the start of each AU, this also limited the maximum size of an extent that could be allocated. By replacing the allocation unit model of previous versions, the need for alignment of allocation units and the restriction on extent sizes was removed.

The VxFS Version 3 disk layout divides the entire file system space into fixed size allocation units. The first allocation unit starts at block zero and all allocation units are a fixed length of 32K blocks. (An exception may be the last AU, which occupies whatever space remains at the end of the file system). Because the first AU starts at block zero instead of part way through the file system as in previous versions, there is no longer a need for explicit AU alignment or padding to be added when creating a file system (see `mkfs_vxfs`(1M)).

The Version 3 file system also moves away from the model of storing AU structural data at the start of an AU and puts all structural information in files. So expanding the file system structures simply requires extending the appropriate structural files. This removes the extent size restriction imposed by the Version 1 and Version 2 layouts.

All Version 3 structural files reside in the *`structural fileset`*, which is similar to the Version 2 attribute fileset. The structural files in the Version 3 disk layout are:

object location table file	Contains the object location table (OLT). As with the Version 2 disk layout, the OLT, which is referenced from the super-block, is used to locate the other structural files.
label file	Encapsulates the super-block and super-block replicas. Although the location of the primary super-block is

	known, the label file can be used to locate super-block copies if there is structural damage to the file system.
device file	Records device information such as volume length and volume label, and contains pointers to other structural files.
fileset header file	Holds information on a per-fileset basis. This may include the inode of the fileset's inode list file, the maximum number of inodes allowed, an indication of whether the file system supports large files, and the inode number of the quotas file if the fileset supports quotas. When a file system is created, there are two filesets—the *structural fileset* defines the file system structure, the *primary fileset* contains user data.
inode list file	Both the primary fileset and the structural fileset have their own set of inodes stored in an inode list file. Only the inodes in the primary fileset are visible to users. When the number of inodes is increased, the kernel increases the size of the inode list file.
inode allocation unit file	Holds the free inode map, extended operations map, and a summary of inode resources.
log file	Maps the block used by the file system intent log.
extent allocation unit state file	Indicates the allocation state of each AU by defining whether each AU is free, allocated as a whole (no bitmaps allocated), or expanded, in which case the bitmaps associated with each AU determine which extents are

	allocated.
extent allocation unit summary file	Contains the AU summary for each allocation unit, which contains the number of free extents of each size. The summary for an extent is created only when an allocation unit is expanded for use.
free extent map file	Contains the free extent maps for each of the allocation units.
quotas file	If the file system supports quotas, there is a quotas file which is used to track the resources allocated to each user.

Figure 2-10, “VxFS Version 3 Disk Layout” shows how the kernel and utilities build information about the structure of the file system. The super-block location is in a known location from which the OLT can be located. From the OLT, the initial extents of the structural inode list can be located along with the inode number of the fileset header file. The initial inode list extents contain the inode for the fileset header file from which the extents associated with the fileset header file are obtained.

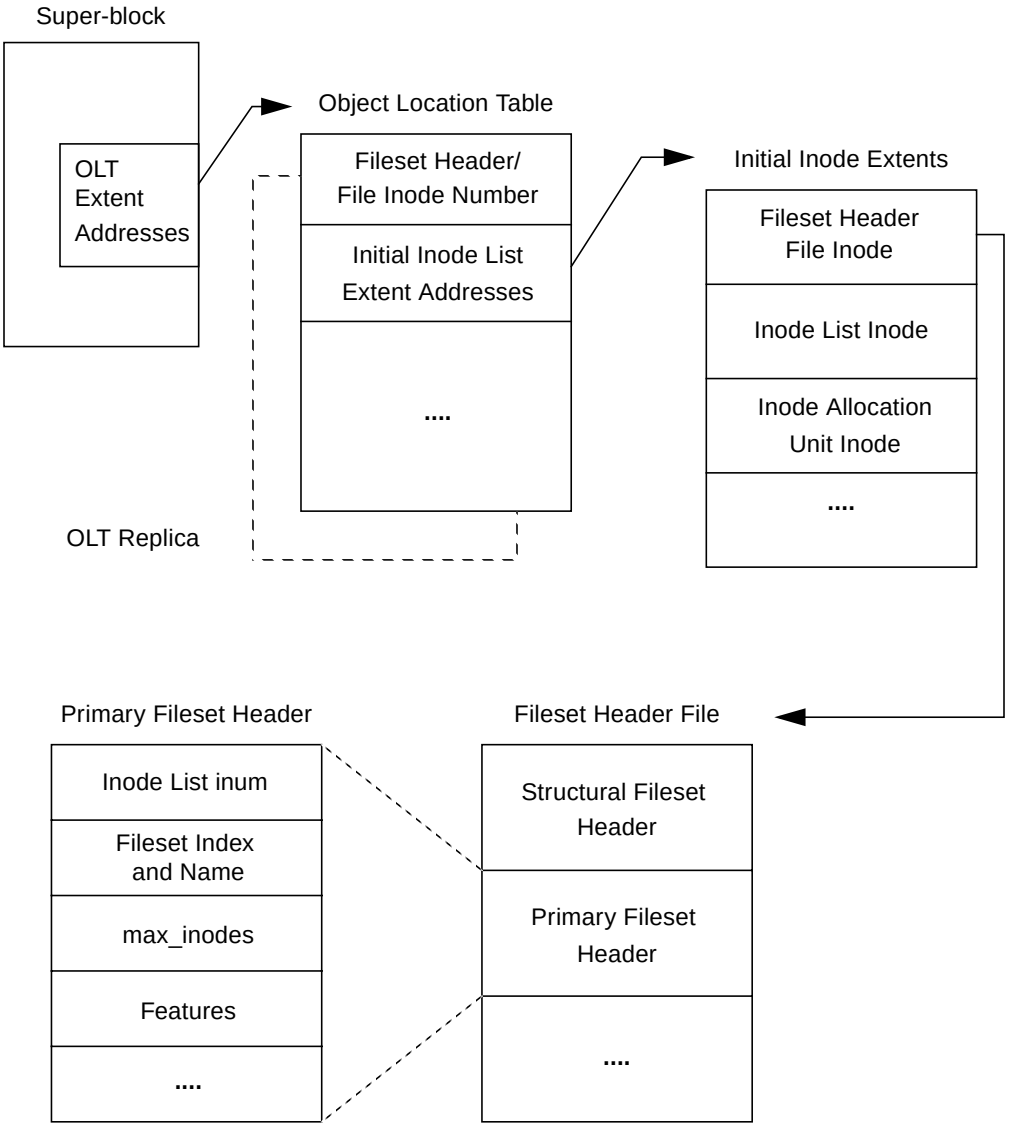
As an example, when mounting the file system, the kernel needs to access the primary fileset in order to access its inode list, inode allocation unit, quotas file and so on. The required information is obtained by accessing the fileset header file from which the kernel can locate the appropriate entry in the file and access the required information.

The VxFS Version 4 Disk Layout

The Version 4 disk layout supports Access Control Lists.

The Version 4 disk layout does not include significant physical changes from the Version 3 disk layout. Instead, the policies implemented for Version 4 are different, allowing for performance improvements, file system shrinking, and other enhancements.

Figure 2-10 VxFS Version 3 Disk Layout



3 Extent Attributes

Introduction

The VxFS file system allocates disk space to files in groups of one or more adjacent blocks called *extents*. VxFS defines an application interface that allows programs to control various aspects of the extent allocation for a given file (see Chapter 6 , “Application Interface”). The extent allocation policies associated with a file are referred to as *extent attributes*.

The VxFS `getext` and `setext` commands allows users to view or manipulate file extent attributes. In addition, the `vxdump`, `vxrestore`, `mv`, `cp`, and `cpio` commands preserve extent attributes when a file is backed up, moved, copied, or archived.

NOTE `setext` functionality is available only with the optional HP OnLineJFS product.

The following topics are covered in this chapter:

- “Attribute Specifics”
  - — “Reservation: Preallocating Space to a File”
  - — “Fixed Extent Size”
  - — “Other Controls”
- “Commands Related to Extent Attributes”
  - — “Failure to Preserve Extent Attributes”

Attribute Specifics

The two basic extent attributes associated with a file are its *reservation* and its *fixed extent size*. The user can preallocate space to the file by manipulating a file's reservation; the user can also override the default allocation policy of the file system by setting a fixed extent size.

Other policies determine the way these attributes are expressed during the allocation process. The user can specify that:

- the space reserved for a file must be contiguous
- no allocations should be made for a file beyond the current reservation
- unused reservation should be released when the file is closed
- space should be allocated but no reservation should be assigned
- the file size should be changed to immediately incorporate the allocated space

Some of the extent attributes are persistent and become part of the on-disk information about the file, while other attributes are temporary and lost after the file is closed or the system is rebooted. The persistent attributes are similar to the file's permissions and are actually written in the inode for the file. When a file is copied, moved, or archived, only the persistent attributes of the source file can be preserved in the new file (see "Other Controls" for more information).

In general, the user will only set extent attributes for reservation. Many of the attributes are designed for applications that are tuned to a particular pattern of I/O or disk alignment (see `mkfs_vxfs`(1M) and Chapter 6 , "Application Interface" for more information).

Reservation: Preallocating Space to a File

VxFS makes it possible to preallocate space to a file at the time of the request rather than when data is written into the file. This space cannot be allocated to other files in the file system. VxFS prevents any unexpected out-of-space condition on the file system by ensuring that a file's required space will be associated with the file before it is required.

Persistent reservation is not released when a file is truncated. The reservation must be cleared or the file must be removed to free reserved space.

Fixed Extent Size

The VxFS default allocation policy uses a variety of heuristics to determine how to make an allocation to a file when a write requires additional space. The policy attempts to balance the two goals of optimum I/O performance through large allocations and minimal file system fragmentation through allocation from space available in the file system that best fits the data.

Setting a fixed extent size overrides the default allocation policies for a file and always serves as a persistent attribute. Be careful to choose an extent size appropriate to the application when using fixed extents. An advantage of VxFS's extent based allocation policies is that they rarely use indirect blocks compared to block based file systems; VxFS eliminates many instances of disk access that stem from indirect references. However, a small extent size can eliminate this advantage.

Files with aggressive allocation sizes tend to be more contiguous and have better I/O characteristics. However, the overall performance of the file system degrades because the unused space fragments free space by breaking large extents into smaller pieces. By erring on the side of minimizing fragmentation for the file system, files may become so non-contiguous that their I/O characteristics would degrade.

Fixed extent sizes are particularly appropriate in the following situations:

- If a file is large and sparse and its write size is fixed, a fixed extent size that is a multiple of the write size can minimize space wasted by blocks that do not contain user data as a result of misalignment of write and extent sizes. (The default extent size for a sparse file is 8K.)
- If a file is large and contiguous, a large fixed extent size can minimize the number of extents in the file.

Custom applications may also use fixed extent sizes for specific reasons, such as the need to align extents to cylinder or striping boundaries on disk.

Other Controls

The auxiliary controls on extent attributes determine:

- whether allocations are aligned
- whether allocations are contiguous
- whether the file can be written beyond its reservation
- whether an unused reservation is released when the file is closed
- whether the reservation is a persistent attribute of the file
- when the space reserved for a file will actually become part of the file

Alignment

Specific alignment restrictions coordinate a file's allocations with a particular I/O pattern or disk alignment (see `mkfs_vxfs`(1M) and Chapter 6 , "Application Interface" for details). Alignment can only be specified if a fixed extent size has also been set. Setting alignment restrictions on allocations is best left to well designed applications.

Contiguity

A reservation request can specify that its allocation remain contiguous (all one extent). Maximum contiguity of a file optimizes its I/O characteristics.

NOTE

Fixed extent sizes or alignment will cause the file system to return an error message reporting insufficient space if no suitably sized (or aligned) extent is available. This may happen even if the file system has plenty of free space and the fixed extent size is large.

Write Operations Beyond Reservation

A reservation request can specify that no allocations can take place after a write operation fills up the last available block in the reservation. This specification can be used in a similar way to `ulimit` to prevent a file's uncontrolled growth.

Reservation Trimming

A reservation request can specify that any unused reservation be released when the file is closed. The file is not completely closed until all processes open against the file have closed it.

Reservation Persistence

A reservation request can ensure the reservation does not become a persistent attribute of the file. Unused reservation is discarded when the file is closed.

Including Reservation in the File

A reservation request can make sure the size of the file is adjusted to include the reservation. Normally, the space of the reservation is not included in the file until an extending write operation requires it. A reservation that immediately changes the file size can generate large temporary files. Unlike a `ftruncate` operation that increases the size of a file, this type of reservation does not perform zeroing of the blocks included in the file and limits this facility to users with appropriate privileges. The data that appears in the file may have been previously contained in another file.

Commands Related to Extent Attributes

The VxFS commands for manipulating extent attributes are `setext` and `getext`; they allow the user to set up files with a given set of extent attributes or view any attributes that are already associated with a file. See `getext`(1M) and `setext`(1M) for details on using these commands.

NOTE `setext` functionality is available only with the optional HP OnLineJFS product.

The VxFS-specific commands `vxdump` and `vxrestore`, and the `mv`, `cp`, and `cpio` commands, preserve extent attributes when backing up, restoring, moving, or copying files.

