Veritas™ File System Administrator's Guide

Linux

5.1

Veritas File System Administrator's Guide

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Chapter 8

Introducing Veritas File System

This chapter includes the following topics:

- About Veritas File System
- Veritas File System features
- Veritas File System performance enhancements
- Using Veritas File System

About Veritas File System

A file system is simply a method for storing and organizing computer files and the data they contain to make it easy to find and access them. More formally, a file system is a set of abstract data types (such as metadata) that are implemented for the storage, hierarchical organization, manipulation, navigation, access, and retrieval of data.

Veritas File System (VxFS) was the first commercial journaling file system. With journaling, metadata changes are first written to a log (or journal) then to disk. Since changes do not need to be to be written in multiple places, throughput is much faster as the metadata is written asynchronously.

VxFS is also an extent-based, intent logging file system. VxFS is designed for use in operating environments that require high performance and availability and deal with large amounts of data.

VxFS major components include:

- Logging
- Extents

- File system disk layouts

Logging

A key aspect of any file system is how to recover if a system crash occurs. Earlier methods required a time-consuming scan of the entire file system. A better solution is the method of logging (or journaling) the metadata of files.

VxFS logs new attribute information into a reserved area of the file system, whenever file system changes occur. The file system writes the actual data to disk only after the write of the metadata to the log is complete. If and when a system crash occurs, the system recovery code analyzes the metadata log and tries to clean up only those files. Without logging, a file system check (`fsck`) must look at all of the metadata.

Intent logging minimizes system downtime after abnormal shutdowns by logging file system transactions. When the system is halted unexpectedly, this log can be replayed and outstanding transactions completed. The check and repair time for file systems can be reduced to a few seconds, regardless of the file system size.

By default, VxFS file systems log file transactions before they are committed to disk, reducing time spent checking and repairing file systems after the system is halted unexpectedly.

Extents

An extent is a contiguous area of storage in a computer file system, reserved for a file. When starting to write to a file, a whole extent is allocated. When writing to the file again, the data continues where the previous write left off. This reduces or eliminates file fragmentation.

Since VxFS is an extent-based file system, addressing is done through extents (which can consist of multiple blocks) rather than in single-block segments. Extents can therefore enhance file system throughput.

File system disk layouts

The disk layout is the way file system information is stored on disk. On VxFS, several disk layout versions, numbered 1 through 7, were created to support various new features and specific UNIX environments. Currently, only the Version 6 and 7 disk layouts are supported.

Veritas File System features

VxFS includes the following features:

- Extent-based allocation

  Extents allow disk I/O to take place in units of multiple blocks if storage is allocated in consecutive blocks.
- Extent attributes

  Extent attributes are the extent allocation policies associated with a file.
- Fast file system recovery

  VxFS provides fast recovery of a file system from system failure.
- 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, and large file sizes.
- Enhanced performance mode

  VxFS provides mount options to improve performance.
- Large files and file systems support

  VxFS supports files larger than two gigabytes and large file systems up to 256 terabytes.
- Storage Checkpoints

  Backup and restore applications can leverage Storage Checkpoint, a disk- and I/O-efficient copying technology for creating periodic frozen images of a file system.

  See the *Veritas Storage Foundation Advanced Features Administrator's Guide*.
- Online backup

  VxFS provides online data backup using the snapshot feature.
- Quotas

  VxFS supports quotas, which allocate per-user and per-group quotas and limit the use of two principal resources: files and data blocks.
- Cluster File System

  Clustered file systems are an extension of VxFS that support concurrent direct media access from multiple systems.
- Improved database performance
- Cross-platform data sharing

  Cross-platform data sharing allows data to be serially shared among heterogeneous systems where each system has direct access to the physical devices that hold the data.

  See the *Veritas Storage Foundation Advanced Features Administrator's Guide*.
- File Change Log

The VxFS File Change Log tracks changes to files and directories in a file system.

- Multi-volume support

  The multi-volume support feature allows several volumes to be represented by a single logical object.

- Dynamic Storage Tiering

  The Dynamic Storage Tiering (DST) option allows you to configure policies that automatically relocate files from one volume to another, or relocate files by running file relocation commands, which can improve performance for applications that access specific types of files.

  See the *Veritas Storage Foundation Advanced Features Administrator's Guide*.

- Storage Foundation Thin Reclamation

  The Thin Reclamation feature allows you to release free data blocks of a VxFS file system to the free storage pool of a Thin Storage LUN. This feature is only supported on file systems mounted on a VxVM volume.

  See the *Veritas Storage Foundation Advanced Features Administrator's Guide*.

Extent-based allocation

Disk space is allocated in 512-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 system sizes of up to 1 TB, and 8K for file system sizes 1 TB or larger.

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.

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.

Extent allocation only slightly alters the interpretation of addressed blocks from the inode structure compared to block based inodes. A VxFS inode references 10 direct extents, each of which are pairs of starting block addresses and lengths in blocks.

The VxFS inode supports different types of extents, namely `ext4` and `typed`. Inodes with `ext4` extents also point to two indirect address extents, which contain the addresses of first and second extents:

first	Used for single indirection. Each entry in the extent indicates the starting block number of an indirect data extent
second	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. By default, regular file inodes also use an 8K indirect data extent size that can be altered with `vxtunefs`; these inodes allocate the indirect data extents in clusters to simulate larger extents.

Typed extents

VxFS has an 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	Identifies uniquely 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	Is the starting file system block of the extent.
number of blocks	Is the number of contiguous blocks in the extent.

`Typed` extents have the following characteristics:

- 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 optimized I/O in VxFS.
- 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 and directories 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. VxFS 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.

See the `setext`(1) and `getext`(1) manual pages.

The `vxtunefs` command allows the administrator to set or view the default indirect data extent size of a file system.

See the `vxtunefs`(1M) manual page.

Fast file system recovery

Most file systems rely on full structural verification by the `fsck` utility as the only means to recover from a system failure. For large disk configurations, this involves a time-consuming process of checking the entire structure, verifying that the file system is intact, and correcting any inconsistencies. VxFS provides fast recovery with the VxFS intent log and VxFS intent log resizing features.

VxFS intent log

VxFS reduces system failure recovery times by tracking file system activity in the VxFS intent log. This feature records pending changes to the file system structure in a circular intent log. The intent log recovery feature is not readily apparent to users or a system administrator except during a system failure. 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. Replaying the intent log may not completely recover the damaged file system structure if there was a disk hardware failure; hardware problems may require a complete system check using the `fsck` utility provided with VxFS.

See "The log option and data integrity" on page 20.

VxFS intent log resizing

The VxFS intent log is allocated when the file system is first created. The size of the intent log is based on the size of the file system—the larger the file system, the larger the intent log. The maximum default intent log size for disk layout Version 6 and 7 is 64 megabytes.

With the Version 6 and 7 disk layouts, you can dynamically increase or decrease the intent log size using the `logsize` option of the `fsadm` command. Increasing the size of the intent log can improve system performance because it reduces the number of times the log wraps around. However, increasing the intent log size can lead to greater times required for a log replay if there is a system failure.

Note: Inappropriate sizing of the intent log can have a negative impact on system performance.

See the `mkfs_vxfs`(1M) and the `fsadm_vxfs`(1M) manual pages.

Extended mount options

The VxFS file system provides the following enhancements to the `mount` command:

- Enhanced data integrity modes
- Enhanced performance mode
- Temporary file system mode
- Improved synchronous writes
- Support for large file sizes

See "Mounting a VxFS file system" on page 30.

See the `mount_vxfs`(1M) manual page.

Enhanced data integrity modes

For most UNIX file systems, including VxFS, the default mode for writing to a file is delayed, or buffered, meaning that the data to be written is copied to the file system cache and later flushed to disk.

A delayed write provides much better performance than synchronously writing the data to disk. However, in the event of a system failure, data written shortly before the failure may be lost since it was not flushed to disk. In addition, if space was allocated to the file as part of the write request, and the corresponding data was not flushed to disk before the system failure occurred, uninitialized data can appear in the file.

For the most common type of write, delayed extending writes (a delayed write that increases the file size), VxFS avoids the problem of uninitialized data appearing in the file by waiting until the data has been flushed to disk before updating the new file size to disk. If a system failure occurs before the data has been flushed to disk, the file size has not yet been updated to be uninitialized data, thus no uninitialized data appears in the file. The unused blocks that were allocated are reclaimed.

The blkclear option and 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.

The closesync option and 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.

The log option and data integrity

File systems are typically asynchronous in that structural changes to the file system are not immediately written to disk, which provides better performance. However, recent changes made to a system can be lost if a system failure occurs. Specifically, attribute changes to files and recently created files may disappear.

The `mount -o log` intent logging option guarantees that all structural changes to the file system are logged to disk before the system call returns to the application. With this option, the `rename`(2) system call flushes the source file to disk to guarantee the persistence of the file data before renaming it. The `rename()` call is also guaranteed to be persistent when the system call returns. The changes to file system data and metadata caused by the `fsync`(2) and `fdatasync`(2) system calls are guaranteed to be persistent once the calls return.

Enhanced performance mode

VxFS has a mount option that improves performance: `delaylog`.

The delaylog option and enhanced performance

The default VxFS logging mode, `mount -o delaylog`, increases performance by delaying the logging of some structural changes. However, `delaylog` does not provide the equivalent data integrity as the previously described modes because 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 mode

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. VxFS provides the `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

VxFS provides superior performance for synchronous write applications. The `mount -o datainlog` option greatly improves the performance of small synchronous writes.

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

Warning: The use of the `-o convosync=dsync` option violates POSIX semantics.

Support for large files

With VxFS, you can create, mount, and manage file systems containing large files (files larger than one terabyte).

Warning: Some applications and utilities may not work on large files.

Storage Checkpoints

To increase availability, recoverability, and performance, Veritas File System offers on-disk and online backup and restore capabilities that facilitate frequent and efficient backup strategies. Backup and restore applications can leverage a Storage Checkpoint, a disk- and I/O-efficient copying technology for creating periodic frozen images of a file system. Storage Checkpoints present a view of a file system at a point in time, and subsequently identifies and maintains copies of the original file system blocks. Instead of using a disk-based mirroring method, Storage Checkpoints save disk space and significantly reduce I/O overhead by using the free space pool available to a file system.

Storage Checkpoint functionality is separately licensed.

Online backup

VxFS provides online data backup using the snapshot feature. An image of a mounted file system instantly becomes an exact read-only copy of the file system at a specific point in time. The original file system is called the snapped file system, the copy is called the snapshot.

When changes are made to the snapped file system, the old data is 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 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`)

See “About snapshot file systems” on page 69.

Quotas

VxFS supports quotas, which allocate per-user and per-group quotas and limit the use of two principal resources: files and data blocks. You can assign quotas for each of these resources. Each quota consists of two limits for each resource: hard limit and soft limit.

The hard limit represents an absolute limit on data blocks or files. A user can never exceed the hard limit under any circumstances.

The soft limit is lower than the hard limit and can be exceeded for a limited amount of time. This allows users to exceed limits temporarily as long as they fall under those limits before the allotted time expires.

See "About quota limits" on page 77.

Cluster file systems

Veritas Storage Foundation Cluster File System (SFCFS) allows clustered severs to mount and use a file system simultaneously as if all applications using the file system were running on the same server. The Veritas Volume Manager cluster functionality (CVM) makes logical volumes and raw device applications accessile through a cluster.