Most of these commands include a command line option (`-e`) for maintaining extent attributes on files. This option specifies dealing with a VxFS file that has extent attribute information including reserved space, a fixed extent size, and extent alignment. The extent attribute information may be lost if the destination file system does not support extent attributes, has a different block size than the source file system, or lacks free extents appropriate to satisfy the extent attribute requirements.

The `-e` option takes any of the following keywords as an argument:

`warn`	Issues a warning message if extent attribute information cannot be maintained (the default)
`force`	Fails the copy if extent attribute information cannot be maintained
`ignore`	Ignores extent attribute information entirely

The commands that move, copy, or archive files (`mv`, `cp` and `cpio`) use the `-e` option with arguments of `ignore`, `warn`, or `force`.

For example, the `mv` command could be used with the `-e` option to produce the following results:

- The `ignore` keyword loses any extent attributes for files.
- The `warn` keyword issues a warning if extent attributes for a file cannot be preserved. Such a situation may take place if the file is moved into a non-VxFS file system; the file would ultimately be moved while the extent attributes would be lost.

- The `force` keyword issues an error if attributes are lost and the file is not relocated.

  The `ls` command has an `-e` option, which prints the extent attributes of the file.

Failure to Preserve Extent Attributes

Whenever a file is copied, moved, or archived using commands that preserve extent attributes, there is nevertheless the possibility of losing the attributes. Such a failure might occur for three reasons:

- The file system receiving a copied, moved, or restored file from an archive is not a VxFS type. Since other file system types do not support the extent attributes of the VxFS file system, the attributes of the source file are lost during the migration.
- The file system receiving a copied, moved, or restored file is a VxFS type but does not have enough free space to satisfy the extent attributes. For example, consider a 50K file and a reservation of 1 MB. If the target file system has 500K free, it could easily hold the file but fail to satisfy the reservation.
- The file system receiving a copied, moved, or restored file from an archive is a VxFS type but the different block sizes of the source and target file system make extent attributes impossible to maintain. For example, consider a source file system of block size 1024, a target file system of block size 4096, and a file that has a fixed extent size of 3 blocks (3072 bytes). This fixed extent size adapts to the source file system but cannot translate onto the target file system.

The same source and target file systems in the preceding example with a file carrying a fixed extent size of 4 could preserve the attribute; a 4 block (4096 byte) extent on the source file system would translate into a 1 block extent on the target.

On a system with mixed block sizes, a copy, move, or restoration operation may or may not succeed in preserving attributes. It is recommended that the same block size be used for all file systems on a given system.

4 Online Backup

Introduction

This chapter describes the online backup facility provided with the VxFS file system. The snapshot feature of VxFS can be used to create a snapshot image of a mounted file system, which becomes a duplicate read-only copy of the mounted file system.

NOTE Snapshot file systems are available only with the optional HP OnLineJFS product.

The following topics are covered in this chapter:

- "Snapshot File Systems"
  - — "Snapshot File System Disk Structure"
  - — "How a Snapshot File System Works"
- "Using a Snapshot File System for Backup"
  - — "Creating a Snapshot File System"
  - — "Making a Backup"
- "Performance of Snapshot File Systems"

Snapshot File Systems

The VxFS file system provides a mechanism for taking snapshot images of mounted file systems, which is useful for making backups.The *snapshot file system* is an exact image of the original file system, which is referred to as the *snapped file system*. The snapshot is a consistent view of the file system "snapped" at the point in time the snapshot is made. Selected files can be backed up from the snapshot (using standard utilities such as `cpio` or `cp`) or the entire file system image can be backed up (using the `vxdump` or `fscat` utilities).

The `mount` command is used to create a snapshot file system; there is no `mkfs` step involved. A snapshot file system is always read-only and exists only as long as it and the file system that has been snapped are mounted. A snapped file system cannot be unmounted until any corresponding snapshots are first unmounted. A snapshot file system ceases to exist when unmounted. While it is possible to have multiple snapshots of a file system made at different times, it is not possible to make a snapshot of a snapshot.

This chapter describes the creation of snapshot file systems and gives some examples of backing up all or part of a file system using the snapshot mechanism.

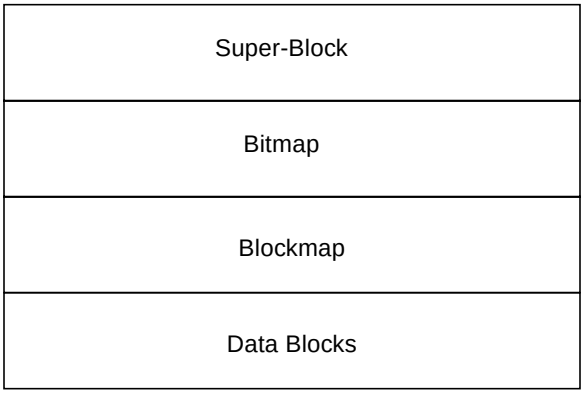
Snapshot File System Disk Structure

A snapshot file system consists of:

- a super-block
- a bitmap
- a blockmap
- data blocks copied from the snapped file system

Figure 4-1, "The Snapshot Disk Structure," shows the disk structure of a snapshot file system.

Figure 4-1 The Snapshot Disk Structure



The super-block is similar to the super-block ofa normal VxFS file system, however, the magic number is different and many of the fields are meaningless.

Immediately following the super-block is the bitmap. The bitmap contains one bit for every block on the snapped file system. Initially, all bitmap entries are zero. A set bit indicates that the appropriate block was copied from the snapped file system to the snapshot. In this case, the appropriate position in the blockmap will reference the copied block,

Following the bitmap is the blockmap. It contains one entryfor each block on the snapped file system. Initially, all entries are zero. When a block is copied from the snapped file system to the snapshot, the appropriate entry in the blockmap is changed to contain the block number on the snapshot file system that holds the data from the snapped file system.

The data blocks used by the snapshot file system are located after the blockmap. These are filled by any data copied from the snapped file system, starting from the front of the data block area.

How a Snapshot File System Works

A snapshot file system is created by mounting an empty disk slice as a snapshot of a currently mounted file system. The bitmap, blockmap and super-block are initialized and then the currently mounted file system is frozen (see “Freeze and Thaw”, for a description of the VX_FREEZE ioctl). Once the file system to be snapped is frozen, the snapshot is enabled and mounted and the snapped file system is thawed. The snapshot appears as an exact image of the snapped file system at the time the snapshot

was made.

Initially, the snapshot file system satisfies read requests by simply finding the data on the snapped file system and returning it to the requesting process. When an inode update or a write changes the data in block *n* of the snapped file system, the old data is first read and copied to the snapshot before the snapped file system is updated. The bitmap entry for block *n* is changed from 0 to 1 (indicating that the data for block *n* can be found on the snapped file system). The blockmap entry for block *n* is changed from 0 to the block number on the snapshot file system containing the old data.

A subsequent read request for block *n* on the snapshot file system will be satisfied by checking the bitmap entry for block *n* and reading the data from the indicated block on the snapshot file system, rather than from block *n* on the snapped file system. Subsequent writes to block *n* on the snapped file system do not result in additional copies to the snapshot file system, since the old data only needs to be saved once.

All updates to the snapped file system for inodes, directories, data in files, extent maps, etc., are handled in this fashion so that the snapshot can present a consistent view of all file system structures for the snapped file system for the time when the snapshot was created. As data blocks are changed on the snapped file system, the snapshot will gradually fill with data copied from the snapped file system.

The amount of disk space required for the snapshot depends on the rate of change of the snapped file system and the amount of time the snapshot is maintained. In the worst case, the snapped file system is completely full and every file is removed and rewritten. The snapshot file system would need enough blocks to hold a copy of every block on the snapped file system, plus additional blocks for the data structures that make up the snapshot file system. This is approximately 101 percent of the size of the snapped file system. Normally, most file systems do not undergo changes at this extreme rate. During periods of low activity, the snapshot should only require two to six percent of the blocks of the snapped file system. During periods of high activity, the snapshot might require 15 percent of the blocks of the snapped file system. These percentages tend to be lower for larger file systems and higher for smaller ones.

NOTE

If a snapshot file system runs out of space for changed data blocks, it is disabled and all further access to it fails. This does not affect the snapped

file system.

Using a Snapshot File System for Backup

Once a snapshot file system is created, it can be used to perform a consistent backup of the snapped file system. Backup programs that function using the standard file system tree (such as `cpio`) can be used without modification on a snapshot file system, since the snapshot presents the same data as the snapped file system. Backup programs that access the disk structures of a VxFS file system need to be snapshot-aware to work correctly with a snapshot file system. The VxFS utilities understand snapshot file systems and make suitable modifications in their behavior so that their operation on a snapshot file system is indistinguishable from that on a normal file system.

Other backup programs that normally read the raw disk image cannot work on snapshots without modification. These programs can use the `fscat` command to obtain a raw image of the entire file system identical to that which would have been obtained by a `dd` of the disk device containing the snapped file system at the exact moment the snapshot was created. The `snapread` ioctl takes arguments similar to those of the `read` system call and returns the same results as would have been obtained by performing a read on the disk device containing the snapped file system at the exact time the snapshot was created. In both cases, however, the snapshot file system provides a consistent image of the snapped file system with all activity complete; it is an instantaneous read of the entire file system. This is a marked contrast to the results that would be obtained by a `dd` or `read` of the disk device of an active file system.

If a complete backup of a snapshot file system is made through a utility such as `vxdump` and is later restored, it will be necessary to `fsck` the restored file system because the snapshot file system is only consistent and not clean. The file system may have some extended inode operations that must be completed, though there should be no other changes. Since the snapshot file system is not writable, it cannot be fully checked. However, the `fsck -n` command can be used to report any inconsistencies.

Creating a Snapshot File System

A snapshot file system is created by using the `-o snapof=` option of the `mount` command. The `-o snapsize=` option may also be required if the

device being mounted does not identify the device size in its disk label, or if a size smaller than the entire device is desired. Use the following syntax to create a snapshot file system:

```
mount -F vxfs -o
snapof=special|mount_point,snapsize=snapshot_size \
snapshot_special snapshot_mount_point
```

The snapshot file system must be created large enough to hold any blocks on the snapped file system that may be written to while the snapshot file system exists. If a snapshot file system runs out of blocks to hold copied data, it will be disabled and all further access to the snapshot file system will fail.

During a period of low activity when the system is relatively inactive (for example, on nights and weekends), the snapshot only needs to contain two to six percent of the blocks of the snapped file system. During a period of higher activity, the snapshot of an "average" file system might require 15 percent of the blocks of the snapped file system, though most file systems do not experience this much turnover of data over an entire day. These percentages tend to be lower for larger file systems and higher for smaller ones. You should manage the blocks allocated to the snapshot based on such things as file system usage and duration of backups.

NOTE A snapshot file system ceases to exist when unmounted. If remounted, it will be a fresh snapshot of the snapped file system. A snapshot file system must be unmounted before the corresponding snapped file system can be unmounted. If you try to unmount a file system that has an existing snapshot, `umount` will fail with a "`Device Busy`" message, and `fuser` will not indicate the problem.

CAUTION Any existing data on the disk used for the snapshot is overwritten and lost.

Making a Backup

Here are some typical examples of making a backup of a 300,000 block file system named `/home` (which exists on disk `/dev/dsk/c0t0d0`) using a snapshot file system on `/dev/dsk/c0t1d0` with a snapshot mount

point of /backup/home:

- To back up files changed within the last week using cpio:

```
# mount -F vxfs -o snapof=/dev/dsk/c0t0d0, \
snapsize=100000 /dev/dsk/c0t1d0 /backup/home
# cd /backup
# find home -ctime -7 -depth -print | \
cpio -oc > /dev/rmt/0m
# umount /backup/home
```

- To do a full backup of /dev/dsk/c0t0d0 and use dd to control blocking of output onto tape device using vxdump:

```
# vxdump f - /dev/rdsk/c0t0d0 | dd bs=128k >
/dev/rmt/0m
```

- To do a level 3 backup of /dev/dsk/c0t0d0 and collect those files that have changed in the current directory:

```
# vxdump 3f - /dev/rdsk/c0t0d0 | vxrestore -xf -
```

- To do a full backup of a snapshot file system:

```
# mount -o snapof=/dev/dsk/c0t0d0,snapsize=100000 \
/dev/dsk/c0t1d0 /backup/home
# vxdump f - /dev/rdsk/c0t1d0 | dd bs=128k >
/dev/rmt/0m
```

The vxdump utility will ascertain whether /dev/rdsk/c0t1d0 is a snapshot mounted as /backup/home and do the appropriate work to get the snapshot data through the mount point.

Performance of Snapshot File Systems

Snapshot file systems maximize the performance of the snapshot at the expense of writes to the snapped file system. Reads from a snapshot file system will typically perform at nearly the throughput of reads from a normal VxFS file system, allowing backups to proceed at the full speed of the VxFS file system.

The performance of reads from the snapped file system should not be affected. Writes to the snapped file system, however, typically average two to three times as long as without a snapshot, since the initial write to a data block now requires a read of the old data, a write of the data to the snapshot, and finally the write of the new data to the snapped file system. If multiple snapshots of the same snapped file system exist, writes will be even slower. Only the initial write to a block suffers this penalty, however, so operations like writes to the intent log or inode updates proceed at normal speed after the initial write.

Reads from the snapshot file system are impacted if the snapped file system is busy, since the snapshot reads are slowed by all of the disk I/O associated with the snapped file system.

The overall impact of the snapshot is dependent on the read to write ratio of an application and the mixing of the I/O operations. As an example, Oracle running an OLTP workload on a snapped file system was measured at about 15 to 20 percent slower than a file system that was not snapped.

5 Performance and Tuning

Introduction

For any file system, the ability to provide peak performance is important. Adjusting the available VxFS file system options provides a way to optimize system performance. This chapter describes tools that an administrator can use to optimize VxFS. For information on optimizing an application for use with VxFS, see Chapter 6 , “Application Interface.”

The following topics are covered in this chapter:

- “Choosing a Block Size”
- “Choosing an Intent Log Size”
- “Choosing Mount Options”
  - “log”
  - “delaylog”
  - “tmplog”
  - “nolog”
  - “nodatainlog”
  - “blkclear”
  - “mincache”
  - “convosync”
  - “Combining mount Options”
- “Kernel Tuneables”
  - “Internal Inode Table Size”
- “Monitoring Free Space”
  - “Monitoring Fragmentation”
- “I/O Tuning”
  - “Tuning VxFS I/O Parameters”
  - “Tuneable VxFS I/O Parameters”

Choosing a Block Size

You specify the block size when a file system is created; it cannot be changed later. The standard HFS file system defaults to a block size of 8K with a 1K fragment size. This means that space is allocated to small files (up to 8K) in 1K increments. Allocations for larger files are done in 8K increments except for the last block, which may be a fragment. Because many files are small, the fragment facility saves a large amount of space compared to allocating space 8K at a time.

The unit of allocation in VxFS is a block. There are no fragments because storage is allocated in extents that consist of one or more blocks. The smallest block size available is 1K, which is also the default block size for VxFS file systems created on file systems of less than 8 gigabytes.

Choose a block size based on the type of application being run. For example, if there are many small files, a 1K block size may save space. For large file systems, with relatively few files, a larger block size is more appropriate. The trade-off of specifying larger block sizes is a decrease in the amount of space used to hold the free extent bitmaps for each allocation unit, an increase in the maximum extent size, and a decrease in the number of extents used per file versus an increase in the amount of space wasted at the end of files that are not a multiple of the block size. Larger block sizes use less disk space in file system overhead, but consume more space for files that are not a multiple of the block size. The easiest way to judge which block sizes provide the greatest system efficiency is to try representative system loads against various sizes and pick the fastest.

Choosing an Intent Log Size

The intent log size is chosen when a file system is created and cannot be subsequently changed. The `mkfs` utility uses a default intent log size of 1024 blocks. The default size is sufficient for most workloads. If the system is used as an NFS server or for intensive synchronous write workloads, performance may be improved using a larger log size.

With larger intent log sizes, recovery time is proportionately longer and the file system may consume more system resources (such as memory) during normal operation.

There are several system performance benchmark suites for which VxFS performs better with larger log sizes. As with block sizes, the best way to pick the log size is to try representative system loads against various sizes and pick the fastest.

Choosing Mount Options

In addition to the standard `mount` mode (`log` mode), VxFS provides `blkclear`, `delaylog`, `tmplog`, `nolog`, and `nodatainlog` modes of operation. Caching behavior can be altered with the `mincache` option, and the behavior of `O_SYNC` and `D_SYNC` (see `fcntl`(2)) writes can be altered with the `convosync` option.

The `delaylog` and `tmplog` modes are capable of significantly improving performance. The improvement over `log` mode is typically about 15 to 20 percent with `delaylog`; with `tmplog`, the improvement is even higher. Performance improvement varies, depending on the operations being performed and the workload. Read/write intensive loads should show less improvement, while file system structure intensive loads (such as `mkdir`, `create`, and `rename`) may show over 100 percent improvement. The best way to select a mode is to test representative system loads against the logging modes and compare the performance results.

Most of the modes can be used in combination. For example, a desktop machine might use both the `blkclear` and `mincache=closesync` modes.

Additional information on `mount` options can be found in `mount_vxfs`(1M).

log

The default logging mode is `log`. With `log` mode, VxFS guarantees that all structural changes to the file system have been logged on disk when the system call returns. If a system failure occurs, `fsck` replays recent changes so that they will not be lost.

delaylog

In `delaylog` mode, some system calls return before the intent log is written. This logging delay improves the performance of the system, but some changes are not guaranteed until a short time after the system call returns, when the intent log is written. If a system failure occurs, recent changes may be lost. This mode approximates traditional UNIX guarantees for correctness in case of system failures. Fast file system recovery works with this mode.

tmplog

In `tmplog` mode, intent logging is almost always delayed. This greatly improves performance, but recent changes may disappear if the system crashes. This mode is only recommended for temporary file systems. Fast file system recovery works with this mode.

nolog

Same as `tmplog`.

nodatainlog

The `nodatainlog` mode should be used on systems with disks that do not support bad block revectoring. Normally, a VxFS file system uses the intent log for synchronous writes. The inode update and the data are both logged in the transaction, so a synchronous write only requires one disk write instead of two. When the synchronous write returns to the application, the file system has told the application that the data is already written. If a disk error causes the data update to fail, then the file must be marked bad and the entire file is lost.

If a disk supports bad block revectoring, then a failure on the data update is unlikely, so logging synchronous writes should be allowed. If the disk does not support bad block revectoring, then a failure is more likely, so the `nodatainlog` mode should be used.

A `nodatainlog` mode file system should be approximately 50 percent slower than a standard mode VxFS file system for synchronous writes. Other operations are not affected.

blkclear

The `blkclear` mode is used in increased data security environments. The `blkclear` mode guarantees that uninitialized storage never appears in files. The increased integrity is provided by clearing extents on disk when they are allocated within a file. Extending writes are not affected by this mode. A `blkclear` mode file system should be approximately 10 percent slower than a standard mode VxFS file system, depending on the workload.

mincache

The mincache mode has five suboptions:

- mincache=closesync
- mincache=direct
- mincache=dsync
- mincache=unbuffered
- mincache=tmpcache

NOTE

The mincache=direct, mincache=dsync, mincache=unbuffered, and mincache=tmpcache modes are only available with the HP OnLineJFS product.

The mincache=closesync mode is useful in desktop environments where users are likely to shut off the power on the machine without halting it first. In this mode, any changes to the file are flushed to disk when the file is closed.

To improve performance, most file systems do not synchronously update data and inode changes to disk. If the system crashes, files that have been updated within the past minute are in danger of losing data. With the mincache=closesync mode, if the system crashes or is switched off, only files that are currently open can lose data. A mincache=closesync mode file system should be approximately 15 percent slower than a standard mode VxFS file system, depending on the workload.

The mincache=direct, mincache=unbuffered, and mincache=dsync modes are used in environments where applications are experiencing reliability problems caused by the kernel buffering of I/O and delayed flushing of non-synchronous I/O. The mincache=direct and mincache=unbuffered modes guarantee that all non-synchronous I/O requests to files will be handled as if the VX_DIRECT or VX_UNBUFFERED caching advisories had been specified. The mincache=dsync mode guarantees that all non-synchronous I/O requests to files will be handled as if the VX_DSYNC caching advisory had been specified. Refer to vxfsio(7) for explanations of VX_DIRECT, VX_UNBUFFERED, and VX_DSYNC. The mincache=direct, mincache=unbuffered, and mincache=dsync modes also flush file data on close as mincache=closesync does.

Since the mincache=direct, mincache=unbuffered, and mincache=dsync modes change non-synchronous I/O to synchronous I/O, there can be a substantial degradation in throughput for small to medium size files for most applications. Since the VX_DIRECT and VX_UNBUFFERED advisories do not allow any caching of data, applications that would normally benefit from caching for reads will usually experience less degradation with the mincache=dsync mode. mincache=direct and mincache=unbuffered require significantly less CPU time than buffered I/O.

If performance is more important than data integrity, the mincache=tmpcache mode may be used. The mincache=tmpcache mode disables special delayed extending write handling, trading off less integrity for better performance. Unlike the other mincache modes, tmpcache does not flush the file to disk when it is closed. When this option is used, garbage may appear in a file that was being extended when a crash occurred.

convosync

NOTE Use of the convosync=dsync option violates POSIX guarantees for synchronous I/O.

The "convert osync" (convosync) mode has five suboptions: convosync=closesync, convosync=direct, convosync=dsync, convosync=unbuffered, and convosync=delay.

NOTE The convosync option is available only with the HP OnLineJFS product.

The convosync=closesync mode converts synchronous and data synchronous writes to non-synchronous writes and flushes the changes to the file to disk when the file is closed.

The convosync=delay mode causes synchronous and data synchronous writes to be delayed rather than to take effect immediately. No special action is performed when closing a file. This option effectively cancels any data integrity guarantees normally provided by opening a file with O_SYNC. See open(2), fcntl(2), and vxfsio(7) for more information on O_SYNC.

CAUTION

Extreme care should be taken when using the convosync=closesync or convosync=delay mode because they actually change synchronous I/O into non-synchronous I/O. This may cause applications that use synchronous I/O for data reliability to fail if the system crashes and synchronously written data is lost.

The convosync=direct and convosync=unbuffered mode convert synchronous and data synchronous reads and writes to direct reads and writes.

The convosync=dsync mode converts synchronous writes to data synchronous writes.

As with closesync, the direct, unbuffered, and dsync modes flush changes to the file to disk when it is closed. These modes can be used to speed up applications that use synchronous I/O. Many applications that are concerned with data integrity specify the O_SYNC fcntl in order to write the file data synchronously. However, this has the undesirable side effect of updating inode times and therefore slowing down performance. The convosync=dsync, convosync=unbuffered, and convosync=direct modes alleviate this problem by allowing applications to take advantage of synchronous writes without modifying inode times as well.

NOTE

Before using convosync=dsync, convosync=unbuffered, or convosync=direct, make sure that all applications that use the file system do not require synchronous inode time updates for O_SYNC writes.

Combining mount Options

Although mount options can be combined arbitrarily, some combinations do not make sense. The following examples provide some common and reasonable mount option combinations.

Example 1 - Desktop File System

```
# mount -F vxfs -o log,mincache=closesync
/dev/dsk/c1t3d0 /mnt
```

This guarantees that when a file is closed, its data is synchronized to disk and cannot be lost. Thus, once an application is exited and its files are closed, no data will be lost even if the system is immediately turned off.

Example 2 - Temporary File System or Restoring from Backup

```
# mount -F vxfs -o
tmplog,convosync=delay,mincache=tmpcache \
/dev/dsk/c1t3d0 /mnt
```

This combination might be used for a temporary file system where performance is more important than absolute data integrity. Any O_SYNC writes are performed as delayed writes and delayed extending writes are not handled specially (which could result in a file that contains garbage if the system crashes at the wrong time). Any file written 30 seconds or so before a crash may contain garbage or be missing if this mount combination is in effect. However, such a file system will do significantly less disk writes than a log file system, and should have significantly better performance, depending on the application.

Example 3 - Data Synchronous Writes

```
# mount -F vxfs -o log,convosync=dsync /dev/dsk/c1t3d0
/mnt
```

This combination would be used to improve the performance of applications that perform O_SYNC writes, but only require data synchronous write semantics. Their performance can be significantly improved if the file system is mounted using convosync=dsync without any loss of data integrity.

Kernel Tuneables

This section describes the kernel tuneables in VxFS.

Internal Inode Table Size

VxFS caches inodes in an *inode table* (see Table 5-1, “Inode Table Size”). There is a tuneable in VxFS called vx_ninode that determines the number of entries in the inode table.

A VxFS file system obtains the value of vx_ninode from the system configuration file used for making the kernel (/stand/system for example). This value is used to determine the number of entries in the VxFS inode table. By default, vx_ninode initializes at zero; the file system then computes a value based on the system memory size (see Table 5-1, “Inode Table Size”). To change the computed value of vx_ninode, you can add an entry to the system configuration file. For example:

```
vx_ninode1000000
```

sets the inode table size to 1,000,000 inodes after making a new kernel using mk_kernel and then rebooting.

The number of inodes in the inode table is calculated according to the following table. The first column is the amount of system memory, the second is the number of inodes. If the available memory is a value between two entries, the value of vx_ninode is interpolated.

Table 5-1 Inode Table Size

Total Memory in Mbytes	Maximum Number of Inodes
8	400
16	1000
32	2500
64	6000
128	8000
256	16,000
512	32,000
1024	64,000
2048	128,000
8192	256,000
32,768	512,000
131,072	1,024,000

Monitoring Free Space

In general, VxFS works best if the percentage of free space in the file system does not get below 10 percent. This is because file systems with 10 percent or more free space have less fragmentation and better extent allocation. Regular use of the `df_vxfs`(1M) command to monitor free space is desirable. Full file systems may have an adverse effect on file system performance. Full file systems should therefore have some files removed, or should be expanded (see `fsadm_vxfs`(1M) for a description of online file system expansion).

NOTE The reorganization and resize features of `fsadm_vxfs`(1M) are available only with the optional HP OnLineJFS product.

Monitoring Fragmentation

Fragmentation reduces performance and availability. Regular use of `fsadm`'s fragmentation reporting and reorganization facilities is therefore advisable.

The easiest way to ensure that fragmentation does not become a problem is to schedule regular defragmentation runs from `cron`.