Beginning with SFCFS 5.0, SFCFS uses a symmetric architecture in which all nodes in the cluster can simultaneously function as metadata severs. SFCFS still as some remnants of the old master/slave or primary/secondary concept. The first server to mount each cluster file system becomes its primary; all other nodes in the cluster become secondaries. Applications access the user data in files directly from the server on which they are running. Each SFCFS node has its own intent log. File system operations, such as allocating or deleting files, can originate from any node in the cluster.

Installing VxFS and enabling the cluster feature does not create a cluster file system configuration. File system clustering requires other Veritas products to enable communication services and provide storage resources. These products are packaged with VxFS in the Storage Foundation Cluster File System to provide a complete clustering environment.

See the *Veritas Storage Foundation Cluster File System Administrator's Guide*.

SFCFS functionality is separately licensed.

Cross-platform data sharing

Cross-platform data sharing (CDS) allows data to be serially shared among heterogeneous systems where each system has direct access to the physical devices that hold the data. This feature can be used only in conjunction with Veritas Volume Manager (VxVM).

See the *Veritas Storage Foundation Cross-Platform Data Sharing Administrator's Guide*.

File Change Log

The VxFS File Change Log (FCL) tracks changes to files and directories in a file system. The File Change Log can be used by applications such as backup products, webcrawlers, search and indexing engines, and replication software that typically scan an entire file system searching for modifications since a previous scan. FCL functionality is a separately licensed feature.

See "About the File Change Log file" on page 86.

Multi-volume support

The multi-volume support (MVS) feature allows several volumes to be represented by a single logical object. All I/O to and from an underlying logical volume is directed by way of volume sets. This feature can be used only in conjunction with VxVM. MVS functionality is a separately licensed feature.

See "About multi-volume support" on page 94.

Dynamic Storage Tiering

The Dynamic Storage Tiering (DST) option is built on multi-volume support technology. Using DST, you can map more than one volume to a single file system. You can then configure policies that automatically relocate files from one volume to another, or relocate files by running file relocation commands. Having multiple volumes lets you determine where files are located, which can improve performance for applications that access specific types of files. DST functionality is a separately licensed feature and is available with the `VRTSfppm` package.

Thin Reclamation of a file system

Storage is allocated from a Thin Storage LUN when files are created and written to a file system. This storage is not given back to the Thin Storage LUN when a file is deleted or the file size is shrunk. As such, the file system must perform the explicit task of releasing the free storage to the Thin Storage LUN. This is performed by the Storage Foundation Thin Reclamation feature. Thin Reclamation is only supported on VxFS file systems mounted on a VxVM volume.

Veritas File System performance enhancements

Traditional file systems employ block-based allocation schemes that provide adequate random access and latency for small files, but which limit throughput for larger files. As a result, they are less than optimal for commercial environments.

VxFS addresses this file system performance issue through an alternative allocation method and increased user control over allocation, I/O, and caching policies.

See "Using Veritas File System" on page 26.

VxFS provides the following performance enhancements:

- Data synchronous I/O
- Direct I/O and discovered direct I/O
- Support for files and file systems up to 256 terabytes
- Support for files up to 8 exabytes
- Enhanced I/O performance
- Caching advisories
- Enhanced directory features
- Explicit file alignment, extent size, and preallocation controls
- Tunable I/O parameters
- Tunable indirect data extent size
- Integration with VxVM™
- Support for large directories

Note: VxFS reduces the file lookup time in directories with an extremely large number of files.

About enhanced I/O performance

VxFS provides enhanced I/O performance by applying an aggressive I/O clustering policy, integrating with VxVM, and allowing application specific parameters to be set on a per-file system basis.

Enhanced I/O clustering

I/O clustering is a technique of grouping multiple I/O operations together for improved performance. 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.

VxVM integration

VxFS interfaces with VxVM to determine the I/O characteristics of the underlying volume and perform I/O accordingly. VxFS also uses this information when using mkfs to perform proper allocation unit alignments for efficient I/O operations from the kernel. VxFS also uses this information when using mkfs to perform proper allocation unit alignments for efficient I/O operations from the kernel.

As part of VxFS/VxVM integration, VxVM exports a set of I/O parameters to achieve better I/O performance. This interface can enhance performance for different volume configurations such as RAID-5, striped, and mirrored volumes. Full stripe writes are important in a RAID-5 volume for strong I/O performance. VxFS uses these parameters to issue appropriate I/O requests to VxVM.

Application-specific parameters

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

- Discovered Direct I/O
  All sizes above this value would be performed as direct I/O.
- Maximum Direct I/O Size
  This value defines the maximum size of a single direct I/O.

See the `vxtunefs`(1M) and `tunefstab`(4) manual pages.

Using Veritas File System

There are three main methods to use, manage, modify, and tune VxFS:

- Veritas Enterprise Administrator Graphical User Interface
- Online system administration
- Application program interface

Veritas Enterprise Administrator Graphical User Interface

The Veritas Enterprise Administrator (VEA) console is no longer packaged with Storage Foundation products. Symantec recommends use of Storage Foundation Manager to manage, monitor and report on Storage Foundation product environments. You can download this utility at no charge at http://go.symantec.com/vom. If you wish to continue using VEA, a version is available for download from http://go.symantec.com/vom.

Online system administration

VxFS provides command line interface (CLI) operations that are described throughout this guide and in manual pages.

VxFS allows you to run a number of administration tasks while the file system is online. Two of the more important tasks include:

- Defragmentation
- File system resizing

About defragmentation

Free resources are initially aligned and allocated to files in an order that provides 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 farther along the disk, leaving unused gaps or fragments between areas that are in use. This process is known as fragmentation and leads to degraded performance because the file system has fewer options when assigning a free extent to a file (a group of contiguous data blocks).

VxFS provides the online administration utility `fsadm` to resolve the problem of fragmentation.

The `fsadm` utility defragments a mounted file system by performing the following actions:

- 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.

About file system 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.

VxFS is capable of increasing or decreasing the file system size while in use. Many competing file systems can not do this. 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.

VxVM facilitates expansion using virtual disks that can be increased in size while in use. The VxFS and VxVM packages complement each other to provide online expansion capability. Use the `vxresize` command when resizing both the volume and the file system. The `vxresize` command guarantees that the file system shrinks or grows along with the volume. Do not use the `vxassist` and `fsadm_vxfs` commands for this purpose.

See the `vxresize`(1M) manual page.

See the *Veritas Volume Manager Administrator's Guide*.

Application program interface

Veritas File System Developer's Kit (SDK) provides developers with the information necessary to use the application programming interfaces (APIs) to modify and tune various features and components of File System.

See the *Veritas File System Programmer's Reference Guide*.

VxFS 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.

Expanded application facilities

VxFS provides API functions frequently associated with commercial applications that make it possible to perform the following actions:

- 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

Because these functions are provided using VxFS-specific IOCTL system calls, most existing UNIX system applications do not use them. For portability reasons, these applications must check which file system type they are using before using these functions.

VxFS performance: creating, mounting, and tuning file systems

This chapter includes the following topics:

Creating a VxFS file system

When you create a file system with the `mkfs` command, you can select the following characteristics:

- Block size
- Intent log size

Block size

The unit of allocation in VxFS is a block. Unlike some other UNIX file systems, VxFS does not make use of block fragments for allocation because storage is allocated in extents that consist of one or more blocks.

You specify the block size when creating a file system by using the `mkfs -o bsize` option. The block size cannot be altered after the file system is created. The smallest available block size for VxFS is 1K. The default block size is 1024 bytes for file systems smaller than 1 TB, and 8192 bytes for file systems 1 TB or larger.

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. 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.

For 64-bit kernels, the block size and disk layout version determine the maximum size of the file system you can create.

See "About disk layouts" on page 201.

Intent log size

You specify the intent log size when creating a file system by using the `mkfs -o logsize` option. With the Version 6 or 7 disk layout, you can dynamically increase or decrease the intent log size using the log option of the `fsadm` command. The `mkfs` utility uses a default intent log size of 64 megabytes for disk layout Version 6 and 7. 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.

Mounting a VxFS file system

In addition to the standard mount mode (`delaylog` mode), VxFS provides the following modes of operation:

- `log`
- `delaylog`
- `tmplog`

- `logsize`
- `nodatainlog`
- `blkclear`
- `mincache`
- `convosync`
- `ioerror`
- `largefiles|nolargefiles`
- `cio`
- `mntlock|mntunlock`

Caching behavior can be altered with the `mincache` option, and the behavior of `O_SYNC` and `D_SYNC` writes can be altered with the `convosync` option.

See the `fcntl`(2) manual page.

The `delaylog` and `tmplog` modes can significantly improve 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.

See the `mount_vxfs`(1M) manual page.

The log mode

In log mode, all system calls other than `write`(2), `writev`(2), and `pwrite`(2) are guaranteed to be persistent after the system call returns to the application.

The `rename`(2) system call flushes the source file to disk to guarantee the persistence of the file data before renaming it. In both the `log` and `delaylog` modes, the rename is also guaranteed to be persistent when the system call returns. This benefits shell scripts and programs that try to update a file atomically by writing the new file contents to a temporary file and then renaming it on top of the target file.

The delaylog mode

The default logging mode is delaylog. In delaylog mode, the effects of most system calls other than write(2), writev(2), and pwrite(2) are guaranteed to be persistent approximately 15 to 20 seconds after the system call returns to the application. Contrast this with the behavior of most other file systems in which most system calls are not persistent until approximately 30 seconds or more after the call has returned. Fast file system recovery works with this mode.

The rename(2) system call flushes the source file to disk to guarantee the persistence of the file data before renaming it. In the log and delaylog modes, the rename is also guaranteed to be persistent when the system call returns. This benefits shell scripts and programs that try to update a file atomically by writing the new file contents to a temporary file and then renaming it on top of the target file.

The tmplog mode

In tmplog mode, the effects of system calls have persistence guarantees that are similar to those in delaylog mode. In addition, enhanced flushing of delayed extending writes is disabled, which results in better performance but increases the chances of data being lost or uninitialized data appearing in a file that was being actively written at the time of a system failure. This mode is only recommended for temporary file systems. Fast file system recovery works with this mode.

Note: The term "effects of system calls" refers to changes to file system data and metadata caused by the system call, excluding changes to st_atime.

See the stat(2) manual page.

Persistence guarantees

In all logging modes, VxFS is fully POSIX compliant. The effects of the fsync(2) and fdatasync(2) system calls are guaranteed to be persistent after the calls return. The persistence guarantees for data or metadata modified by write(2), writev(2), or pwrite(2) are not affected by the logging mount options. The effects of these system calls are guaranteed to be persistent only if the O_SYNC, O_DSYNC, VX_DSYNC, or VX_DIRECT flag, as modified by the convosync= mount option, has been specified for the file descriptor.

The behavior of NFS servers on a VxFS file system is unaffected by the log and tmplog mount options, but not delaylog. In all cases except for tmplog, VxFS complies with the persistency requirements of the NFS v2 and NFS v3 standard. Unless a UNIX application has been developed specifically for the VxFS file system in `log` mode, it expects the persistence guarantees offered by most other file systems and experiences improved robustness when used with a VxFS file system mounted in `delaylog` mode. Applications that expect better persistence guarantees than that offered by most other file systems can benefit from the `log`, `mincache=`, and `closesync` mount options. However, most commercially available applications work well with the default VxFS mount options, including the `delaylog` mode.

The logiosize mode

The `logiosize=size` option enhances the performance of storage devices that employ a read-modify-write feature. If you specify `logiosize` when you mount a file system, VxFS writes the intent log in the least *size* bytes or a multiple of *size* bytes to obtain the maximum performance from such devices.

See the `mount_vxfs`(1M) manual page.

The values for *size* can be 512, 1024, 2048, 4096, or 8192.