Defragmentation scheduling should range from weekly (for frequently used file systems) to monthly (for infrequently used file systems). Extent fragmentation should be monitored with `fsadm_vxfs`(1M) or the `-o s` options of `df_vxfs`(1M). There are three factors which can be used to determine the degree of fragmentation:

- percentage of free space in extents of less than eight blocks in length
- percentage of free space in extents of less than 64 blocks in length
- percentage of free space in extents of length 64 blocks or greater

An unfragmented file system will have the following characteristics:

- less than 1 percent of free space in extents of less than eight blocks in length
- less than 5 percent of free space in extents of less than 64 blocks in

length

- more than 5 percent of the total file system size available as free extents in lengths of 64 or more blocks

A badly fragmented file system will have one or more of the following characteristics:

- greater than 5 percent of free space in extents of less than 8 blocks in length
- more than 50 percent of free space in extents of less than 64 blocks in length
- less than 5 percent of the total file system size available as free extents in lengths of 64 or more blocks

The optimal period for scheduling of extent reorganization runs can be determined by choosing a reasonable interval, scheduling `fsadm` runs at the initial interval, and running the extent fragmentation report feature of `fsadm` before and after the reorganization.

The “before” result is the degree of fragmentation prior to the reorganization. If the degree of fragmentation is approaching the figures for bad fragmentation, then the interval between `fsadm` runs should be reduced. If the degree of fragmentation is low, the interval between `fsadm` runs can be increased.

The “after” result is an indication of how well the reorganizer is performing. The degree of fragmentation should be close to the characteristics of an unfragmented file system. The file system may be a candidate for expansion. (Full file systems tend to fragment and are difficult to defragment.) It is also possible that the reorganization is not being performed at a time during which the file system in question is relatively idle.

Directory reorganization is not nearly as critical as extent reorganization, but regular directory reorganization will improve performance. It is advisable to schedule directory reorganization for file systems when the extent reorganization is scheduled. The following is a sample script that is run periodically at 3:00 A.M. from `cron` for a number of file systems:

```
outfile=/tmp/fsadm_out.&212#;/bin/date +'%m%d'&212#;
for i in /home /home2 /project /db
do
```

```
/bin/echo "Reorganizing $i"
/bin/timex fsadm -F vxfs -e -E -s $i
/bin/timex fsadm -F vxfs -s -d -D $i
done > $outfile 2>&1
```

I/O Tuning

NOTE The tuneables and the techniques described in this section are for tuning on a per file system basis and should be used judiciously based on the underlying device properties and characteristics of the applications that use the file system.

Performance of a file system can be enhanced by a suitable choice of I/O sizes and proper alignment of the I/O requests based on the requirements of the underlying special device. VxFS provides tools to tune the file systems.

Tuning VxFS I/O Parameters

The VxFS file system provides a set of tuneable I/O parameters that control some of its behavior.

If the default parameters are not acceptable, then the `/etc/vx/tunefstab` file can be used to set values for I/O parameters. The `mount_vxfs`(1M) command invokes the `vxtunefs`(1M) command to process the contents of the `/etc/vx/tunefstab` file. Please note that the `mount` command will continue even if the call to `vxtunefs` fails or if `vxtunefs` detects invalid parameters. While the file system is mounted, any I/O parameters can be changed using the `vxtunefs` command which can have tuneables specified on the command line or can read them from the `/etc/vx/tunefstab` file. For more details, see `vxtunefs`(1M) and `tunefstab`(4). The `vxtunefs` command can be used to print the current values of the I/O parameters.

Tuneable VxFS I/O Parameters

`read_pref_io` The preferred read request size. The file system uses this in conjunction with the `read_nstream` value to determine how much data to read ahead. The default value is 64K.

`write_pref_io` The preferred write request size. The file system uses this in conjunction with the `write_nstream` value to determine how to do flush behind on writes. The default value is 64K.

`read_nstream`	The number of parallel read requests of size `read_pref_io` to have outstanding at one time. The file system uses the product of `read_nstream` multiplied by `read_pref_io` to determine its read ahead size. The default value for `read_nstream` is 1.
`write_nstream`	The number of parallel write requests of size `write_pref_io` to have outstanding at one time. The file system uses the product of `write_nstream` multiplied by `write_pref_io` to determine when to do flush behind on writes. The default value for `write_nstream` is 1.
`default_indir_size`	On VxFS, files can have up to ten direct extents of variable size stored in the inode. Once these extents are used up, the file must use indirect extents which are a fixed size that is set when the file first uses indirect extents. These indirect extents are 8K by default. The file system does not use larger indirect extents because it must fail a write and return `ENOSPC` if there are no extents available that are the indirect extent size. For file systems with a lot of large files, the 8K indirect extent size is too small. The files that get into indirect extents use a lot of smaller extents instead of a few larger ones. By using this parameter, the default indirect extent size can be increased so large that files in indirects use fewer larger extents. The tuneable `default_indir_size` should be used carefully. If it is set too large, then writes will fail when they are unable to allocate extents of the indirect extent size to a file. In general, the fewer and the larger the files on a file system, the larger the `default_indir_size` can be set. This parameter should generally be set to some multiple of the `read_pref_io` parameter. `default_indir_size` is not applicable on Version 4 disk layouts.
`discovered_direct_iosz`	Any file I/O requests larger than the `discovered_direct_iosz` are handled as discovered direct I/O. A discovered direct I/O is unbuffered similar to direct I/O, but it does not require a synchronous commit of the inode when the file is extended or blocks are allocated. For larger I/O requests, the CPU time for copying the data into the page cache and the cost of using memory to buffer the I/O data becomes more expensive than the cost of doing the disk I/O. For these I/O requests, using discovered direct I/O is more efficient than regular I/O. The default value of this parameter is 256K.

`initial_extent_size`	Changes the default initial extent size. VxFS determines, based on the first write to a new file, the size of the first extent to be allocated to the file. Normally the first extent is the smallest power of 2 that is larger than the size of the first write. If that power of 2 is less than 8K, the first extent allocated is 8K. After the initial extent, the file system increases the size of subsequent extents (see `max_seqio_extent_size`) with each allocation. Since most applications write to files using a buffer size of 8K or less, the increasing extents start doubling from a small initial extent. `initial_extent_size` can change the default initial extent size to be larger, so the doubling policy will start from a much larger initial size and the file system will not allocate a set of small extents at the start of file. Use this parameter only on file systems that will have a very large average file size. On these file systems it will result in fewer extents per file and less fragmentation. `initial_extent_size` is measured in file system blocks.
`max_buf_data_size`	The maximum buffer size allocated for file data; either 8K bytes or 64K bytes. Use the larger value for workloads where large reads/writes are performed sequentially. Use the smaller value on workloads where the I/O is random or is done in small chunks. 8K bytes is the default value.
`max_direct_iosz`	The maximum size of a direct I/O request that will be issued by the file system. If a larger I/O request comes in, then it is broken up into `max_direct_iosz` chunks. This parameter defines how much memory an I/O request can lock at once, so it should not be set to more than 20 percent of memory.
`max_diskq`	Limits the maximum disk queue generated by a single file. When the file system is flushing data for a file and the number of pages being flushed exceeds `max_diskq`, processes will block until the amount of data being flushed decreases. Although this doesn't limit the actual disk queue, it prevents flushing processes from making the system unresponsive. The default value is 1 MB.
`max_seqio_extent_size`	Increases or decreases the maximum size of an extent. When the file system is following its default allocation policy for sequential writes to a file, it allocates an initial extent which is large enough for the first write to the file. When additional extents are allocated, they are progressively larger (the algorithm tries to double the size of the file with each new extent) so each extent can hold several writes worth of data. This is done to reduce the total number of extents in anticipation of continued sequential writes. When the file stops being written, any unused space is freed for other files to use. Normally this allocation stops increasing the size of extents at 2048 blocks which prevents one file from holding too much unused space. `max_seqio_extent_size` is measured in file system blocks.

Try to align the parameters to match the geometry of the logical disk. With striping or RAID-5, it is common to set `read_pref_io` to the stripe unit size and `read_nstream` to the number of columns in the stripe. For striping arrays, use the same values for `write_pref_io` and `write_nstream`, but for RAID-5 arrays, set `write_pref_io` to the full stripe size and `write_nstream` to 1.

For an application to do efficient disk I/O, it should issue read requests that are equal to the product of `read_nstream` multiplied by `read_pref_io`. Generally, any multiple or factor of `read_nstream` multiplied by `read_pref_io` should be a good size for performance. For writing, the same rule of thumb applies to the `write_pref_io` and `write_nstream` parameters. When tuning a file system, the best thing to do is try out the tuning parameters under a real life workload.

If an application is doing sequential I/O to large files, it should try to issue requests larger than the `discovered_direct_iosz`. This causes the I/O requests to be performed as discovered direct I/O requests, which are unbuffered like direct I/O but do not require synchronous inode updates when extending the file. If the file is larger than can fit in the cache, then using unbuffered I/O avoids throwing useful data out of the cache and it avoids a lot of CPU overhead.

6 Application Interface

Introduction

The VxFS File System provides enhancements that can be used by applications that require certain performance features. This chapter describes cache advisories and provides information about fixed extent sizes and reservation of space for a file.

This chapter describes how the application writer can optimize applications for use with the VxFS. To optimize VxFS for use with applications, see Chapter 5 , “Performance and Tuning.”

The following topics are covered in this chapter:

- “Cache Advisories”
  - — “Direct I/O”
  - — “Unbuffered I/O”
  - — “Discovered Direct I/O”
  - — “Data Synchronous I/O”
  - — “Other Advisories”
- “Extent Information”
  - — “Space Reservation”
  - — “Fixed Extent Sizes”
  - — “Freeze and Thaw”
- “Get I/O Parameters ioctl”

Cache Advisories

The VxFS file system allows an application to set cache advisories for use when accessing files. These advisories are in memory only and they do not persist across reboots. Some advisories are currently maintained on a per-file, not a per-file-descriptor, basis. This means that only one set of advisories can be in effect for all accesses to the file. If two conflicting applications set different advisories, both use the last advisories that were set.

All advisories are set using the VX_SETCACHE ioctl. The current set of advisories can be obtained with the VX_GETCACHE ioctl. For details on the use of these ioctls, see `vxfsio`(7).

NOTE The VX_SETCACHE ioctl is available only with the HP OnLineJFS product.

Direct I/O

Direct I/O is an unbuffered form of I/O. If the VX_DIRECT advisory is set, the user is requesting direct data transfer between the disk and the user-supplied buffer for reads andwrites. This bypasses the kernel buffering of data, and reduces the CPU overhead associated with I/O by eliminating the data copy between the kernel buffer and the user's buffer. This also avoids taking up space in the buffer cache that might be better used for something else. The direct I/O feature can provide significant performance gains for some applications.

For an I/O operation to be performed as direct I/O, it must meet certain alignment criteria. The alignment constraints are usually determined by the disk driver, the disk controller, and the system memory management hardware and software. The file offset must be aligned on a 4-byte boundary.

If a request fails to meet the alignment constraints for direct I/O, the request is performed as data synchronous I/O. If the file is currently being accessed by using memory mapped I/O, any direct I/O accesses are done as data synchronous I/O.

Since direct I/O maintains the same data integrity as synchronous I/O, it can be used in many applications that currently use synchronous I/O. If a

direct I/O request does not allocate storage or extend the file, the inode is not immediately written.

The CPU cost of direct I/O is about the same as a raw disk transfer. For sequential I/O to very large files, using direct I/O with large transfer sizes can provide the same speed as buffered I/O with much less CPU overhead.

If the file is being extended or storage is being allocated, direct I/O must write the inode change before returning to the application. This eliminates some of the performance advantages of direct I/O.

The direct I/O and VX_DIRECT advisories are maintained on a per-file-descriptor basis.

Unbuffered I/O

If the VX_UNBUFFERED advisory is set, I/O behavior is the same as direct I/O with the VX_DIRECT advisory set, so the alignment constraints that apply to direct I/O also apply to unbuffered. For I/O with unbuffered I/O, however, if the file is being extended, or storage is being allocated to the file, inode changes are not updated synchronously before the write returns to the user. The VX_UNBUFFERED advisory is maintained on a per-file-descriptor basis.

Discovered Direct I/O

Discovered Direct I/O is not a cache advisory that the user can set using the VX_SETCACHE ioctl. When the file system gets an I/O request larger than the default size of 128K, it tries to use direct I/O on the request. For large I/O sizes, Discovered Direct I/O can perform much better than buffered I/O.

Discovered Direct I/O behavior is similar to direct I/O and has the same alignment constraints, except writes that allocate storage or extend the file size do not require writing the inode changes before returning to the application.

Data Synchronous I/O

If the VX_DSYNC advisory is set, the user is requesting data synchronous I/O. In synchronous I/O, the data is written, and the inode is written with updated times and (if necessary) an increased file size. In data synchronous I/O, the data is transferred to disk synchronously before the

write returns to the user. If the file is not extended by the write, the times are updated in memory, and the call returns to the user. If the file is extended by the operation, the inode is written before the write returns.

Like direct I/O, the data synchronous I/O feature can provide significant application performance gains. Since data synchronous I/O maintains the same data integrity as synchronous I/O, it can be used in many applications that currently use synchronous I/O. If the data synchronous I/O does not allocate storage or extend the file, the inode is not immediately written. The data synchronous I/O does not have any alignment constraints, so applications that find it difficult to meet the alignment constraints of direct I/O should use data synchronous I/O.

If the file is being extended or storage is allocated, data synchronous I/O must write the inode change before returning to the application. This case eliminates the performance advantage of data synchronous I/O.

The direct I/O and VX_DSYNC advisories are maintained on a per-file-descriptor basis.

Other Advisories

The VX_SEQ advisory indicates that the file is being accessed sequentially. When the file is being read, the maximum read-ahead is always performed. When the file is written, instead of trying to determine whether the I/O is sequential or random by examining the write offset, sequential I/O is assumed. The pages for the write are not immediately flushed. Instead, pages are flushed some distance behind the current write point.

The VX_RANDOM advisory indicates that the file is being accessed randomly. For reads, this disables read-ahead. For writes, this disables the flush-behind. The data is flushed by the pager, at a rate based on memory contention.

The VX_NOREUSE advisory is used as a modifier. If both VX_RANDOM and VX_NOREUSE are set, pages are immediately freed and put on the quick reuse free list as soon as the data has been used. If VX_NOREUSE is set when doing sequential I/O, pages are also put on the quick reuse free list when they are flushed. The VX_NOREUSE may slow down access to the file, but it can reduce the cached data held by the system. This can allow more data to be cached for other files and may speed up those accesses.

Extent Information

The VX_SETEXT ioctl allows an application to reserve space for a file, and set fixed extent sizes and file allocation flags. The current state of much of this information can be obtained by applications using the VX_GETEXT ioctl (the getext command provides access to this functionality). For details, see getext(1M), setext(1M), and vxfsio(7).

NOTE The VX_SETEXT ioctl is available only with the HP OnLineJFS product.

Each invocation of the VX_SETEXT ioctl affects all the elements in the vx_ext structure. When using VX_SETEXT, always use the following procedure:

Step 1. Use VX_GETEXT to read the current settings.

Step 2. Modify the values to be changed.

Step 3. Call VX_SETEXT to set the values.

NOTE Follow this procedure carefully. Otherwise, a fixed extent size could be cleared when the reservation is changed.

Space Reservation

Storage can be reserved for a file at any time. When a VX_SETEXT ioctl is issued, the reservation value is set in the inode on disk. If the file size is less than the reservation amount, the kernel allocates space to the file from the current file size up to the reservation amount. When the file is truncated, space below the reserved amount is not freed. The VX_TRIM, VX_NOEXTEND, VX_CHGSIZE, VX_NORESERVE and VX_CONTIGUOUS flags can be used to modify reservation requests.

NOTE VX_NOEXTEND is the only one of these flags that is persistent; the other flags may have persistent effects, but they are not returned by the

VX_GETEXT ioctl.

If the VX_TRIM flag is set, when the last close occurs on the inode, the reservation is trimmed to match the file size and the VX_TRIM flag is cleared. Any unused space is freed. This can be useful if an application needs enough space for a file, but it is not known how large the file will become. Enough space can be reserved to hold the largest expected file, and when the file has been written and closed, any extra space will be released.

If the VX_NOEXTEND flag is set, an attempt to write beyond the current reservation, which requires the allocation of new space for the file, fails instead. To allocate new space to the file, the space reservation must be increased. This can be used like `ulimit` to prevent a file from using too much space.

If the VX_CONTIGUOUS flag is set, any space allocated to satisfy the current reservation request is allocated in one extent. If there is not one extent large enough to satisfy the request, the request fails. For example, if a file is created and a 1 MB contiguous reservation is requested, the file size is set to zero and the reservation to 1 MB. The file will have one extent that is 1 MB long. If another reservation request is made for a 3 MB contiguous reservation, the new request will find that the first 1 MB is already allocated and allocate a 2 MB extent to satisfy the request. If there are no 2 MB extents available, the request fails. (Extents are, by definition, contiguous.)

NOTE Because VX_CONTIGUOUS is not a persistent flag, space will not be allocated contiguously after doing a file system restore.

If the VX_NORESERVE flag is set, the reservation value in the inode is not changed. This flag is used by applications to do temporary reservation. Any space past the end of the file is given up when the file is closed. For example, if the cp command is copying a file that is 1 MB long, it can request a 1 MB reservation with the VX_NORESERVE flag set. The space is allocated, but the reservation in the file is left at 0. If the program aborts for any reason or the system crashes, the unused space past the end of the file is released. When the program finishes, there is no cleanup because the reservation was never recorded on disk.

If the VX_CHGSIZE flag is set, the file size is increased to match the

reservation amount. This flag can be used to create files with uninitialized data. Because this allows uninitialized data in files, it is restricted to users with appropriate privileges.

It is possible to use these flags in combination. For example, using VX_CHGSIZE and VX_NORESERVE changes the file size but does not set any reservation. When the file is truncated, the space is freed. If the VX_NORESERVE flag had not been used, the reservation would have been set on disk along with the file size.

Space reservation is used to make sure applications do not fail because the file system is out of space. An application can preallocate space for all the files it needs before starting to do any work. By allocating space in advance, the file is optimally allocated for performance, and file accesses are not slowed down by the need to allocate storage. This allocation of resources can be important in applications that require a guaranteed response time.

With very large files, use of space reservation can avoid the need to use indirect extents. It can also improve performance and reduce fragmentation by guaranteeing that the file consists of large contiguous extents. Sometimes when critical file systems run out of space, cron jobs, mail, or printer requests fail. These failures are harder to track if the logs kept by the application cannot be written due to a lack of space on the file system.

By reserving space for key log files, the logs will not fail when the system runs out of space. Process accounting files can also have space reserved so accounting records will not be lost if the file system runs out of space. In addition, by using the VX_NOEXTEND flag for log files, the maximum size of these files can be limited. This can prevent a runaway failure in one component of the system from filling the file system with error messages and causing other failures. If the VX_NOEXTEND flag is used for log files, the logs should be cleaned up before they reach the size limit in order to avoid losing information.

Fixed Extent Sizes

The VxFS file system uses the I/O size of write requests, and a default policy, when allocating space to a file. For some applications, this may not work out well. These applications can set a fixed extent size, so that all new extents allocated to the file are of the fixed extent size.

By using a fixed extent size, an application can reduce allocations and guarantee good extent sizes for a file. An application can reserve most of

the space a file needs, and then set a relatively large fixed extent size. If the file grows beyond the reservation, any new extents are allocated in the fixed extent size.

Another use of a fixed extent size occurs with sparse files. The file system usually does I/O in page size multiples. When allocating to a sparse file, the file system allocates pages as the smallest default unit. If the application always does sub-page I/O, it can request a fixed extent size to match its I/O size and avoid wasting extra space.

When setting a fixed extent size, an application should not select too large a size. When all extents of the required size have been used, attempts to allocate new extents fail: this failure can happen even though there are blocks free in smaller extents.

Fixed extent sizes can be modified by the VX_ALIGN flag. If the VX_ALIGN flag is set, then any future extents allocated to the file are aligned on a fixed extent size boundary relative to the start of the allocation unit. This can be used to align extents to disk striping boundaries or physical disk boundaries.

The VX_ALIGN flag is persistent and is returned by the VX_GETEXT ioctl.

Freeze and Thaw

The VX_FREEZE ioctl is used to freeze a file system. Freezing a file system temporarily blocks all I/O operations to a file system and then performs a sync on the file system. When the VX_FREEZE ioctl is issued, all access to the file system is blocked at the system call level. Current operations are completed and the file system is synchronized to disk. Freezing provides a stable, consistent file system.

When the file system is frozen, any attempt to use the frozen file system, except for a VX_THAW ioctl, is blocked until a process executes the VX_THAW ioctl or the time-out on the freeze expires.

Get I/O Parameters ioctl

VxFS provides the VX_GET_IOPARAMETERS ioctl to get the recommended I/O sizes to use on a file system. This ioctl can be used by the application to make decisions about the I/O sizes issued to VxFS for a file or file device. For more details on this ioctl, refer to vxfsio(7). For a discussion on various I/O parameters, refer to Chapter 5 , “Performance and Tuning,” and vxtunefs (1M).

7 Quotas

Introduction

The VxFS File System supports BSD-style user quotas. The quota system limits the use of two principal resources of a file system: files and data blocks. For each of these resources, users may be assigned quotas.

The following topics are covered in this chapter:

- “Quota Limits”
- “Quotas File on VxFS”
- “Quota Commands”
- “quotacheck With VxFS”
- “Using Quotas”

Quota Limits

Quota limits for individual users can be set up for file and data block usage on a file system. A user quota consists of limits for these resources. The following limits can be set for each resource:

- The *hard limit* is an absolute limit that cannot be exceeded under any circumstances.
- The *soft limit* (which is lower than the hard limit) can be exceeded, but only for a limited time. The time limit can be configured on a per-file system basis, and a default value of seven days is set by VxFS. There are separate time limits for files and data blocks.

An example of the use of soft limits is when the user needs to run applications that might generate large temporary files. In cases like these, quota limit violations may be allowed for a limited duration. However, if the user continuously exceeds the soft limit, no further allocations are allowed after the expiration of the time limit.

The system administrator is responsible for assigning hard and soft limits to the users, as well as setting associated time limits. Although file and data block limits can be set individually for each user, the time limits apply to the file system as a whole. Quota information associated with user IDs is stored in a quotas file, as described in “Quotas File”.

Quotas File on VxFS

A *quotas* file (named quotas) must exist in the root directory of a file system for any of the quota commands to work. This is a BSD quotas implementation requirement, and is also applicable to VxFS quotas. The quotas file in the root directory is referred to as the *external quotas* file. VxFS also maintains an *internal quotas* file for its internal use.

The quota administration commands read and write the external quotas file to get or change usage limits. The internal quotas file is used to maintain counts of data blocks and inodes used by each user. When quotas are turned on, the quota limits are copied from the external quotas file into the internal quotas file. While quotas are on, all the changes in the usage information as well as changes to quotas are registered in the internal quotas file. When quotas are turned off, the contents of the internal quotas file are flushed into the external quotas file so that all data is in sync between the two files.

Quota Commands

NOTE Most of the quotas commands in VxFS (as with HFS) are similar to BSD quotas commands. However, the VxFS quotacheck command is an exception—it is not equivalent to the BSD quotacheck command.

In general, quota administration for VxFS is performed using commands similar to HFS quota commands. The VxFS mount command supports a special mount option (-o quota), which can be used to turn on quotas at mount time.

For additional information on the quota commands, see the corresponding manual pages.

quotacheck With VxFS

The standard practice with most quota implementations is to mount all file systems and then run a quotacheck on each one. quotacheck reads all the inodes on disk and calculates the usage for each user. This can be costly, and because the file system is mounted, the usage can change while quotacheck is running. VxFS does not support this quotacheck functionality.

With VxFS, quotacheck is automatically performed (if necessary) at the time quotas are turned on. A quotacheck is necessary if the file system has changed with respect to the usage information as recorded in the internal quotas file. This only happens if the file system has been written with quotas turned off or if there has been structural damage to the file system that required a full fsck.

quotacheck reads information for each inode off the disk and rebuilds the internal quotas file. It is possible that while quotas were not on, quota limits were changed by the system administrator. These changes are stored in the external quotas file. As part of enabling quotas processing, quota limits are read from the external quotas file into the internal quotas file.

Using Quotas

To use the quota functionality on a file system, quotas need to be turned on. Quotas can be turned on either at mount time or any time after a file system is mounted.

NOTE Before turning on quotas, the root directory of the file system must contain a file owned by root, called quotas.

Quotas can be turned on for a file system at mount time by giving an option to the mount command:

```
# mount -F vxfs -o quota special /mount_point
```

edquota is a quota editor. User quotas can be set up with the edquota command by the superuser:

```
# edquota username
```

edquota creates a temporary file for the given user; this file contains on-disk quotas for each mounted file system that has a quotas file. It is not necessary that quotas be turned on for edquota to work. However, the quota limits will be applicable only after quotas are turned on for a given file system.

The soft and hard limits can be modified or assigned desired values. For any user, usage can never exceed the hard limit.

Time limits can be modified using the command:

```
# edquota -t
```

Modified time limits apply to the entire file system and cannot be set selectively for each user.

The quota command can be used to view a user's disk quotas and usage on VxFS file systems:

```
# quota -v username
```

This displays the user's quotas and disk usage on all mounted VxFS file systems where the quotas file exists.

To turn off quotas for a mounted file system, enter:

```
# umount /mount_point
# mount -F vxfs special /mount_point
```

A Kernel Messages

Introduction

This appendix contains a listing of diagnostic or error messages generated by the VxFS file system kernel. Each message is accompanied by an explanation and a suggestion on how to handle or correct the underlying problem.

The following topics are covered in this chapter:

- "File System Response to Problems"
  - — "Marking an Inode Bad"
  - — "Disabling Transactions"
  - — "Disabling the File System"
  - — "Recovering a Disabled File System"
- "Kernel Messages"
  - — "Global Message IDs"

File System Response to Problems

When the file system encounters problems, it responds in one of three ways:

- marks an inode bad
- disables transactions
- disables the file system

Marking an Inode Bad

Inodes can be marked bad if an inode update or a directory-block update fails. In these types of failures, the file system doesn't know what information is on the disk, and considers all the information that it finds to be invalid. After an inode is marked bad, the kernel still permits access to the file name, but any attempt to access the data in the file or change the inode fails.

Disabling Transactions

If the file system detects an error while writing the intent log, it disables transactions. After transactions are disabled, the files in the file system can still be read or written, but no block or inode frees or allocations, structural changes, directory entry changes, or other changes to metadata are allowed.