The nodatainlog mode

Use the `nodatainlog` mode on systems with disks that do not support bad block revectoring. Usually, 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 metadata 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 is approximately 50 percent slower than a standard mode VxFS file system for synchronous writes. Other operations are not affected.

The blkclear mode

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. This mode does not affect extending writes. A `blkclear` mode file system is approximately 10 percent slower than a standard mode VxFS file system, depending on the workload.

The mincache mode

The mincache mode has the following suboptions:

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

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 open files can lose data. A `mincache=closesync` mode file system could be approximately 15 percent slower than a standard mode VxFS file system, depending on the workload.

The following describes where to use the mincache modes:

- The `mincache=direct`, `mincache=unbuffered`, and `mincache=dsync` modes are used in environments where applications have 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 are 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 are handled as if the `VX_DSYNC` caching advisory had been specified.

  Refer to the `vxfsio`(7) manual page for explanations of `VX_DIRECT`, `VX_UNBUFFERED`, and `VX_DSYNC`, as well as for the requirements for direct I/O.
- The `mincache=direct`, `mincache=unbuffered`, and `mincache=dsync` modes also flush file data on close as `mincache=closesync` does.

Because the `mincache=direct`, `mincache=unbuffered`, and `mincache=dsync` modes change non-synchronous I/O to synchronous I/O, throughput can substantially degrade for small to medium size files with most applications. Since the VX_DIRECT and VX_UNBUFFERED advisories do not allow any caching of data, applications that normally benefit from caching for reads 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, you can use the mincache=tmpcache mode. 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 the file is closed. When the mincache=tmpcache option is used, bad data can appear in a file that was being extended when a crash occurred.

The convosync mode

The convosync (convert osync) mode has the following suboptions:

- convosync=closesync

Note: 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.

- convosync=delay
- convosync=direct
- convosync=dsync

Note: The convosync=dsync option violates POSIX guarantees for synchronous I/O.

- convosync=unbuffered

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 the open(2), fcntl(2), and vxfsio(7) manual pages.

Warning: Be very careful when using the convosync=closesync or convosync=delay mode because they actually change synchronous I/O into non-synchronous I/O. Applications that use synchronous I/O for data reliability may fail if the system crashes and synchronously written data is lost.

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.

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.

The ioerror mode

This mode sets the policy for handling I/O errors on a mounted file system. I/O errors can occur while reading or writing file data or metadata. The file system can respond to these I/O errors either by halting or by gradually degrading. The ioerror option provides five policies that determine how the file system responds to the various errors. All policies limit data corruption, either by stopping the file system or by marking a corrupted inode as bad.

The policies are the following:

- disable
- nodisable
- wdisable
- mwdisable
- mdisable

The disable policy

If disable is selected, VxFS disables the file system after detecting any I/O error. You must then unmount the file system and correct the condition causing the I/O error. After the problem is repaired, run fsck and mount the file system again. In most cases, replay fsck to repair the file system. A full fsck is required only in cases of structural damage to the file system's metadata. Select disable in environments where the underlying storage is redundant, such as RAID-5 or mirrored disks.

The nodisable policy

If nodisable is selected, when VxFS detects an I/O error, it sets the appropriate error flags to contain the error, but continues running. Note that the degraded condition indicates possible data or metadata corruption, not the overall performance of the file system.

For file data read and write errors, VxFS sets the VX_DATAIOERR flag in the super-block. For metadata read errors, VxFS sets the VX_FULLFSCK flag in the super-block. For metadata write errors, VxFS sets the VX_FULLFSCK and VX_METAIOERR flags in the super-block and may mark associated metadata as bad on disk. VxFS then prints the appropriate error messages to the console.

See “File system response to problems” on page 153.

You should stop the file system as soon as possible and repair the condition causing the I/O error. After the problem is repaired, run fsck and mount the file system again. Select nodisable if you want to implement the policy that most closely resembles the error handling policy of the previous VxFS release.

The wdisable and mwdisable policies

If wdisable (write disable) or mwdisable (metadata-write disable) is selected, the file system is disabled or degraded, depending on the type of error encountered. Select wdisable or mwdisable for environments where read errors are more likely to persist than write errors, such as when using non-redundant storage. mwdisable is the default ioerror mount option for local mounts.

See the mount_vxfs(1M) manual page.

The mdisable policy

If mdisable (metadata disable) is selected, the file system is disabled if a metadata read or write fails. However, the file system continues to operate if the failure is confined to data extents. mdisable is the default ioerror mount option for cluster mounts.

The largefiles|nolargefiles option

The section includes the following topics :

- Creating a file system with large files
- Mounting a file system with large files
- Managing a file system with large files

VxFS supports sparse files up to 16 terabytes, and non-sparse files up to 2 terabytes - 1 kilobyte.

Note: Applications and utilities such as backup may experience problems if they are not aware of large files. In such a case, create your file system without large file capability.

Creating a file system with large files

To create a file system with a file capability:

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

Specifying largefiles sets the largefiles flag. This lets the file system to hold files that are two gigabytes or larger. This is the default option.

Specifying largefiles sets the largefiles flag. This lets the file system to hold files that are two gigabytes or larger. This is the default option.

To clear the flag and prevent large files from being created:

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

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.

Because the mount command defaults to match the current setting of the on-disk flag if specified without the largefiles or nolargefiles option, the best practice is not to specify either option. After a file system is mounted, you can use the fsadm utility to change the large files option.

Managing a file system with large files

Managing a file system with large files includes the following tasks:

- Determining the current status of the large files flag
- Switching capabilities on a mounted file system
- Switching capabilities on an unmounted file system

To determine the current status of the `largefiles` flag, type either of the following commands:

```
# mkfs -t vxfs -m special_device
# /opt/VRTS/bin/fsadm mount_point | special_device
```

To switch capabilities on a mounted file system:

```
# /opt/VRTS/bin/fsadm -o [no]largefiles mount_point
```

To switch capabilities on an unmounted file system:

```
# /opt/VRTS/bin/fsadm -o [no]largefiles special_device
```

You cannot change a file system to `nolargefiles` if it contains large files.

See the `mount_vxfs`(1M), `fsadm_vxfs`(1M), and `mkfs_vxfs`(1M) manual pages.

The cio option

The `cio` (Concurent I/O) option specifies the file system to be mounted for concurrent readers and writers. Concurrent I/O is a licensed feature of VxFS. If `cio` is specified, but the feature is not licensed, the `mount` command prints an error message and terminates the operation without mounting the file system. The `cio` option cannot be disabled through a remount. To disable the `cio` option, the file system must be unmounted and mounted again without the `cio` option.

The mntlock|mntunlock option

The `mntlock` option prevents a file system from being unmounted by an application. This option is useful for applications that do not want the file systems that the applications are monitoring to be improperly unmounted by other applications or administrators.

The `mntunlock` option of the `vxumount` command reverses the `mntlock` option if you previously locked the file system.

Combining mount command 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.

To mount a desktop file system using options:

```
# mount -t vxfs -o log,mincache=closesync \
 /dev/vx/dsk/diskgroup/volume /mnt
```

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

To mount a temporary file system or to restore from backup:

```
# mount -t vxfs -o tmplog,convosync=delay,mincache=tmpcache \
/dev/vx/dsk/diskgroup/volume /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. This could result in a file that contains corrupted data if the system crashes. Any file written 30 seconds or so before a crash may contain corrupted data or be missing if this mount combination is in effect. However, such a file system does significantly less disk writes than a log file system, and should have significantly better performance, depending on the application.

To mount a file system for synchronous writes:

```
# mount -t vxfs -o log,convosync=dsync \
/dev/vx/dsk/diskgroup/volume /mnt
```

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

Tuning the VxFS file system

This section describes the following kernel tunable parameters in VxFS:

- Tuning inode table size
- Veritas Volume Manager maximum I/O size

Tuning inode table size

VxFS caches inodes in an inode table. The tunable for VxFS to determine the number of entries in its inode table is vxfs_ninode.

VxFS uses the value of vxfs_ninode in /etc/modprobe.conf as the number of entries in the VxFS inode table. By default, the file system uses a value of vxfs_ninode, which is computed based on system memory size. To increase the value, make the following change in /etc/modprobe.conf and reboot:

```
options vxfs vxfs_ninode=new_value
```

The new parameters take affect after a reboot or after the VxFS module is unloaded and reloaded. The VxFS module can be loaded using the modprobe command or automatically when a file system is mounted.

See the modprobe(8) manual page.

Note: New parameters in the /etc/modprobe.conf file are not read by the insmod vxfs command.

Veritas Volume Manager maximum I/O size

When using VxFS with Veritas Volume Manager (VxVM), VxVM by default breaks up I/O requests larger than 256K. When using striping, to optimize performance, the file system issues I/O requests that are up to a full stripe in size. If the stripe size is larger than 256K, those requests are broken up.

To avoid undesirable I/O breakup, you can increase the maximum I/O size by changing the value of the vol_maxio parameter in the /etc/modprobe.conf file.

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 command to monitor free space is desirable.

See the df_vxfs(1M) manual page.

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 the fsadm_vxfs(1M) manual page.

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 using the `cron` command.

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` command.

To determine the degree of fragmentation, use the following factors:

- Percentage of free space in extents of less than 8 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 has the following characteristics:

- Less than 1 percent of free space in extents of less than 8 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 has 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, reduce the interval between `fsadm` runs. If the degree of fragmentation is low, increase the interval between fsadm runs.

The “after” result is an indication of how well the reorganizer has performed. The degree of fragmentation should be close to the characteristics of an unfragmented file system. If not, it may be a good idea to resize the file system; 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 improves 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=/var/spool/fsadm/out.`/bin/date +'%m%d'`
for i in /home /home2 /project /db
do
  /bin/echo "Reorganizing $i"
  /usr/bin/time /opt/VRTS/bin/fsadm -e -E -s $i
  /usr/bin/time /opt/VRTS/bin/fsadm -s -d -D $i
done > $outfile 2>&1
```

Thin Reclamation

Veritas File System (VxFS) supports reclamation of free storage on a Thin Storage LUN. Free storage is reclaimed using the `fsadm` command or the `vxfs_ts_reclaim` API. You can perform the default reclamation or aggressive reclamation. If you used a file system for a long time and must perform reclamation on the file system, Symantec recommends that you run aggressive reclamation. Aggressive reclamation compacts the allocated blocks, which creates larger free blocks that can potentially be reclaimed.

See the `fsadm_vxfs`(1M) and `vxfs_ts_reclaim`(3) manual pages.

Thin Reclamation is only supported on file systems mounted on a VxVM volume.

The following example performs aggressive reclamation of free storage to the Thin Storage LUN on a VxFS file system mounted at `/mnt1`:

```
# /opt/VRTS/bin/fsadm -R /mnt1
```

Veritas File System also supports reclamation of a portion of the file system using the `vxfs_ts_reclaim`() API.

See the *Veritas File System Programmer's Reference Guide*.

Note: Thin Reclamation is a slow process and may take several hours to complete, depending on the file system size. Thin Reclamation is not guaranteed to reclaim 100% of the free space.

You can track the progress of the Thin Reclamation process by using the `vxtask list` command when using the Veritas Volume Manager (VxVM) command `vxdisk reclaim`.

See the `vxtask`(1M) and `vxdisk`(1M) manual pages.

You can administer Thin Reclamation using VxVM commands.

See the *Veritas Volume Manager Administrator's Guide*.

Tuning I/O

The 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.

Note: The following tunables and the techniques work on a per file system basis. Use them judiciously based on the underlying device properties and characteristics of the applications that use the file system.