Disabling the File System

If an error occurs that compromises the integrity of the file system, VxFS disables itself. If the intent log fails or an inode-list error occurs, the super-block is ordinarily updated (setting the VX_FULLFSCK flag) so that the next `fsck` does a full structural check. If this super-block update fails, any further changes to the file system can cause inconsistencies that are undetectable by the intent log replay. To avoid this situation, the file system disables itself.

Recovering a Disabled File System

When the file system is disabled, no data can be written to the disk.

Although some minor file system operations still work, most simply return EIO. The only thing that can be done when the file system is disabled is to do a umount and run a full fsck.

Although a log replay may produce a clean file system, do a full structural check to be safe. To do a full structural check, enter:

```
# fsck -F vxfs -o full -y /dev/rdsk/c1t0d0
```

The file system usually becomes disabled because of disk errors. Disk failures that disable a file system should be fixed as quickly as possible (see fsck_vxfs(1M)).

Kernel Messages

This section lists the VxFS kernel error messages in numerical order. The *Explanation* sub-section for each message describes the problem, the *Action* sub-section suggests possible solutions.

Each section lists the text of the message. In some cases, several variants of the same message are listed separately. In some cases, variants are shown together with a pipe symbol (|) separating the words that vary (for example, `read|write` means that the message will include either the word `read` or the word `write`). Text in *italic* font indicates text that will be replaced with a specific value in the message.

Global Message IDs

Each time a VxFS kernel message is displayed on the system console, it is displayed along with a monatomically increasing message ID, shown in the `msgcnt` field. This ID guarantees that the sequence of events is known in order to help analyze file system problems.

Each message is also written to an internal kernel buffer and can be viewed in the file `/var/adm/syslog/syslog.log` .

In some cases, additional data is written to the kernel buffer. For example, if an inode is marked bad, the contents of the bad inode are written. When an error message is displayed on the console, you can use the unique message ID to find the message in `/var/adm/syslog/syslog.log` and obtain the additional information.

Message 001

NOTICE: msgcnt x: vxfs: mesg 001: vx_nospace - *mount_point* file system full (n block extent)

- Explanation

  The file system is out of space.

  Often, there is plenty of space and one runaway process used up all the remaining free space. In other cases, the available free space becomes fragmented and unusable for some files.

- Action

  Monitor the free space in the file system and prevent it from

becoming full. If a runaway process has used up all the space, stop that process, find the files created by the process, and remove them. If the file system is out of space, remove files, defragment, or expand the file system.

To remove files, use the `find` command to locate the files that are to be removed. To get the most space with the least amount of work, remove large files or file trees that are no longer needed. To defragment or expand the file system, use `fsadm_vxfs`(1M).

Message 002

WARNING: msgcnt x: vxfs: mesg 002: vx_snap_strategy - *mount_point* file system write attempt to read-only file system
WARNING: msgcnt x: vxfs: mesg 002: vx_snap_copyblk - *mount_point* file system write attempt to read-only file system

- Explanation

  The kernel tried to write to a read-only file system. This is an unlikely problem, but if it occurs, the file system is disabled.

- Action

  The file system was not written, so no action is required. Report this as a bug to your customer support organization.

Message 003, 004, 005

WARNING: msgcnt x: vxfs: mesg 003: vx_mapbad - *mount_point* file system free extent bitmap in au *aun* marked bad
WARNING: msgcnt x: vxfs: mesg 004: vx_mapbad - *mount_point* file system free inode bitmap in au *aun* marked bad
WARNING: msgcnt x: vxfs: mesg 005: vx_mapbad - *mount_point* file system inode extended operation bitmap in au *aun* marked bad

- Explanation

  If there is an I/O failure while writing a bitmap, the map is marked bad. The kernel considers the maps to be invalid, so does not do any more resource allocation from maps. This situation can cause the file system to report `out of space` or `out of inode` error messages even though `df` may report an adequate amount of free space.

  This error may also occur due to bitmap inconsistencies. If a bitmap fails a consistency check, or blocks are freed that are already free in

the bitmap, the file system has been corrupted. This may have occurred because a user or process wrote directly to the device or used `fsdb` to change the file system.

The VX_FULLFSCK flag is set. If the map that failed was a free extent bitmap, and the VX_FULLFSCK flag can't be set, then the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Unmount the file system and use `fsck` to run a full structural check.

Message 006, 007

WARNING: msgcnt *x*: vxfs: mesg 006: vx_sumupd - *mount_point* file system summary update in au *aun* failed
WARNING: msgcnt *x*: vxfs: mesg 007: vx_sumupd - *mount_point* file system summary update in inode au *iaun* failed

- Explanation

  An I/O error occurred while writing the allocation unit or inode allocation unit bitmap summary to disk. This sets the VX_FULLFSCK flag on the file system. If the VX_FULLFSCK flag can't be set, the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem was caused by a disk failure, replace the disk before the file system is mounted for write access, and use `fsck` to run a full structural check.

Message 008, 009

WARNING: msgcnt *x*: vxfs: mesg 008: vx_direrr: *caller_id* - *mount_point* file system inode *inumber* block *blkno* error *errno*
WARNING: msgcnt *x*: vxfs: mesg 009: vx_direrr: *caller_id* - *mount_point* file system inode *inumber* immediate directory error *errno*

- Explanation

  A directory operation failed in an unexpected manner. *caller_id* identifies the routine that generated the message. The mount point, inode, and block number identify the failing directory. If the inode is

an immediate directory, the directory entries are stored in the inode, so no block number is reported. If the error is ENOENT or ENOTDIR, an inconsistency was detected in the directory block. This inconsistency could be a bad free count, a corrupted hash chain, or any similar directory structure error. If the error is EIO or ENXIO, an I/O failure occurred while reading or writing the disk block.

The VX_FULLFSCK flag is set in the super-block so that fsck will do a full structural check the next time it is run.

- Action

  Check the console log for I/O errors. If the problem was caused by a disk failure, replace the disk before the file system is mounted for write access. Unmount the file system and use fsck to run a full structural check.

Message 010 **WARNING: msgcnt *x*: vxfs: mesg 010: vx_ialloc - *mount_point* file system inode *inumber* not free**

- Explanation

  When the kernel allocates an inode from the free inode bitmap, it checks the mode and link count of the inode. If either is non-zero, the free inode bitmap or the inode list is corrupted.

  The VX_FULLFSCK flag is set in the super-block so that fsck will do a full structural check the next time it is run.

- Action

  Unmount the file system and use fsck to run a full structural check.

Message 011 **NOTICE: msgcnt *x*: vxfs: mesg 011: vx_noinode - *mount_point* file system out of inodes**

- Explanation

  The file system is out of inodes.

- Action

  Monitor the free inodes in the file system. If the file system is getting full, create more inodes either by removing files or by expanding the file system. File system resizing is described in “Online System Administration” in Chapter 1 , “The VxFS File System” and in fsadm_vxfs(1M).

Message 012 **WARNING: msgcnt *x*: vxfs: mesg 012: vx_iget - *mount_point* file system invalid inode number *inumber***

- Explanation

  When the kernel tries to read an inode, it checks the inode number against the valid range. If the inode number is out of range, the data structure that referenced the inode number is incorrect and must be fixed.

  The VX_FULLFSCK flag is set in the super-block so that `fsck` will do a full structural check the next time it is run.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 013 **`WARNING: msgcnt` *`x`*`: vxfs: mesg 013: vx_iposition - `*`mount_point`**` file system inode `*`inumber`**` invalid inode list extent`**

- Explanation

  For a Version 2 and above disk layout, the inode list is dynamically allocated. When the kernel tries to read an inode, it must look up the location of the inode in the inode list file. If the kernel finds a bad extent, the inode can't be accessed. All of the inode list extents are validated when the file system is mounted, so if the kernel finds a bad extent, the integrity of the inode list is questionable. This is a very serious error.

  The VX_FULLFSCK flag is set in the super-block and the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 014 **`WARNING: msgcnt `*`x`*`: vxfs: mesg 014: vx_iget - inode table overflow`**

- Explanation

  All the system in-memory inodes are busy and an attempt was made to use a new inode.

- Action

  Look at the processes that are running and determine which processes are using inodes. If it appears there are runaway processes, they might be tying up the inodes. If the system load appears normal, increase the `vx_ninode` parameter in the kernel (see "Internal Inode

Table Size" in Chapter 5 , "Performance and Tuning").

NOTE The tuneable parameter vx_ninode is used to set the value of vxfs_ninode.

Message 015

WARNING: msgcnt *x*: vxfs: mesg 015: vx_ibadinactive - *mount_point* file system can't mark inode *inumber* bad
WARNING: msgcnt *x*: vxfs: mesg 015: vx_ilisterr - *mount_point* file system can't mark inode *inumber* bad

- Explanation

  An attempt to mark an inode bad on disk, and the super-block update to set the VX_FULLFSCK flag, failed. This indicates that a catastrophic disk error may have occurred since both an inode list block and the super-block had I/O failures. The file system is disabled to preserve file system integrity.

- Action

  Unmount the file system and use fsck to run a full structural check. Check the console log for I/O errors. If the disk failed, replace it before remounting the file system.

Message 016

WARNING: msgcnt *x*: vxfs: mesg 016: vx_ilisterr - *mount_point* file system error reading inode *inumber*

- Explanation

  An I/O error occurred while reading the inode list. The VX_FULLFSCK flag is set.

- Action

  Check the console log for I/O errors. If the problem was caused by a disk failure, replace the disk before the file system is mounted for write access. Unmount the file system and use fsck to run a full structural check.

Message 017

WARNING: msgcnt *x*: vxfs: mesg 017: vx_attr_getblk - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_attr_iget - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_attr_indadd - *mount_point* file system inode *inumber* marked bad

WARNING: msgcnt *x*: vxfs: mesg 017: vx_attr_indtrunc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_attr_iremove - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_bmap - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_bmap_indirect_ext4 - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_delbuf_flush - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_dio_iovec - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_dirbread - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_dircreate - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_dirlook - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_doextop_iau - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_doextop_now - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_do_getpage - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_enter_ext4 - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_exttrunc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_get_alloc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_ilisterr - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_ilock - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_indtrunc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_iread - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_iremove - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_iremove_attr - *mount_point* file system inode *inumber* marked bad

WARNING: msgcnt *x*: vxfs: mesg 017: vx_logwrite_flush - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_oltmount_iget - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_overlay_bmap - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_readnomap - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_reorg_trunc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_stablestore - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_tranitimes - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_trunc - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_write_alloc2 - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_write_default - *mount_point* file system inode *inumber* marked bad
WARNING: msgcnt *x*: vxfs: mesg 017: vx_zero_alloc - *mount_point* file system inode *inumber* marked bad

- Explanation

  When inode information is no longer dependable, the kernel marks it bad on disk. The most common reason for marking an inode bad is a disk I/O failure. If there is an I/O failure in the inode list, on a directory block, or an indirect address extent, the integrity of the data in the inode, or the data the kernel tried to write to the inode list, is questionable. In these cases, the disk driver prints an error message and one or more inodes are marked bad.

  The kernel also marks an inode bad if it finds a bad extent address, invalid inode fields, or corruption in directory data blocks during a validation check. A validation check failure indicates the file system has been corrupted. This usually occurs because a user or process has written directly to the device or used `fsdb` to change the file system.

  The `VX_FULLFSCK` flag is set in the super-block so `fsck` will do a full structural check the next time it is run.

- Action

  Check the console log for I/O errors. If the problem is a disk failure,

replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process is writing to the device, report the problem to your customer support organization. In either case, unmount the file system and use `fsck` to run a full structural check.

Message 019 **`WARNING: msgcnt x: vxfs: mesg 019: vx_log_add - mount_point file system log overflow`**

- Explanation

  Log ID overflow. When the log ID reaches `VX_MAXLOGID` (approximately one billion by default), a flag is set so the file system resets the log ID at the next opportunity. If the log ID has not been reset, when the log ID reaches `VX_DISLOGID` (approximately `VX_MAXLOGID` plus 500 million by default), the file system is disabled. Since a log reset will occur at the next 60 second sync interval, this should never happen.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 020 **`WARNING: msgcnt x: vxfs: mesg 020: vx_logerr - mount_point file system log error errno`**

- Explanation

  Intent log failed. The kernel will try to set the `VX_FULLFSCK` and `VX_LOGBAD` flags in the super-block to prevent running a log replay. If the super-block can't be updated, the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Check the console log for I/O errors. If the disk failed, replace it before remounting the file system.

Message 021 **`WARNING: msgcnt x: vxfs: mesg 021: vx_fs_init - mount_point file system validation failure`**

- Explanation

  When a VxFS file system is mounted, the structure is read from disk. If the file system is marked clean, the structure is correct and the first block of the intent log is cleared.

  If there is any I/O problem or the structure is inconsistent, the kernel

sets the VX_FULLFSCK flag and the mount fails.

If the error isn't related to an I/O failure, this may have occurred because a user or process has written directly to the device or used `fsdb` to change the file system.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process is writing to the device, report the problem to your customer support organization. In either case, unmount the file system and use `fsck` to run a full structural check.

Message 022 **`WARNING: msgcnt x: vxfs: mesg 022: vx_mountroot - root file system remount failed`**

- Explanation

  The remount of the root file system failed. The system will not be usable if the root file system can't be remounted for read/write access.

  When a VxFS root file system is first mounted, it is mounted for read-only access. After `fsck` is run, the file system is remounted for read/write access. The remount fails if `fsck` completed a resize operation or modified a file that was opened before the `fsck` was run. It also fails if an I/O error occurred during the remount.