Tuning VxFS I/O parameters

VxFS provides a set of tunable I/O parameters that control some of its behavior. These I/O parameters are useful to help the file system adjust to striped or RAID-5 volumes that could yield performance superior to a single disk. Typically, data streaming applications that access large files see the largest benefit from tuning the file system.

VxVM queries

VxVM receives the following queries during configuration:

- The file system queries VxVM to determine the geometry of the underlying volume and automatically sets the I/O parameters.

  Note: When using file systems in multiple volume sets, VxFS sets the VxFS tunables based on the geometry of the first component volume (volume 0) in the volume set.

- The mount command queries VxVM when the file system is mounted and downloads the I/O parameters.

If the default parameters are not acceptable or the file system is being used without VxVM, then the /etc/vx/tunefstab file can be used to set values for I/O parameters. The mount command reads the /etc/vx/tunefstab file and downloads any parameters specified for a file system. The tunefstab file overrides any values obtained from VxVM. While the file system is mounted, any I/O parameters can be changed using the vxtunefs command which can have tunables specified on the command line or can read them from the /etc/vx/tunefstab file.

See the vxtunefs(1M) and tunefstab(4) manual pages.

The vxtunefs command can be used to print the current values of the I/O parameters.

To print the values, type the following command:

```
# vxtunefs -p mount_point
```

The following is an example tunefstab file:

```
/dev/vx/dsk/userdg/netbackup
 read_pref_io=128k,write_pref_io=128k,read_nstream=4,write_nstream=4
 /dev/vx/dsk/userdg/metasave
 read_pref_io=128k,write_pref_io=128k,read_nstream=4,write_nstream=4
 /dev/vx/dsk/userdg/solbuild
 read_pref_io=64k,write_pref_io=64k,read_nstream=4,write_nstream=4
 /dev/vx/dsk/userdg/solrelease
 read_pref_io=64k,write_pref_io=64k,read_nstream=4,write_nstream=4
 /dev/vx/dsk/userdg/solpatch
 read_pref_io=128k,write_pref_io=128k,read_nstream=4,write_nstream=4
```

Tunable I/O parameters

Table 2-1 provides a list and description of these parameters.

Table 2-1 Tunable VxFS I/O parameters

Parameter	Description
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.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
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.
discovered_direct_iosz	Any file I/O requests larger than 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.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
fcl_keeptime	Specifies the minimum amount of time, in seconds, that the VxFS File Change Log (FCL) keeps records in the log. When the oldest 8K block of FCL records have been kept longer than the value of fcl_keeptime, they are purged from the FCL and the extents nearest to the beginning of the FCL file are freed. This process is referred to as "punching a hole." Holes are punched in the FCL file in 8K chunks. If the fcl_maxalloc parameter is set, records are purged from the FCL if the amount of space allocated to the FCL exceeds fcl_maxalloc, even if the elapsed time the records have been in the log is less than the value of fcl_keeptime. If the file system runs out of space before fcl_keeptime is reached, the FCL is deactivated. Either or both of the fcl_keeptime or fcl_maxalloc parameters must be set before the File Change Log can be activated.
fcl_maxalloc	Specifies the maximum amount of space that can be allocated to the VxFS File Change Log (FCL). The FCL file is a sparse file that grows as changes occur in the file system. When the space allocated to the FCL file reaches the fcl_maxalloc value, the oldest FCL records are purged from the FCL and the extents nearest to the beginning of the FCL file are freed. This process is referred to as “punching a hole.” Holes are punched in the FCL file in 8K chunks. If the file system runs out of space before fcl_maxalloc is reached, the FCL is deactivated. The minimum value of fcl_maxalloc is 4 MB. The default value is fs_size/33. Either or both of the fcl_maxalloc or fcl_keeptime parameters must be set before the File Change Log can be activated. fcl_maxalloc does not apply to disk lay out Versions 1 through 5.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
`fcl_winterval`	Specifies the time, in seconds, that must elapse before the VxFS File Change Log (FCL) records a data overwrite, data extending write, or data truncate for a file. The ability to limit the number of repetitive FCL records for continuous writes to the same file is important for file system performance and for applications processing the FCL. `fcl_winterval` is best set to an interval less than the shortest interval between reads of the FCL by any application. This way all applications using the FCL can be assured of finding at least one FCL record for any file experiencing continuous data changes. `fcl_winterval` is enforced for all files in the file system. Each file maintains its own time stamps, and the elapsed time between FCL records is per file. This elapsed time can be overridden using the VxFS FCL sync public API. See the `vxfs_fcl_sync`(3) manual page.
`hsm_write_ prealloc`	For a file managed by a hierarchical storage management (HSM) application, hsm_write_prealloc preallocates disk blocks before data is migrated back into the file system. An HSM application usually migrates the data back through a series of writes to the file, each of which allocates a few blocks. By setting `hsm_write_ prealloc` (`hsm_write_ prealloc=1`), a sufficient number of disk blocks are allocated on the first write to the empty file so that no disk block allocation is required for subsequent writes. This improves the write performance during migration. The `hsm_write_ prealloc` parameter is implemented outside of the DMAPI specification, and its usage has limitations depending on how the space within an HSM-controlled file is managed. It is advisable to use `hsm_write_ prealloc` only when recommended by the HSM application controlling the file system.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
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 with each allocation. See max_seqio_extent_size. 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 starts from a much larger initial size and the file system does not allocate a set of small extents at the start of file. Use this parameter only on file systems that have a very large average file size. On these file systems it results in fewer extents per file and less fragmentation. initial_extent_size is measured in file system blocks.
inode_aging_count	Specifies the maximum number of inodes to place on an inode aging list. Inode aging is used in conjunction with file system Storage Checkpoints to allow quick restoration of large, recently deleted files. The aging list is maintained in first-in-first-out (fifo) order up to maximum number of inodes specified by inode_aging_count. As newer inodes are placed on the list, older inodes are removed to complete their aging process. For best performance, it is advisable to age only a limited number of larger files before completion of the removal process. The default maximum number of inodes to age is 2048.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
`inode_aging_size`	Specifies the minimum size to qualify a deleted inode for inode aging. Inode aging is used in conjunction with file system Storage Checkpoints to allow quick restoration of large, recently deleted files. For best performance, it is advisable to age only a limited number of larger files before completion of the removal process. Setting the size too low can push larger file inodes out of the aging queue to make room for newly removed smaller file inodes.
`max_direct_iosz`	The maximum size of a direct I/O request that are 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 are blocked until the amount of data being flushed decreases. Although this does not 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 because the algorithm tries to double the size of the file with each new extent. As such, 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 262144 blocks, which prevents one file from holding too much unused space. `max_seqio_extent_size` is measured in file system blocks. The default and minimum value of is 2048 blocks.

Table 2-1 Tunable VxFS I/O parameters *(continued)*

Parameter	Description
write_throttle	The write_throttle parameter is useful in special situations where a computer system has a combination of a large amount of memory and slow storage devices. In this configuration, sync operations, such as fsync(), may take long enough to complete that a system appears to hang. This behavior occurs because the file system is creating dirty pages (in-memory updates) faster than they can be asynchronously flushed to disk without slowing system performance. Lowering the value of write_throttle limits the number of dirty pages per file that a file system generates before flushing the pages to disk. After the number of dirty pages for a file reaches the write_throttle threshold, the file system starts flushing pages to disk even if free memory is still available. The default value of write_throttle is zero, which puts no limit on the number of dirty pages per file. If non-zero, VxFS limits the number of dirty pages per file to write_throttle pages. The default value typically generates a large number of dirty pages, but maintains fast user writes. Depending on the speed of the storage device, if you lower write_throttle, user write performance may suffer, but the number of dirty pages is limited, so sync operations complete much faster. Because lowering write_throttle may in some cases delay write requests (for example, lowering write_throttle may increase the file disk queue to the max_diskq value, delaying user writes until the disk queue decreases), it is advisable not to change the value of write_throttle unless your system has a combination of large physical memory and slow storage devices.

File system tuning guidelines

If the file system is being used with VxVM, it is advisable to let the VxFS I/O parameters be set to default values based on the volume geometry.

Note: VxFS does not query VxVM with multiple volume sets. To improve I/O performance when using multiple volume sets, use the `vxtunefs` command.

If the file system is being used with a hardware disk array or volume manager other than VxVM, 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 striped 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 use the following formula to issue read requests:

- read requests = `read_nstream` x 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 performing sequential I/O to large files, the application should try to issue requests larger than `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, using unbuffered I/O avoids removing useful data out of the cache and lessens CPU overhead.

Extent attributes

This chapter includes the following topics:

About extent attributes

Veritas File System (VxFS) 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. The extent allocation policies associated with a file are referred to as extent attributes.

The VxFS `getext` and `setext` commands let you view or manipulate file extent attributes.

The two basic extent attributes associated with a file are its reservation and its fixed extent size. You can preallocate space to the file by manipulating a file's reservation, or 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.

You can specify the following criteria:

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

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

See "Other controls" on page 55.

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 the `mkfs_vxfs`(1M) manual page.

See "About Veritas File System I/O" on page 59.

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.

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

Fixed extent size

The VxFS default allocation policy uses a variety of methods 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. VxFS accomplishes these goals by allocating 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 the VxFS 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 large extents 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 the following conditions:

- 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. 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.

See the `mkfs_vxfs`(1M) manual page.

See “About Veritas File System I/O” on page 59.

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 cause a file system to return an error message reporting insufficient space if no suitably sized (or aligned) extent is available. This can happen even if the file system has sufficient 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 the last available block in the reservation. This request can be used a way similar to the function of the `ulimit` command 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 that the reservation does not become a persistent attribute of the file. The 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. For users who do not have the appropriate privileges, there is a variant request that prevents such users from viewing uninitialized data.

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 the `setext`(1) and `getext`(1) manual pages.

The VxFS-specific commands vxdump and vxrestore 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

Example of setting an extent attribute

The following example creates a file named file1 and preallocates 2 GB of disk space for the file.

To set an extent attribute

1 Create the file file1:

```
# touch file1
```

2 Preallocate 2 GB of disk space for the file file1:

```
# setext -t vxfs -r 2g -f chgsize file1
```

Since the example specifies the -f chgsize option, VxFS immediately incorporates the reservation into the file and updates the file's inode with size and block count information that is increased to include the reserved space.

Example of getting an extent attribute

The following example gets the extent atribute information of a file named file1.

To get an extent attribute's information

- Get the extent attribute information for the file `file1`:

  ```
  # getext -t vxfs file1
  file1: Bsize 1024 Reserve 36 Extent Size 3 align noextend
  ```

  The file `file1` has a block size of 1024 bytes, 36 blocks reserved, a fixed extent size of 3 blocks, and all extents aligned to 3 block boundaries. The file size cannot be increased after the current reservation is exhausted. Reservations and fixed extent sizes are allocated in units of the file system block size.

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 one of the following 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.

Chapter 4

Veritas File System I/O

This chapter includes the following topics:

About Veritas File System I/O

VxFS processes two basic types of file system I/O:

- Sequential
- Random or I/O that is not sequential

For sequential I/O, VxFS employs a read-ahead policy by default when the application is reading data. For writing, it allocates contiguous blocks if possible. In most cases, VxFS handles I/O that is sequential through buffered I/O. VxFS handles random or nonsequential I/O using direct I/O without buffering.

VxFS provides a set of I/O cache advisories for use when accessing files.

See the *Veritas File System Programmer's Reference Guide*.

See the `vxfsio`(7) manual page.