  Usually, the system halts or reboots automatically.

- Action

  Reboot the system. The system either remounts the root cleanly or runs a full structural `fsck` and remounts cleanly. If the remount succeeds, no further action is necessary.

  Check the console log for I/O errors. If the disk has failed, replace it before the file system is mounted for write access.

  If the system won't come up and a full structural `fsck` hasn't been run, reboot the system on a backup root and manually run a full structural `fsck`. If the problem persists after the full structural `fsck` and there are no I/O errors, contact your customer support organization.

Message 023 **`WARNING: msgcnt x: vxfs: mesg 023: vx_unmountroot - root file system is busy and can't be unmounted cleanly`**

- Explanation

  There were active files in the file system and they caused the unmount to fail.

  When the system is halted, the root file system is unmounted. This happens occasionally when a process is hung and it can't be killed before unmounting the root.

- Action

  fsck will run when the system is rebooted. It should clean up the file system. No other action is necessary.

  If the problem occurs every time the system is halted, determine the cause and contact your customer support organization.

Message 024 **WARNING: msgcnt *x*: vxfs: mesg 024: vx_cutwait - *mount_point* file system current usage table update error**

- Explanation

  Update to the current usage table (CUT) failed.

  For a Version 2 disk layout, the CUT contains a fileset version number and total number of blocks used by each fileset.

  The VX_FULLFSCK flag is set in the super-block. If the super-block can't be written, the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 025 **WARNING: msgcnt *x*: vxfs: mesg 025: vx_wsuper - *mount_point* file system super_block update failed**

- Explanation

  An I/O error occurred while writing the super-block during a resize operation. The file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Check the console log for I/O errors. If the problem is a disk failure, replace the disk before the file system is mounted for write access.

Message 026 **WARNING: msgcnt *x*: vxfs: mesg 026: vx_snap_copyblk - *mount_point* primary file system read error**

- Explanation

  Snapshot file system error.

  When the primary file system is written, copies of the original data must be written to the snapshot file system. If a read error occurs on a primary file system during the copy, any snapshot file system that doesn't already have a copy of the data is out of date and must be disabled.

- Action

  An error message for the primary file system prints. Resolve the error on the primary file system and rerun any backups or other applications that were using the snapshot that failed when the error occurred.

Message 027 **WARNING: msgcnt *x*: vxfs: mesg 027: vx_snap_bpcopy - *mount_point* snapshot file system write error**

- Explanation

  A write to the snapshot file system failed.

  As the primary file system is updated, copies of the original data are read from the primary file system and written to the snapshot file system. If one of these writes fails, the snapshot file system is disabled.

- Action

  Check the console log for I/O errors. If the disk has failed, replace it. Resolve the error on the disk and rerun any backups or other applications that were using the snapshot that failed when the error occurred.

Message 028 **WARNING: msgcnt *x*: vxfs: mesg 028: vx_snap_alloc - *mount_point* snapshot file system out of space**

- Explanation

  The snapshot file system ran out of space to store changes.

  During a snapshot backup, as the primary file system is modified, the original data is copied to the snapshot file system. This error can occur if the snapshot file system is left mounted by mistake, if the snapshot file system was given too little disk space, or the primary file system had an unexpected burst of activity. The snapshot file system is disabled.

- Action

  Make sure the snapshot file system was given the correct amount of space. If it was, determine the activity level on the primary file system. If the primary file system was unusually busy, rerun the backup. If the primary file system is no busier than normal, move the backup to a time when the primary file system is relatively idle or increase the amount of disk space allocated to the snapshot file system.

  Rerun any backups that failed when the error occurred.

Message 029, 030

WARNING: msgcnt *x*: vxfs: mesg 029: vx_snap_getbp - *mount_point* snapshot file system block map write error
WARNING: msgcnt *x*: vxfs: mesg 030: vx_snap_getbp - *mount_point* snapshot file system block map read error

- Explanation

  During a snapshot backup, each snapshot file system maintains a block map on disk. The block map tells the snapshot file system where data from the primary file system is stored in the snapshot file system. If an I/O operation to the block map fails, the snapshot file system is disabled.

- Action

  Check the console log for I/O errors. If the disk has failed, replace it. Resolve the error on the disk and rerun any backups that failed when the error occurred.

Message 031

WARNING: msgcnt *x*: vxfs: mesg 031: vx_disable - *mount_point* file system disabled

- Explanation

  File system disabled, preceded by a message that specifies the reason. This usually indicates a serious disk problem.

- Action

  Unmount the file system and use `fsck` to run a full structural check. If the problem is a disk failure, replace the disk before the file system is mounted for write access.

Message 032

WARNING: msgcnt *x*: vxfs: mesg 032: vx_disable - *mount_point* snapshot file system disabled

- Explanation

Snapshot file system disabled, preceded by a message that specifies the reason.

- Action

  Unmount the snapshot file system, correct the problem specified by the message, and rerun any backups that failed due to the error.

Message 033 **WARNING: msgcnt *x*: vxfs: mesg 033: vx_check_badblock - *mount_point* file system had an I/O error, setting VX_FULLFSCK**

- Explanation

  When the disk driver encounters an I/O error, it sets a flag in the super-block structure. If the flag is set, the kernel will set the VX_FULLFSCK flag as a precautionary measure. Since no other error has set the VX_FULLFSCK flag, the failure probably occurred on a data block.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Check the console log for I/O errors. If the problem is a disk failure, replace the disk before the file system is mounted for write access.

Message 034 **WARNING: msgcnt *x*: vxfs: mesg 034: vx_resetlog - *mount_point* file system can't reset log**

- Explanation

  The kernel encountered an error while resetting the log ID on the file system. This happens only if the super-block update or log write encountered a device failure. The file system is disabled to preserve its integrity.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Check the console log for I/O errors. If the problem is a disk failure, replace the disk before the file system is mounted for write access.

Message 035 **WARNING: msgcnt *x*: vxfs: mesg 035: vx_inactive - *mount_point* file system inactive of locked inode *inumber***

- Explanation

  VOP_INACTIVE was called for an inode while the inode was being used. This should never happen, but if it does, the file system is

disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Report as a bug to your customer support organization.

Message 036 **WARNING: msgcnt *x*: vxfs: mesg 036: vx_lctbad - *mount_point* file system link count table *lctnumber* bad**

- Explanation

  Update to the link count table (LCT) failed.

  For a Version 2 and above disk layout, the LCT contains the link count for all the structural inodes. The VX_FULLFSCK flag is set in the super-block. If the super-block can't be written, the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 037 **WARNING: msgcnt *x*: vxfs: mesg 037: vx_metaioerr - *mount_point* file system meta data read|write error**

- Explanation

  A read or a write error occurred while accessing file system metadata. The full `fsck` flag on the file system was set. The message specifies whether the disk I/O that failed was a read or a write.

  File system metadata includes inodes, directory blocks, and the file system log. If the error was a write error, it is likely that some data was lost. This message should be accompanied by another file system message describing the particular file system metadata affected, as well as a message from the disk driver containing information about the disk I/O error.

- Action

  Resolve the condition causing the disk error. If the error was the result of a temporary condition (such as accidentally turning off a disk or a loose cable), correct the condition. Check for loose cables, etc. Unmount the file system and use `fsck` to run a full structural check (possibly with loss of data).

  In case of an actual disk error, if it was a read error and the disk driver remaps bad sectors on write, it may be fixed when `fsck` is run

since fsck is likely to rewrite the sector with the read error. In other cases, you replace or reformat the disk drive and restore the file system from backups. Consult the documentation specific to your system for information on how to recover from disk errors. The disk driver should have printed a message that may provide more information.

Message 038 **WARNING: msgcnt *x*: vxfs: mesg 038: vx_dataioerr - *mount_point* file system file data read|write error**

- Explanation

  A read or a write error occurred while accessing file data. The message specifies whether the disk I/O that failed was a read or a write. File data includes data currently in files and free blocks. If the message is printed because of a read or write error to a file, another message that includes the inode number of the file will print. The message may be printed as the result of a read or write error to a free block, since some operations allocate an extent and immediately perform I/O to it. If the I/O fails, the extent is freed and the operation fails. The message is accompanied by a message from the disk driver regarding the disk I/O error.

- Action

  Resolve the condition causing the disk error. If the error was the result of a temporary condition (such as accidentally turning off a disk or a loose cable), correct the condition. Check for loose cables, etc. If any file data was lost, restore the files from backups. Determine the file names from the inode number (see ncheck_vxfs(1M) for more information.)

  If an actual disk error occurred, make a backup of the file system, replace or reformat the disk drive, and restore the file system from the backup. Consult the documentation specific to your system for information on how to recover from disk errors. The disk driver should have printed a message that may provide more information.

Message 039 **WARNING: msgcnt *x*: vxfs: mesg 039: vx_writesuper - *mount_point* file system super-block write error**

- Explanation

  An attempt to write the file system super block failed due to a disk I/O error. If the file system was being mounted at the time, the mount will fail. If the file system was mounted at the time and the full fsck

flag was being set, the file system will probably be disabled and Message 031 will also be printed. If the super-block was being written as a result of a sync operation, no other action is taken.

- Action

  Resolve the condition causing the disk error. If the error was the result of a temporary condition (such as accidentally turning off a disk or a loose cable), correct the condition. Check for loose cables, etc. Unmount the file system and use fsck to run a full structural check.

  If an actual disk error occurred, make a backup of the file system, replace or reformat the disk drive, and restore the file system from backups. Consult the documentation specific to your system for information on how to recover from disk errors. The disk driver should have printed a message that may provide more information.

Message 040 **WARNING: msgcnt *x*: vxfs: mesg 040: vx_dqbad - *mount_point* file system quota file update error for id *id*.**

- Explanation

  An update to the user quotas file failed for the user ID.

  The quotas file keeps track of the total number of blocks and inodes used by each user, and also contains soft and hard limits for each user ID. The VX_FULLFSCK flag is set in the super-block. If the super-block cannot be written, the file system is disabled.

- Action

  Unmount the file system and use fsck to run a full structural check. Check the console log for I/O errors. If the disk has a hardware failure, it should be repaired before the file system is mounted for write access.

Message 041 **WARNING: msgcnt *x*: vxfs: mesg 041: vx_dqget - *mount_point* file system quota file can't read quota for id *id***

- Explanation

  A read of the user quotas file failed for the uid.

  The quotas file keeps track of the total number of blocks and inodes used by each user, and contains soft and hard limits for each user ID. The VX_FULLFSCK flag is set in the super-block. If the super-block

cannot be written, the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check. Check the console log for I/O errors. If the disk has a hardware failure, it should be repaired before the file system is mounted for write access.

Message 042 **WARNING: msgcnt *x*: vxfs: mesg 042: vx_bsdquotaupdate - *mount_point* file system user|group *id* disk limit reached.**

- Explanation

  The hard limit on blocks was reached. Further attempts to allocate blocks for files owned by the user will fail.

- Action

  Remove some files to free up space.

Message 043 **WARNING: msgcnt *x*: vxfs: mesg 043: vx_bsdquotaupdate - *mount_point* file system user|group *id* disk quota exceeded too long**

- Explanation

  The soft limit on blocks was exceeded continuously for longer than the soft quota time limit. Further attempts to allocate blocks for files will fail.

- Action

  Remove some files to free up space.

Message 044 **WARNING: msgcnt *x*: vxfs: mesg 044: vx_bsdquotaupdate - warning: *mount_point* file system user|group *id* disk quota exceeded.**

- Explanation

  The soft limit on blocks is exceeded. The soft limit can be exceeded for a certain amount of time before allocations begin to fail. Once the soft quota time limit has expired, further attempts to allocate blocks for files will fail.

- Action

  Remove some files to free up space.

Message 045

WARNING: msgcnt *x*: vxfs: mesg 045: vx_bsdiquotaupdate - *mount_point* file system user|group *id* inode limit reached.

- Explanation

  The hard limit on inodes was exceeded. Further attempts to create files owned by the user will fail.

- Action

  Remove some files to free inodes.

Message 046

WARNING: msgcnt *x*: vxfs: mesg 046: vx_bsdiquotaupdate - *mount_point* file system user|group *id* inode quota exceeded too long

- Explanation

  The soft limit on inodes has been exceeded continuously for longer than the soft quota time limit. Further attempts to create files owned by the user will fail.

- Action

  Remove some files to free inodes.

Message 047

WARNING: msgcnt *x*: vxfs: mesg 047: vx_bsdiquotaupdate - warning: *mount_point* file system user|group *id* inode quota exceeded

- Explanation

  The soft limit on inodes was exceeded. The soft limit can be exceeded for a certain amount of time before attempts to create new files begin to fail. Once the time limit has expired, further attempts to create files owned by the user will fail.

- Action

  Remove some files to free inodes.

Message 048, 049

WARNING: msgcnt *x*: vxfs: mesg 048: vx_dqread - warning: *mount_point* file system external user|group quota file read failed
WARNING: msgcnt *x*: vxfs: mesg 049: vx_dqwrite - warning: *mount_point* file system external user|group quota file write failed.

- Explanation

To maintain reliable usage counts, VxFS maintains the user and group quotas files as structural files in the structural fileset. These files are updated as part of the transactions that allocate and free blocks and inodes. For compatibility with the quota administration utilities, VxFS also supports the standard user visible quota files.

When quotas are turned off, synced, or new limits are added, VxFS tries to update the external quota files. When quotas are enabled, VxFS tries to read the quota limits from the external quotas file. If these reads or writes fail, the external quotas file is out of date.

- Action

  Determine the reason for the failure on the external quotas file and correct it. Recreate the quotas file.

Message 050, 051, 052, 053, 054, 055

- These messages do not apply to HP-UX systems.

Message 056

WARNING: msgcnt *x*: vxfs: mesg 056: vx_mapbad - *mount_point* file system extent allocation unit state bitmap number *number* marked bad

- Explanation

  If there is an I/O failure while writing a bitmap, the map is marked bad. The kernel considers the maps to be invalid, so does not do any more resource allocation from maps. This situation can cause the file system to report “out of space” or “out of inode” error messages even though `df` may report an adequate amount of free space.

  This error may also occur due to bitmap inconsistencies. If a bitmap fails a consistency check, or blocks are freed that are already free in the bitmap, the file system has been corrupted. This may have occurred because a user or process wrote directly to the device or used `fsdb` to change the file system.

  The VX_FULLFSCK flag is set. If the VX_FULLFSCK flag can’t be set, the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Unmount the file system and use `fsck` to run a full

structural check.

Message 057 **WARNING: msgcnt *x*: vxfs: mesg 057: vx_esum_bad - *mount_point* file system extent allocation unit summary number *number* marked bad**

- Explanation

  An I/O error occurred reading or writing an extent allocation unit summary.

  The VX_FULLFSCK flag is set. If the VX_FULLFSCK flag can't be set, the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Unmount the file system and use fsck to run a full structural check.

Message 058 **WARNING: msgcnt *x*: vxfs: mesg 058: vx_isum_bad - *mount_point* file system inode allocation unit summary number *number* marked bad**

- Explanation

  An I/O error occurred reading or writing an inode allocation unit summary.

  The VX_FULLFSCK flag is set. If the VX_FULLFSCK flag cannot be set, the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Unmount the file system and use fsck to run a full structural check.

Message 059 **WARNING: msgcnt *x*: vxfs: mesg 059: vx_snap_getbitbp - *mount_point* snapshot file system bitmap write error**

- Explanation

An I/O error occurred while writing to the snapshot file system bitmap. There is no problem with the snapped file system, but the snapshot file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Restart the snapshot on an error free disk partition. Rerun any backups that failed when the error occurred.

Message 060 **WARNING: msgcnt *x*: vxfs: mesg 060: vx_snap_getbitbp - *mount_point* snapshot file system bitmap read error**

- Explanation

  An I/O error occurred while reading the snapshot file system bitmap. There is no problem with snapped file system, but the snapshot file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process was writing to the device, report the problem to your customer support organization. Restart the snapshot on an error free disk partition. Rerun any backups that failed when the error occurred.

Message 061 **WARNING: msgcnt *x*: vxfs: mesg 061: vx_resize - *mount_point* file system remount failed**

- Explanation

  During a file system resize, the remount to the new size failed. The VX_FULLFSCK flag is set and the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check. After the check, the file system shows the new size.

Message 062 **NOTICE: msgcnt *x*: vxfs: mesg 062: vx_attr_creatop - invalid disposition returned by attribute driver**

- Explanation

A registered extended attribute intervention routine returned an invalid return code to the VxFS driver during extended attribute inheritance.

- Action

  Determine which vendor supplied the registered extended attribute intervention routine and contact their customer support organization.

Message 063 **WARNING: msgcnt *x*: vxfs: mesg 063: vx_fset_markbad - *mount_point* file system *mount_point* fileset (index *number*) marked bad**

- Explanation

  An error occurred while reading or writing a fileset structure. VX_FULLFSCK flag is set. If the VX_FULLFSCK flag can't be set, the file system is disabled.

- Action

  Unmount the file system and use `fsck` to run a full structural check.

Message 064 **WARNING: msgcnt *x*: vxfs: mesg 064: vx_ivalidate - *mount_point* file system inode *number* version number exceeds fileset's**

- Explanation

  During inode validation, a discrepancy was found between the inode version number and the fileset version number. The inode may be marked bad, or the fileset version number may be changed, depending on the ratio of the mismatched version numbers.

  VX_FULLFSCK flag is set. If the VX_FULLFSCK flag can't be set, the file system is disabled.

- Action

  Check the console log for I/O errors. If the problem is a disk failure, replace the disk. If the problem is not related to an I/O failure, find out how the disk became corrupted. If no user or process is writing to the device, report the problem to your customer support organization. In either case, unmount the file system and use `fsck` to run a full structural check.

Message 066 **NOTICE: msgcnt *x*: vxfs: mesg 066: DMAPI mount event - *buffer***

- Explanation

  An HSM (Hierarchical Storage Management) agent responded to a DMAPI mount event and returned a message in *buffer*.

- Action

  Consult the HSM product documentation for the appropriate response to the message.

Message 067 **WARNING: msgcnt *x*: vxfs: mesg 067: mount of *device_path* requires HSM agent**

- Explanation

  The file system mount failed because the file system was marked as being under the management of an HSM agent, and no HSM agent was found during the mount.

- Action

  Restart the HSM agent and try to mount the file system again.

Message 068 **WARNING: msgcnt *x*: vxfs: mesg 068: ncsize parameter is greater than 80% of the vxfs_ninode parameter; increasing the value of vxfs:vxfs_ninode**

- Explanation

  The value auto-tuned for the vx_ninode parameter is less than 125% of the ncsize parameter. This message occurs only if one of the system tuneable parameters—ncsize, vx_ninode, maxusers, or max_nprocs—is set manually in the file /etc/system.

- Action

  To prevent this message from occurring, set vx_ninode to at least 125% of the value of ncsize. The best way to do this is to adjust ncsize down, rather than adjusting vx_ninode up. For more information on performance and tuning, see Chapter 5 , “Performance and Tuning”.

NOTE The tuneable parameter vx_ninode is used to set the value of vxfs_ninode.

Message 069 **WARNING: msgcnt *x*: vxfs: mesg 069: memory usage**

specified by the vxfs:vxfs_ninode and vxfs:vx_bc_bufhwm parameters exceeds available memory; the system may hang under heavy load

- Explanation

  The value of the system tuneable parameters—vx_ninode and vx_bc_bufhwm—add up to a value that is more than 66% of the kernel virtual address space or more than 50% of the physical system memory. VxFS inodes require approximately one kilobyte each, so both values can be treated as if they are in units of one kilobyte.

- Action

  To avoid a system hang, reduce the value of one or both parameters to less than 50% of physical memory or to 66% of kernel virtual memory. For more information on performance and tuning, see Chapter 5 , “Performance and Tuning”.

NOTE The tuneable parameter vx_ninode is used to set the value of vxfs_ninode.

Message 070 **WARNING: msgcnt *x*: vxfs: mesg 070: checkpoint *checkpoint_name* removed from file system *mount_point***

- Explanation

  The file system ran out of space while updating a checkpoint. The checkpoint was removed to allow the operation to complete.

- Action

  Increase the size of the file system. If the file system size cannot be increased, remove files to create sufficient space for new checkpoints. Monitor capacity of the file system closely to ensure it does not run out of space. See fsadm_vxfs(1M) for more information.

Message 071 **NOTICE: msgcnt *x*: vxfs: mesg 071: cleared data I/O error flag in *mount_point* file system**

- Explanation

  The user data I/O error flag was reset when the file system was mounted. This message indicates e that a read or write error occurred (see “Message 038”) while the file system was previously mounted.

- Action

  Informational only, no action required.

Glossary

access control list (ACL) The information that identifies specific users or groups and their access privileges for a particular file or directory.

allocation unit A group of consecutive blocks on a file system that contain resource summaries, free resource maps, and data blocks. Allocation units also contain copies of the super-block.

asynchronous writes A delayed write in which the data is written to a page in the system's page cache, but is not written to disk before the write returns to the caller. This improves performance, but carries the risk of data loss if the system crashes before the data is flushed to disk.

buffered I/O During a read or write operation, data usually goes through an intermediate kernel buffer before being copied between the user buffer and disk. If the same data is repeatedly read or written, this kernel buffer acts as a cache, which can improve performance. See *unbuffered I/O* and *direct I/O*.

contiguous file A file in which data blocks are physically adjacent on the underlying media.

current usage table A table containing fileset information, such as the number of blocks currently used by the fileset. Not used in the Version 3 or 4 disk layout.

data block A block that contains the actual data belonging to files and directories.

data synchronous writes A form of synchronous I/O that writes the file data to disk before the write returns, but only marks the inode for later update. If the file size changes, the inode will be written before the write returns. In this mode, the file data is guaranteed to be on the disk before the write returns, but the inode modification times may be lost if the system crashes.

defragmentation The process of reorganizing data on disk by making file data blocks physically adjacent to reduce access times.

direct extent An extent that is referenced directly by an inode.

direct I/O An unbuffered form of I/O that bypasses the kernel's buffering of data. With direct I/O, the file system transfers data directly between the disk and the user-supplied buffer. See *buffered I/O* and *unbuffered I/O*.

discovered direct I/O Discovered Direct I/O behavior is similar to direct I/O and has the same alignment constraints, except writes that allocate storage or extend the file size do not require writing the inode changes before returning to the application.

extent A group of contiguous file system data blocks treated as a single unit. An extent is defined by the address of the starting block and a length.

extent attribute A policy that determines how a file allocates extents.

external quotas file A quotas file (named quotas) must exist in the root directory of a file system for quota-related commands to work. See *quotas file* and *internal quotas file*.

file system block The fundamental minimum size of allocation in a file system. This is equivalent to the HFS fragment size.

fileset A collection of files within a file system.

fixed extent size An extent attribute used to override the default allocation policy of the file system and set all allocations for a file to a specific fixed size.

GB Gigabyte (230 bytes or 1024 megabytes).

hard limit The hard limit is an absolute limit on system resources for individual users for file and data block usage on a file system. See *quota*.

I/O clustering The grouping of multiple I/O operations to achieve better performance.

indirect address extent An extent that contains references to other extents, as opposed to file data itself. A *single* indirect address extent references indirect data extents. A *double* indirect address extent references single indirect address extents.

indirect data extent An extent that contains file data and is referenced via an indirect address extent.

inode A unique identifier for each file within a file system that contains the data and metadata associated with that file.

inode allocation unit A group of consecutive blocks containing inode allocation information for a given fileset. This information is in the form of a resource summary and a free inode map.

intent logging A method of recording pending changes to the file system structure. These changes are recorded in a circular *intent log* file.

internal quotas file VxFS maintains an internal quotas file for its internal usage. The internal quotas file maintains counts of blocks and inodes used by each user. See *quotas* and *external quotas file*.

K Kilobyte (210 bytes or 1024 bytes).

large file A file larger than two gigabytes. VxFS supports files up to one terabyte in size.

large file system A file system more than two gigabytes in size. VxFS supports file systems up to one terabyte in size.

latency For file systems, this typically refers to the amount of time it takes a given file system operation to return to the user.

metadata Structural data describing the attributes of files on a disk.

MB Megabyte (2^{20} bytes or 1024 kilobytes).

object location table (OLT) The information needed to locate important file system structural elements. The OLT is written to a fixed location on the underlying media (or disk).

object location table replica A copy of the OLT in case of data corruption. The OLT replica is written to a fixed location on the underlying media (or disk).

page file A fixed-size block of virtual address space that can be mapped

onto any of the physical addresses available on a system.

preallocation A method of allowing an application to guarantee that a specified amount of space is available for a file, even if the file system is otherwise out of space.

primary fileset The files that are visible and accessible to the user.

quotas Quota limits on system resources for individual users for file and data block usage on a file system. See *hard limit* and *soft limit*.

quotas file The quotas commands read and write the external quotas file to get or change usage limits. When quotas are turned on, the quota limits are copied from the external quotas file to the internal quotas file. See *quotas*, *internal quotas file*, and *external quotas file*.

reservation An extent attribute used to preallocate space for a file.

snapshot file system An exact copy of a mounted file system at a specific point in time. Used to do online backups.

snapped file system A file system whose exact image has been used to create a snapshot file system.

soft limit The soft limit is lower than a hard limit. The soft limit can be exceeded for a limited time. There are separate time limits for files and blocks. See *hard limit* and *quota*.

storage checkpoint A facility that provides a consistent and stable view of a file system or database image and keeps track of modified data blocks since the last checkpoint.

structural fileset The files that define the structure of the file system. These files are not visible or accessible to the user.

super-block A block containing critical information about the file system such as the file system type, layout, and size. The VxFS super-block is always located 8192 bytes from the beginning of the file system and is 8192 bytes long.

synchronous writes A form of synchronous I/O that writes the file data to disk, updates the inode times, and writes the updated inode to

disk. When the write returns to the caller, both the data and the inode have been written to disk.

TB Terabyte (240 bytes or 1024 gigabytes).

transaction Updates to the file system structure that are grouped together to ensure they are all completed

throughput For file systems, this typically refers to the number of I/O operations in a given unit of time.

I/O I/O that bypasses the kernel cache to increase I/O performance. This is similar to direct I/O, except when a file is extended; for direct I/O, the inode is written to disk synchronously, for unbuffered I/O, the inode update is delayed. See *buffered I/O* and *direct I/O*.

volume A virtual disk which represents an addressable range of disk blocks used by applications such as file systems or databases.

vxfs The name of the VERITAS File System type

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