Buffered and Direct I/O

VxFS responds with read-ahead for sequential read I/O. This results in buffered I/O. The data is prefetched and retained in buffers for the application. The data buffers are commonly referred to as VxFS buffer cache. This is the default VxFS behavior.

On the other hand, direct I/O does not buffer the data when the I/O to the underlying device is completed. This saves system resources like memory and CPU usage. Direct I/O is possible only when alignment and sizing criteria are satisfied.

See "Direct I/O requirements" on page 60.

All of the supported platforms have a VxFS buffered cache. Each platform also has either a page cache or its own buffer cache. These caches are commonly known as the file system caches.

Direct I/O does not use these caches. The memory used for direct I/O is discarded after the I/O is complete,

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 and writes. 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.

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

Direct I/O requirements

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 requirements for direct I/O are as follows:

- The starting file offset must be aligned to a 512-byte boundary.
- The ending file offset must be aligned to a 512-byte boundary, or the length must be a multiple of 512 bytes.
- The memory buffer must start on an 8-byte boundary.

Direct I/O versus synchronous I/O

Because 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.

Direct I/O CPU overhead

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.

Discovered Direct I/O

Discovered Direct I/O is a file system tunable that is set using the `vxtunefs` command. When the file system gets an I/O request larger than the `discovered_direct_iosz`, 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.

See “Tuning I/O” on page 44.

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 I/O. For 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.

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.

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

Data synchronous I/O vs. synchronous I/O

Like direct I/O, the data synchronous I/O feature can provide significant application performance gains. Because 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.

Concurrent I/O

Concurrent I/O (`VX_CONCURRENT`) allows multiple processes to read from or write to the same file without blocking other `read`(2) or `write`(2) calls. POSIX semantics requires `read` and `write` calls to be serialized on a file with other `read` and `write` calls. With POSIX semantics, a `read` call either reads the data before or after the `write` call occurred. With the `VX_CONCURRENT` advisory set, the `read` and `write` operations are not serialized as in the case of a character device. This advisory is generally used by applications that require high performance for accessing data and do not perform overlapping writes to the same file. It is the responsibility of the application or the running threads to coordinate the `write` activities to the same file when using Concurrent I/O.

Concurrent I/O can be enabled in the following ways:

- By specifying the `VX_CONCURRENT` advisory flag for the file descriptor in the `VX_SETCACHE` ioctl command. Only the `read`(2) and `write`(2) calls occurring through this file descriptor use concurrent I/O. The `read` and `write` operations occurring through other file descriptors for the same file will still follow the POSIX semantics.
  See `vxfsio`(7) manual page.

- By using the cio mount option. The read(2) and write(2) operations occurring on all of the files in this particular file system will use concurrent I/O.
  See "The cio option" on page 39.
  See the mount_vxfs(1M) manual page.

Cache advisories

VxFS allows an application to set cache advisories for use when accessing files. VxFS cache advisories enable applications to help monitor the buffer cache and provide information on how better to tune the buffer cache to improve performance gain.

The basic function of the cache advisory is to let you know whether you could have avoided a later re-read of block X if the buffer cache had been a little larger. Conversely, the cache advisory can also let you know that you could safely reduce the buffer cache size without putting block X into jeopardy.

These advisories are in memory only and do not persist across reboots. Some advisories are currently maintained on a per-file, not a per-file-descriptor, basis. Only one set of advisories can be in effect for all accesses to the file. If two conflicting applications set different advisories, both must use the advisories that were last set.

All advisories are set using the VX_SETCACHE ioctl command. The current set of advisories can be obtained with the VX_GETCACHE ioctl command.

See the vxfsio(7) manual page.

Freezing and thawing a file system

Freezing a file system is a necessary step for obtaining a stable and consistent image of the file system at the volume level. Consistent volume-level file system images can be obtained and used with a file system snapshot tool. The freeze operation flushes all buffers and pages in the file system cache that contain dirty metadata and user data. The operation then suspends any new activity on the file system until the file system is thawed.

The VX_FREEZE ioctl command 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.

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

Getting the I/O size

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.

See the vxtunefs(1M) and vxfsio(7) manual pages.

See "Tuning I/O" on page 44.

Enabling and disabling Concurrent I/O for a DB2 database

Concurrent I/O is not turned on by default and must be enabled manually. You must manually disable Concurrent I/O if you choose not to use it in the future.

Enabling Concurrent I/O

Because you do not need to extend name spaces and present the files as devices, you can enable Concurrent I/O on regular files.

Before enabling Concurrent I/O, review the following information:

Prerequisites	■ To use the Concurrent I/O feature, the file system must be a VxFS file system. ■ Make sure the mount point on which you plan to mount the file system exists. ■ Make sure the DBA can access the mount point.

Usage notes	- Files that are open and using Concurrent I/O cannot be opened simultaneously by a different user not using the Concurrent I/O feature. - Veritas NetBackup cannot backup a database file if the file is open and using Concurrent I/O. However, you can still backup the database online using the utility. - When a file system is mounted with the Concurrent I/O option, do not enable Quick I/O. DB2 will not be able to open the Quick I/O files and the instance start up will fail. Quick I/O is not available on Linux. - If the Quick I/O feature is availabe, do not use any Quick I/O tools if the database is using Concurrent I/O. - See the `mount_vxfs`(1M) manual page for more information about mount settings.

Enabling Concurrent I/O on a file system using mount with the -o cio option

You can enable Concurrent I/O by using `mount` with the `-o cio` option.

To enable Concurrent I/O on a file system using mount with the -o cio option

◆ Mount the file system using the `-o cio` option:

```
# /usr/sbin/mount -t vxfs -o cio special /mount_point
```

- *special* is a block special device
- */mount_point* is the directory where the file system will be mounted.

For example, to mount a file system named `/datavol` on a mount point named `/db2data`:

```
# /usr/sbin/mount -t vxfs -o cio /dev/vx/dsk/db2dg/datavol \
/db2data
```

Enabling Concurrent I/O on a DB2 tablespace

Alternately, you can enable Concurrent I/O on a new DB2 tablespace by using the `db2 -v` command.

To enable Concurrent I/O on a new DB2 tablespace

1 Use the `db2 -v "create regular tablespace..."` command with the `no file system caching` option when you create the new tablespace.

2 Set all other parameters according to your system requirements.

To enable Concurrent I/O on an existing DB2 tablespace

◆ Use the DB2 `no file system caching` option:

```
# db2 -v "alter tablespace tablespace_name no file system caching"
```

tablespace_name is the name of the tablespace for which you are enabling Concurrent I/O.

To verify that Concurrent I/O has been set for a particular DB2 tablespace

1 Use the DB2 `get snapshot` option to check for Concurrent I/O:

```
# db2 -v "get snapshot for tablespaces on dbname"
```

dbname is the database name.

2 Find the tablespace that you want to check and look for the `File system caching` attribute. If you see `File system caching = No`, then Concurrent I/O is enabled.

Disabling Concurrent I/O

If you must disable Concurrent I/O, use the DB2 `file system caching` option.

To disable Concurrent I/O on a DB2 tablespace

◆ Use the DB2 `file system caching` option:

```
# db2 -v "alter tablespace tablespace_name file system caching"
```

tablespace_name is the name of the tablespace for which you are disabling Concurrent I/O.

Enabling and disabling Concurrent I/O

Concurrent I/O is not turned on by default and must be enabled manually. You will also have to manually disable Concurrent I/O if you choose not to use it in the future.

Enabling Concurrent I/O

Because you do not need to extend name spaces and present the files as devices, you can enable Concurrent I/O on regular files.

Before enabling Concurrent I/O, review the following:

Prerequisites

- To use the Concurrent I/O feature, the file system must be a VxFS file system.
- Make sure the mount point on which you plan to mount the file system exists.
- Make sure the DBA can access the mount point.

Disabling Concurrent I/O

Chapter 5

Online backup using file system snapshots

This chapter includes the following topics:

About snapshot file systems

A snapshot file system is an exact image of a VxFS file system, referred to as the snapped file system, that provides a mechanism for making backups. The snapshot is a consistent view of the file system "snapped" at the point in time the snapshot is made. You can select files to back up from the snapshot using a standard utility such as `cpio` or `cp`, or back up the entire file system image using the `vxdump` or `fscat` utilities.

You use the mount command to create a snapshot file system; the `mkfs` command is not required. A snapshot file system is always read-only. A snapshot file system exists only as long as it and the snapped file system are mounted and ceases to exist when unmounted. A snapped file system cannot be unmounted until all of its snapshots are unmounted. Although 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.

Note: A snapshot file system ceases to exist when unmounted. If mounted again, it is actually a fresh snapshot of the snapped file system. A snapshot file system must be unmounted before its dependent snapped file system can be unmounted. Neither the `fuser` command nor the `mount` command will indicate that a snapped file system cannot be unmounted because a snapshot of it exists.

On cluster file systems, snapshots can be created on any node in the cluster, and backup operations can be performed from that node. The snapshot of a cluster file system is accessible only on the node where it is created, that is, the snapshot file system itself cannot be cluster mounted.

See the *Veritas Storage Foundation Cluster File System Administrator's Guide.*

Snapshot file system backups

After a snapshot file system is created, the snapshot maintains a consistent backup of data in the snapped file system.

Backup programs, such as `cpio`, that back up a standard file system tree can be used without modification on a snapshot file system because the snapshot presents the same data as the snapped file system. Backup programs, such as `vxdump`, that access the disk structures of a file system require some modifications to handle a snapshot file system.

VxFS utilities recognize snapshot file systems and modify their behavior so that they operate the same way on snapshots as they do on standard file systems. Other backup programs that typically read the raw disk image cannot work on snapshots without altering the backup procedure.

These other backup programs can use the `fscat` command to obtain a raw image of the entire file system that is identical to an image obtainable by running a `dd` command on 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 that are obtainable 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 much different than the results that would be obtained by a `dd` or `read` command on the disk device of an active file system.

Creating a snapshot file system

You create a snapshot file system by using the `-o snapof=` option of the `mount` command. The `-o snapsize=` option may also be required if the device you are mounting does not identify the device size in its disk label, or if you want a size smaller than the entire device.

You must make the snapshot file system 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 runs out of blocks to hold copied data, the snapshot is disabled and further attempts to access the snapshot file system fail.

During periods of low activity (such as nights and weekends), a snapshot typically requires about two to six percent of the blocks of the snapped file system. During a period of high activity, the snapshot of a typical file system may require 15 percent of the blocks of the snapped file system. Most file systems do not turn over 15 percent of data in a single day. These approximate percentages tend to be lower for larger file systems and higher for smaller file systems. You can allocate blocks to a snapshot based on characteristics such as file system usage and duration of backups.

Warning: Any existing data on the device used for the snapshot is overwritten.

To create a snapshot file system

◆ Mount the file system with the `-o snapof=` option:

```
# mount -t vxfs -o snapof=/ \
snapped_mount_point_mnt, snapsize=snapshot_size \
snapshot_special snapshot_mount_point
```

Backup examples

In the following examples, the `vxdump` utility is used to ascertain whether `/dev/rdsk/fsvol/vol1` is a snapshot mounted as `/backup/home` and does the appropriate work to get the snapshot data through the mount point.

These are typical examples of making a backup of a 300,000 block file system named `/home` using a snapshot file system on a Volume Manager volume with a snapshot mount point of `/backup/home`.

To create a backup using a snapshop file system

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

```
# mount -t vxfs -o snapof=/home,snapsize=100000 \
/dev/vx/dsk/fsvol/vol1 /backup/home
# cd /backup
# find home -ctime -7 -depth -print | cpio -oc > /dev/st1
# umount /backup/home
```

2 To do a level 3 backup of /dev/vx/rdsk/fsvol/vol1 and collect those files that have changed in the current directory:

```
# vxdump 3f - /dev/vx/rdsk/fsvol/vol1 | vxrestore -xf -
```

3 To do a full backup of /home, which exists on disk /dev/vx/rdsk/fsvol/vol1, and use dd to control blocking of output onto tape device using vxdump:

```
# mount -t vxfs -o snapof=/home,snapsize=100000 \
/dev/vx/dsk/fsvol/vol1 /backup/home
# vxdump f - /dev/vx/rdsk/fsvol/vol1 | dd bs=128k > /dev/st1
```

Snapshot file system performance

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 typically perform at nearly the throughput rates of reads from a standard VxFS file system.

The performance of reads from the snapped file system are generally not affected. However, writes to the snapped file system, typically average two to three times as long as without a snapshot. This is because the initial write to a data block requires reading the old data, writing the data to the snapshot, and then writing the new data to the snapped file system. If there are multiple snapshots of the same snapped file system, writes are even slower. Only the initial write to a block experiences this delay, so operations such as 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 because the snapshot reads are slowed by 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. For example, a database application running an online transaction processing (OLTP) workload on a snapped file system was measured at about 15 to 20 percent slower than a file system that was not snapped.

Differences between snapshots and Storage Checkpoints

While snapshots and Storage Checkpoints both create a point-in-time image of a file system and only the changed data blocks are updated, snapshops and Storage Checkpoint differ in the following ways:

Table 5-1 Differences between snapshots and Storage Checkpoints

Snapshots	Storage Checkpoints
Require a separate device for storage	Reside on the same device as the original file system
Are read-only	Can be read-only or read-write
Are transient	Are persistent
Cease to exist after being unmounted	Can exist and be mounted on their own
Track changed blocks on the file system level	Track changed blocks on each file in the file system

Storage Checkpoints also serve as the enabling technology for two other Symantec product features: Block-Level Incremental Backups and Storage Rollback, which are used extensively for backing up databases.

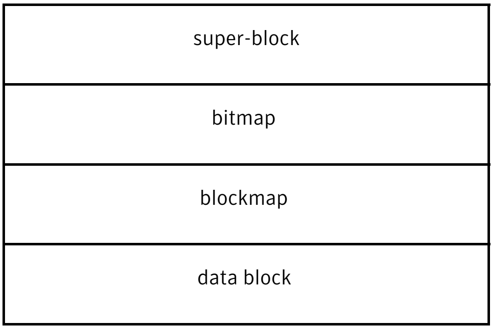
About snapshot file system disk structure

A snapshot file system consists of:

- A super-block
- A bitmap
- A blockmap
- Data blocks copied from the snapped file system

The following figure shows the disk structure of a snapshot file system.

Figure 5-1 The Snapshot Disk Structure



The super-block is similar to the super-block of a standard VxFS file system, but the magic number is different and many of the fields are not applicable.

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 references the copied block.

The blockmap contains one entry for 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 are filled by data copied from the snapped file system, starting from the beginning 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. After 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.

See “Freezing and thawing a file system” on page 63.

Initially, the snapshot file system satisfies read requests by 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 snapshot 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, instead of from block n on the snapped file system. This technique is called copy-on-write. 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, and so forth, are handled in this fashion so that the snapshot can present a consistent view of all file system structures on the snapped file system for the time when the snapshot was created. As data blocks are changed on the snapped file system, the snapshot gradually fills 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.

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

Chapter 6

Quotas

This chapter includes the following topics:

About quota limits

Veritas File System (VxFS) supports user and group quotas. The quota system limits the use of two principal resources of a file system: files and data blocks. For each of these resources, you can assign quotas to individual users and groups to limit their usage.

You can set the following kinds of limits for each of the two resources:

hard limit

An absolute limit that cannot be exceeded under any circumstances.

soft limit

Must be lower than the hard limit, and can be exceeded, but only for a limited time. The time limit can be configured on a per-file system basis only. The VxFS default limit is seven days.

Soft limits are typically used when a user must run an application that could generate large temporary files. In this case, you can allow the user to exceed the quota limit for a limited time. No allocations are allowed after the expiration of the time limit. Use the `vxedquota` command to set limits.

See “Using quotas” on page 80.

Although file and data block limits can be set individually for each user and group, the time limits apply to the file system as a whole. The quota limit information is associated with user and group IDs and is stored in a user or group quota file.

See "About quota files on Veritas File System" on page 78.

The quota soft limit can be exceeded when VxFS preallocates space to a file.

See "About extent attributes" on page 53.

About quota files on Veritas File System

A quotas file (named `quotas`) must exist in the root directory of a file system for any of the quota commands to work. For group quotas to work, there must be a `quotas.grp` file. The files in the file system's mount point are referred to as the external quotas file. VxFS also maintains an internal quotas file for its own use.

The quota administration commands read and write to the external quotas file to obtain or change usage limits. VxFS uses the internal file 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 and changes to quotas are registered in the internal quotas file. When quotas are turned off, the contents of the internal quotas file are copied into the external quotas file so that all data between the two files is synchronized.

VxFS supports group quotas in addition to user quotas. Just as user quotas limit file system resource (disk blocks and the number of inodes) usage on individual users, group quotas specify and limit resource usage on a group basis. As with user quotas, group quotas provide a soft and hard limit for file system resources. If both user and group quotas are enabled, resource utilization is based on the most restrictive of the two limits for a given user.

To distinguish between group and user quotas, VxFS quota commands use a `-g` and `-u` option. The default is user quotas if neither option is specified. One exception to this rule is when you specify the `-o quota` option as a `mount` command option. In this case, both user and group quotas are enabled. Support for group quotas also requires a separate group quotas file. The VxFS group quota file is named `quotas.grp`. The VxFS user quotas file is named `quotas`. This name was used to distinguish it from the `quotas.user` file used by other file systems under Linux.

About quota commands

Note: The quotacheck command is an exception—VxFS does not support an equivalent command.

See "About quota checking with Veritas File System" on page 79.

Quota support for various file systems is implemented using the generic code provided by the Linux kernel. However, VxFS does not use this generic interface. VxFS instead supports a similar set of commands that work only for VxFS file systems.

VxFS supports the following quota-related commands:

vxedquota	Edits quota limits for users and groups. The limit changes made by vxedquota are reflected both in the internal quotas file and the external quotas file.
vxrepquota	Provides a summary of quotas and disk usage.
vxquot	Provides file ownership and usage summaries.
vxquota	Views quota limits and usage.
vxquotaon	Turns quotas on for a mounted VxFS file system.
vxquotaoff	Turns quotas off for a mounted VxFS file system.

In addition to these commands, the VxFS mount command supports a special mount option (-o quota|userquota|groupquota), which can be used to turn on quotas at mount time. You can also selectively enable or disable user or group quotas on a VxFS file system during remount or on a mounted file system.

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

Note: When VxFS file systems are exported via NFS, the VxFS quota commands on the NFS client cannot query or edit quotas. You can use the VxFS quota commands on the server to query or edit quotas.

About quota checking with Veritas File System

The standard practice with most quota implementations is to mount all file systems and then run a quota check on each one. The quota check reads all the inodes on disk and calculates the usage for each user and group. This can be time consuming, and because the file system is mounted, the usage can change while quotacheck is running.

VxFS does not support a `quotacheck` command. With VxFS, quota checking is performed automatically, if necessary, at the time quotas are turned on. A quota check is necessary if the file system has changed with respect to the usage information as recorded in the internal quotas file. This happens only if the file system was written with quotas turned off, or if there was structural damage to the file system that required a full file system check.

See the `fsck_vxfs`(1M) manual page.

A quota check generally reads information for each inode on 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

The VxFS quota commands are used to manipulate quotas.

Turning on quotas

To use the quota functionality on a file system, quotas must be turned on. You can turn quotas on at mount time or after a file system is mounted.

Note: Before turning on quotas, the root directory of the file system must contain a file for user quotas named `quotas`, and a file for group quotas named `quotas.grp` owned by root.

To turn on quotas

1 To turn on user and group quotas for a VxFS file system, enter:

```
# vxquotaon /mount_point
```

2 To turn on only user quotas for a VxFS file system, enter:

```
# vxquotaon -u /mount_point
```

3 To turn on only group quotas for a VxFS file system, enter:

```
# vxquotaon -g /mount_point
```

Turning on quotas at mount time

Quotas can be turned on with the mount command when you mount a file system.

To turn on quotas at mount time

1 To turn on user or group quotas for a file system at mount time, enter:

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

2 To turn on only user quotas, enter:

```
# mount -t vxfs -o usrquota special /mount_point
```

3 To turn on only group quotas, enter:

```
# mount -t vxfs -o grpquota special /mount_point
```

Editing user and group quotas

You can set up user and group quotas using the vxedquota command. You must have superuser privileges to edit quotas.

vxedquota 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 vxedquota to work. However, the quota limits are applicable only after quotas are turned on for a given file system.

To edit quotas

1 Specify the -u option to edit the quotas of one or more users specified by username:

```
# vxedquota [-u] username
```

Editing the quotas of one or more users is the default behavior if the -u option is not specified.

2 Specify the -g option to edit the quotas of one or more groups specified by groupname:

```
# vxedquota -g groupname
```

Modifying time limits

The soft and hard limits can be modified or assigned values with the `vxedquota` command. For any user or group, usage can never exceed the hard limit after quotas are turned on.

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

To modify time limits

1. Specify the `-t` option to modify time limits for any user:

   ```
   # vxedquota [-u] -t
   ```

2. Specify the `-g` and `-t` options to modify time limits for any group:

   ```
   # vxedquota -g -t
   ```

Viewing disk quotas and usage

Use the `vxquota` command to view a user's or group's disk quotas and usage on VxFS file systems.

To display disk quotas and usage

1. To display a user's quotas and disk usage on all mounted VxFS file systems where the quotas file exists, enter:

   ```
   # vxquota -v [-u] username
   ```

2. To display a group's quotas and disk usage on all mounted VxFS file systems where the `quotas.grp` file exists, enter:

   ```
   # vxquota -v -g groupname
   ```

Displaying blocks owned by users or groups

Use the `vxquot` command to display the number of blocks owned by each user or group in a file system.

To display the number of blocks owned by users or groups

1 To display the number of files and the space owned by each user, enter:

```
# vxquot [-u] -f filesystem
```

2 To display the number of files and the space owned by each group, enter:

```
# vxquot -g -f filesystem
```

Turning off quotas

Use the `vxquotaoff` command to turn off quotas.

To turn off quotas

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

```
# vxquotaoff /mount_point
```

2 To turn off only user quotas for a VxFS file system, enter:

```
# vxquotaoff -u /mount_point
```

3 To turn off only group quotas for a VxFS file system, enter:

```
# vxquotaoff -g /mount_point
```

Chapter 7

File Change Log

This chapter includes the following topics:

About File Change Log

The VxFS File Change Log (FCL) tracks changes to files and directories in a file system.

Applications that typically use the FCL are usually required to:

- scan an entire file system or a subset
- discover changes since the last scan

These applications may include: backup utilities, webcrawlers, search engines, and replication programs.

Note: The FCL tracks when the data has changed and records the change type, but does not track the actual data changes. It is the responsibility of the application to examine the files to determine the changed data.

FCL functionality is a separately licensable feature.

See the *Veritas Storage Foundation Release Notes*.

About the File Change Log file

File Change Log records file system changes such as creates, links, unlinks, renaming, data appended, data overwritten, data truncated, extended attribute modifications, holes punched, and miscellaneous file property updates.

FCL stores changes in a sparse file in the file system namespace. The FCL file is located in `mount_point/lost+found/changelog`. The FCL file behaves like a regular file, but some operations are prohibited. The standard system calls `open`(2), `lseek`(2), `read`(2) and `close`(2) can access the data in the FCL, while the `write`(2), `mmap`(2) and `rename`(2) calls are not allowed.

Warning: Although some standard system calls are currently supported, the FCL file might be pulled out of the namespace in future VxFS release and these system calls may no longer work. It is recommended that all new applications be developed using the programmatic interface.

The FCL log file contains both the information about the FCL, which is stored in the FCL superblock, and the changes to files and directories in the file system, which is stored as FCL records.

See "File Change Log programmatic interface" on page 89.

In 4.1, the structure of the File Change Log file was exposed through the `/opt/VRTS/include/sys/fs/fcl.h` header file. In this release, the internal structure of the FCL file is opaque. The recommended mechanism to access the FCL is through the API described by the `/opt/VRTSfssdk/5.0/include/vxfsutil.h` header file.

The `/opt/VRTS/include/sys/fs/fcl.h` header file is included in this release to ensure that applications accessing the FCL with the 4.1 header file do not break. New applications should use the new FCL API described in `/opt/VRTSfssdk/5.0/include/vxfsutil.h`. Existing applications should also be modified to use the new FCL API.

With the addition of new record types, the FCL version in this release has been updated to 4. To provide backward compatibility for the existing applications, this release supports multiple FCL versions. Users now have the flexibility of specifying the FCL version for new FCLs. The default FCL version is 4.

See the `fcladm`(1M) man page.

File Change Log administrative interface

The FCL can be set up and tuned through the `fcladm` and `vxtunefs` VxFS administrative commands.

See the `fcladm`(1M) and `vxtunefs`(1M) manual pages.

The FCL keywords for `fcladm` are as follows:

`clear`
Disables the recording of the audit, open, close, and statistical events after it has been set.

`dump`
Creates a regular file image of the FCL file that can be downloaded too an off-host processing system. This file has a different format than the FCL file.

`on`
Activates the FCL on a mounted file system. VxFS 5.0 supports either FCL Versions 3 or 4. If no version is specified, the default is Version 4. Use `fcladm on` to specify the version.

`print`
Prints the contents of the FCL file starting from the specified offset.

`restore`
Restores the FCL file from the regular file image of the FCL file created by the `dump` keyword.

`rm`
Removes the FCL file. You must first deactivate the FCL with the `off` keyword, before you can remove the FCL file.

`set`
Enables the recording of events specified by the 'eventlist' option.

See the `fcladm`(1M) manual page.

`state`
Writes the current state of the FCL to the standard output.

`sync`
Brings the FCL to a stable state by flushing the associated data of an FCL recording interval.

The FCL tunable parameters for `vxtunefs` are as follows:

`fcl_keeptime`

Specifies the duration in seconds that FCL records stay in the FCL file before they can be purged. The first records to be purged are the oldest ones, which are located at the beginning of the file. Additionally, records at the beginning of the file can be purged if allocation to the FCL file exceeds `fcl_maxalloc` bytes. The default value of `fcl_keeptime` is 0. If the `fcl_maxalloc` parameter is set, records are purged from the FCL file if the amount of space allocated to the FCL file exceeds `fcl_maxalloc`. This is true even if the elapsed time the records have been in the log is less than the value of `fcl_keeptime`.

`fcl_maxalloc`

Specifies the maximum number of spaces in bytes to be allocated to the FCL file. When the space allocated exceeds `fcl_maxalloc`, a hole is punched at the beginning of the file. As a result, records are purged and the first valid offset (`fc_foff`) is updated. In addition, `fcl_maxalloc` may be violated if the oldest record has not reached `fcl_keeptime`.

The minimum value of `fcl_maxalloc` is 4 MB. The default value is `fs_size`/33.

`fcl_winterval`

Specifies the time in seconds that must elapse before the FCL records an overwrite, extending write, or a truncate. This helps to reduce the number of repetitive records in the FCL. The `fcl_winterval` timeout is per inode. If an inode happens to go out of cache and returns, its write interval is reset. As a result, there could be more than one write record for that file in the same write interval. The default value is 3600 seconds.

`fcl_ointerval`

The time interval in seconds within which subsequent opens of a file do not produce an additional FCL record. This helps to reduce the number of repetitive records logged in the FCL file. If the tracking of access information is also enabled, a subsequent file open even within the `fcl_ointerval` may produce a record, if it is opened by a different user. Similarly, if the inode is bumped out of cache, this may also produce more than one record within the same open interval.

The default value is 600 sec.

Either or both `fcl_maxalloc` and `fcl_keeptime` must be set to activate the FCL feature. The following are examples of using the `fcladm` command.

To activate FCL for a mounted file system, type the following:

```
# fcladm on mount_point
```

To deactivate the FCL for a mounted file system, type the following:

```
# fcladm off mount_point
```

To remove the FCL file for a mounted file system, on which FCL must be turned off, type the following:

```
# fcladm rm mount_point
```

To obtain the current FCL state for a mounted file system, type the following:

```
# fcladm state mount_point
```

To enable tracking of the file opens along with access information with each event in the FCL, type the following:

```
# fcladm set fileopen,accessinfo mount_point
```

To stop tracking file I/O statistics in the FCL, type the following:

```
# fcladm clear filestats mount_point
```

Print the on-disk FCL super-block in text format to obtain information about the FCL file by using offset 0. Because the FCL on-disk super-block occupies the first block of the FCL file, the first and last valid offsets into the FCL file can be determined by reading the FCL super-block and checking the `fc_foff` field. Enter:

```
# fcladm print 0 mount_point
```

To print the contents of the FCL in text format, of which the offset used must be 32-byte aligned, enter:

```
# fcladm print offset mount_point
```

File Change Log programmatic interface

VxFS provides an enhanced API to simplify reading and parsing the FCL file in two ways:

Simplified reading	The API simplifies user tasks by reducing additional code needed to parse FCL file entries. In 4.1, to obtain event information such as a remove or link, the user was required to write additional code to get the name of the removed or linked file. In this release, the API allows the user to directly read an assembled record. The API also allows the user to specify a filter to indicate a subset of the event records of interest.

Backward compatibility	Providing API access for the FCL feature allows backward compatibility for applications. The API allows applications to parse the FCL file independent of the FCL layout changes. Even if the hidden disk layout of the FCL changes, the API automatically translates the returned data to match the expected output record. As a result, the user does not need to modify or recompile the application due to changes in the on-disk FCL layout.

See “Reverse path name lookup” on page 92.

The following sample code fragment reads the FCL superblock, checks that the state of the FCL is `VX_FCLS_ON`, issues a call to `vxfs_fcl_sync` to obtain a finishing offset to read to, determines the first valid offset in the FCL file, then reads the entries in 8K chunks from this offset. The section process fcl entries is what an application developer must supply to process the entries in the FCL file.

```
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/fcntl.h>
#include <errno.h>
#include <fcl.h>
#include <vxfsutil.h>
#define FCL_READSZ 8192
char* fclname = "/mnt/lost+found/changelog";
int read_fcl(fclname) char* fclname;
{
    struct fcl_sb fclsb;
    uint64_t off, lastoff;
    size_t size;
    char buf[FCL_READSZ], *bufp = buf;
    int fd;
    int err = 0;
    if ((fd = open(fclname, O_RDONLY)) < 0) {
        return ENOENT;
    }
    if ((off = lseek(fd, 0, SEEK_SET)) != 0) {
        close(fd);
        return EIO;
    }
    size = read(fd, &fclsb, sizeof (struct fcl_sb));
    if (size < 0) {
        close(fd);
```

```
            return EIO;
        }
        if (fclsb.fc_state == VX_FCLS_OFF) {
            close(fd);
            return 0;
        }
        if (err = vxfs_fcl_sync(fclname, &lastoff)) {
            close(fd);
            return err;
        }
        if ((off = lseek(fd, off_t, uint64_t)) != uint64_t) {
            close(fd);
            return EIO;
        }
        while (off < lastoff) {
            if ((size = read(fd, bufp, FCL_READSZ)) <= 0) {
                close(fd);
                return errno;
            }
            /* process fcl entries */
            off += size;
        }
        close(fd);
        return 0;
    }
```

Summary of API functions

The following is a brief summary of File Change Log API functions:

`vxfs_fcl_close()` Closes the FCL file and cleans up resources associated with the handle.

`vxfs_fcl_cookie()` Returns an opaque structure that embeds the current FCL activation time and the current offset. This cookie can be saved and later passed to `vxfs_fcl_seek()` function to continue reading from where the application last stopped.

`vxfs_fcl_getinfo()` Returns information such as the state and version of the FCL file.

`vxfs_fcl_open()` Opens the FCL file and returns a handle that can be used for further operations.

`vxfs_fcl_read()` Reads FCL records of interest into a buffer specified by the user.

`vxfs_fcl_seek()`	Extracts data from the specified cookie and then seeks to the specified offset.
`vxfs_fcl_seektime()`	Seeks to the first record in the FCL after the specified time.

Reverse path name lookup

The reverse path name lookup feature obtains the full path name of a file or directory from the inode number of that file or directory. The inode number is provided as an argument to the `vxlsino` administrative command, or the `vxfs_inotopath_gen`(3) application programming interface library function.

The reverse path name lookup feature can be useful for a variety of applications, such as for clients of the VxFS File Change Log feature, in backup and restore utilities, and for replication products. Typically, these applications store information by inode numbers because a path name for a file or directory can be very long, thus the need for an easy method of obtaining a path name.

An inode is a unique identification number for each file in a file system. An inode contains the data and metadata associated with that file, but does not include the file name to which the inode corresponds. It is therefore relatively difficult to determine the name of a file from an inode number. The `ncheck` command provides a mechanism for obtaining a file name from an inode identifier by scanning each directory in the file system, but this process can take a long period of time. The VxFS reverse path name lookup feature obtains path names relatively quickly.

Note: Because symbolic links do not constitute a path to the file, the reverse path name lookup feature cannot track symbolic links to files.

Because of the possibility of errors with processes renaming or unlinking and creating new files, it is advisable to perform a `lookup` or `open` with the path name and verify that the inode number matches the path names obtained.

See the `vxlsino`(1M), `vxfs_inotopath_gen`(3), and `vxfs_inotopath`(3) manual pages.

Chapter 8

Multi-volume file systems

This chapter includes the following topics:

About multi-volume support

VxFS provides support for multi-volume file systems when used in conjunction with the Veritas Volume Manager. Using multi-volume support (MVS), a single file system can be created over multiple volumes, each volume having its own properties. For example, it is possible to place metadata on mirrored storage while placing file data on better-performing volume types such as RAID-1+0 (striped and mirrored).

The MVS feature also allows file systems to reside on different classes of devices, so that a file system can be supported from both inexpensive disks and from expensive arrays. Using the MVS administrative interface, you can control which data goes on which volume types.

About volume types

VxFS utilizes two types of volumes, one of which contains only data, referred to as `dataonly`, and the other of which can contain metadata or data, referred to as `metadataok`.

Data refers to direct extents, which contain user data, of regular files and named data streams in a file system.

Metadata refers to all extents that ar enot regular file or name data stream extents. This includes certain files that appear to be regular files, but are not, such as the File Change Log file.

A volume availability flag is set to specify if a volume is `dataonly` or `metadataok`. The volume availability flag can be set, cleared, and listed with the `fsvoladm` command.

See the `fsvoladm`(1M) manual page.

Features implemented using multi-volume support

The following features can be implemented using multi-volume support:

- Controlling where files are stored can be selected at multiple levels so that specific files or file hierarchies can be assigned to different volumes. This functionality is available in the Veritas File System Dynamic Storage Tiering (DST) feature
- Placing the VxFS intent log on its own volume to minimize disk head movement and thereby increase performance.

- Separating Storage Checkpoints so that data allocated to a Storage Checkpoint is isolated from the rest of the file system.
- Separating metadata from file data.
- Encapsulating volumes so that a volume appears in the file system as a file. This is particularly useful for databases that are running on raw volumes.
- Guaranteeing that a dataonly volume being unavailable does not cause a metadataok volume to be unavailable.

To use the multi-volume file system features, Veritas Volume Manager must be installed and the volume set feature must be accessible.

Volume availability

MVS guarantees that a dataonly volume being unavailable does not cause a metadataok volume to be unavailable. This allows you to mount a multi-volume file system even if one or more component dataonly volumes are missing.

The volumes are separated by whether metadata is allowed on the volume. An I/O error on a dataonly volume does not affect access to any other volumes. All VxFS operations that do not access the missing `dataonly` volume function normally.

Some VxFS operations that do not access the missing `dataonly` volume and function normally include the following:

- Mounting the multi-volume file system, regardless if the file system is read-only or read/write.
- Kernel operations.
- Performing a `fsck` replay. Logged writes are converted to normal writes if the corresponding volume is `dataonly`.
- Performing a full `fsck`.
- Using all other commands that do not access data on a missing volume.

Some operations that could fail if a `dataonly` volume is missing include:

- Reading or writing file data if the file's data extents were allocated from the missing `dataonly` volume.
- Using the `vxdump` command.

Volume availability is supported only on a file system with disk layout Version 7 or later.

Note: Do not mount a multi-volume system with the `ioerror=disable` or `ioerror=wdisable` mount options if the volumes have different availability properties. Symantec recommends the `ioerror=mdisable` mount option both for cluster mounts and for local mounts.

About volume sets

Veritas Volume Manager exports a data object called a volume set. A volume set is a container for one or more volumes, each of which can have its own geometry. Unlike the traditional Volume Manager volume, which can be used for raw I/O access or to contain a file system, a volume set can only be used to contain a VxFS file system.

The Volume Manager `vxvset` command is used to create and manage volume sets. Volume sets cannot be empty. When the last entry is removed, the volume set itself is removed.

Creating and managing volume sets

The following command examples show how to create and manage volume sets.

To create and manage volume sets

1 Create a new volume set from `vol1`:

```
# vxassist -g dg1 make vol1 10m
# vxvset -g dg1 make myvset vol1
```

2 Create two new volumes and add them to the volume set:

```
# vxassist -g dg1 make vol2 50m
# vxassist -g dg1 make vol3 50m
# vxvset -g dg1 addvol myvset vol2
# vxvset -g dg1 addvol myvset vol3
```

3 List the component volumes of the previously created volume set:

```
# vxvset -g dg1 list myvset
VOLUME    INDEX   LENGTH    STATE     CONTEXT
vol1      0       20480     ACTIVE    -
vol2      1       102400    ACTIVE    -
vol3      2       102400    ACTIVE    -
```

4 Use the `ls` command to see that when a volume set is created, the volumes contained by the volume set are removed from the namespace and are instead accessed through the volume set name:

```
# ls -l /dev/vx/rdsk/rootdg/myvset
crw------- 1 root  root  108,70009 May 21 15:37 /dev/vx/rdsk/rootdg/my
```

5 Create a volume, add it to the volume set, and use the `ls` command to see that when a volume is added to the volume set, it is no longer visible in the namespace:

```
# vxassist -g dg1 make vol4 50m
# ls -l /dev/vx/rdsk/rootdg/vol4
crw------- 1 root root 108,70012 May 21 15:43
                            /dev/vx/rdsk/rootdg/vol4
# vxvset -g dg1 addvol myvset vol4
# ls -l /dev/vx/rdsk/rootdg/vol4
/dev/vx/rdsk/rootdg/vol4: No such file or directory
```

Creating multi-volume file systems

When a multi-volume file system is created, all volumes are `dataonly`, except volume zero. The volume availability flag of volume zero cannot be set to `dataonly`.

As metadata cannot be allocated from `dataonly` volumes, enough metadata space should be allocated using `metadataok` volumes. The "file system out of space" error occurs if there is insufficient metadata space available, even if the `df` command shows that there is free space in the file system. The `fsvoladm` command can be used to see the free space in each volume and set the availability flag of the volume.

Unless otherwise specified, VxFS commands function the same on multi-volume file systems the same as the commands do on single-volume file systems.

Example of creating a multi-volume file system

The following procedure is an example of creating a multi-volume file system.

To create a multi-volume file system

1 After a volume set is created, create a VxFS file system by specifying the volume set name as an argument to `mkfs`:

```
# mkfs -t vxfs /dev/vx/rdsk/rootdg/myvset
version 7 layout
327680 sectors, 163840 blocks of size 1024,
log size 1024 blocks largefiles supported
```

After the file system is created, VxFS allocates space from the different volumes within the volume set.

2 List the component volumes of the volume set using of the `fsvoladm` command:

```
# mount -t vxfs /dev/vx/dsk/rootdg/myvset /mnt1
# fsvoladm list /mnt1
devid   size     used   avail   name
0       10240    1280   8960    vol1
1       51200    16     51184   vol2
2       51200    16     51184   vol3
3       51200    16     51184   vol4
```

3 Add a new volume by adding the volume to the volume set, then adding the volume to the file system:

```
# vxassist -g dg1 make vol5 50m
# vxvset -g dg1 addvol myvset vol5
# fsvoladm add /mnt1 vol5 50m
# fsvoladm list /mnt1
devid   size     used   avail   name
0       10240    1300   8940    vol1
1       51200    16     51184   vol2
2       51200    16     51184   vol3
3       51200    16     51184   vol4
4       51200    16     51184   vol5
```

4 List the volume availability flags using the `fsvoladm` command:

```
# fsvoladm queryflags /mnt1
volname    flags
vol1       metadataok
vol2       dataonly
vol3       dataonly
vol4       dataonly
vol5       dataonly
```

5 Increase the metadata space in the file system using the `fsvoladm` command:

```
# fsvoladm clearflags dataonly /mnt1 vol2
# fsvoladm queryflags /mnt1
volname    flags
vol1       metadataok
vol2       metadataok
vol3       dataonly
vol4       dataonly
vol5       dataonly
```

Converting a single volume file system to a multi-volume file system

The following procedure converts a traditional, single volume file system, `/mnt1`, on a single volume `vol1` in the diskgroup `dg1` to a multi-volume file system.

To convert a single volume file system

1 Determine the version of the volume's diskgroup:

```
# vxdg list dg1 | grep version: | awk '{ print $2 }'
105
```

2 If the version is less than 110, upgrade the diskgroup:

```
# vxdg upgrade dg1
```

3 Determine the disk layout version of the file system:

```
# vxupgrade /mnt1
Version 6
```

4 If the disk layout version is 6, upgrade to Version 7:

```
# vxupgrade -n 7 /mnt1
```

5 Unmount the file system:

```
# umount /mnt1
```

6 Convert the volume into a volume set:

```
# vxvset -g dg1 make vset1 vol1
```

7 Edit the `/etc/fstab` file to replace the volume device name, `vol1`, with the volume set name, `vset1`.

8 Mount the file system:

```
# mount -t vxfs /dev/vx/dsk/dg1/vset1 /mnt1
```

9 As necessary, create and add volumes to the volume set:

```
# vxassist -g dg1 make vol2 256M
# vxvset -g dg1 addvol vset1 vol2
```

10 Set the placement class tags on all volumes that do not have a tag:

```
# vxassist -g dg1 settag vol1 vxfs.placement_class.tier1
# vxassist -g dg1 settag vol2 vxfs.placement_class.tier2
```

11 Add the new volumes to the file system:

```
# fsvoladm add /mnt1 vol2 256m
```

Removing a volume from a multi-volume file system

Use the `fsvoladm remove` command to remove a volume from a multi-volume file system. The `fsvoladm remove` command fails if the volume being removed is the only volume in any allocation policy.

Forcibly removing a volume

If you must forcibly remove a volume from a file system, such as if a volume is permanently destroyed and you want to clean up the dangling pointers to the lost volume, use the `fsck -o zapvol=volname` command. The `zapvol` option performs a full file system check and zaps all inodes that refer to the specified volume. The fsck command prints the inode numbers of all files that the command destroys; the file names are not printed. The zapvol option only affects regular files if used on a dataonly volume. However, it could destroy structural files if used on a metadataok volume, which can make the file system unrecoverable. Therefore, the zapvol option should be used with caution on metadataok volumes.

Moving volume 0

Volume 0 in a multi-volume file system cannot be removed from the file system, but you can move volume 0 to different storage using the vxassist move command. The vxassist command creates any necessary temporary mirrors and cleans up the mirrors at the end of the operation.

To move volume 0

◆ Move volume 0:

```
# vxassist -g mydg move vol1 !mydg
```

About allocation policies

To make full use of the multi-volume support feature, you can create allocation policies that allow files or groups of files to be assigned to specified volumes within the volume set.

A policy specifies a list of volumes and the order in which to attempt allocations. A policy can be assigned to a file, a file system, or a Storage Checkpoint created from a file system. When policies are assigned to objects in the file system, you must specify how the policy maps to both metadata and file data. For example, if a policy is assigned to a single file, the file system must know where to place both the file data and metadata. If no policies are specified, the file system places data randomly.

Assigning allocation policies

The following example shows how to assign allocation policies. The example volume set contains four volumes from different classes of storage.

To assign allocation policies

1 List the volumes in the volume set:

```
# vxvset -g rootdg list myvset
VOLUME   INDEX   LENGTH    STATE   CONTEXT
vol1     0       102400    ACTIVE  -
vol2     1       102400    ACTIVE  -
vol3     2       102400    ACTIVE  -
vol4     3       102400    ACTIVE  -
```

2 Create a file system on the `myvset` volume set and mount the file system:

```
# mkfs -t vxfs /dev/vx/rdsk/rootdg/myvset
version 7 layout
204800 sectors, 102400 blocks of size 1024,
log size 1024 blocks
largefiles supported
# mount -t vxfs /dev/vx/dsk/rootdg/myvset /mnt1
```

3 Define three allocation policies, v1, bal_34, and rr_all, that allocate from the volumes using different methods:

```
# fsapadm define /mnt1 v1 vol1
# fsapadm define -o balance -c 64k /mnt1 bal_34 vol3 vol4
# fsapadm define -o round-robin /mnt1 rr_all vol1 vol2 vol3 vol4
# fsapadm list /mnt1
name        order        flags    chunk      num  comps
rr_all      round-robin  0         0         4    vol1, vol2, vol3, vol4
bal_34      balance      0        64.000KB   2    vol3, vol4
v1          as-given     0         0         1    vol1
```

These policies allocate from the volumes as follows:

v1	Allocations are restricted to vol1.
bal_34	Balanced allocations between vol3 and vol4.
rr_all	Round-robin allocations from all four volumes.

4 Assign the policies to various objects in the file system. The data policy must be specified before the metadata policy:

```
# fsapadm assignfile -f inherit /mnt1/appdir bal_34 v1
# fsapadm assignfs /mnt1 rr_all ''
```

These assignments will cause allocations for any files below /mnt1/appdir to use bal_34 for data, and v1 for metadata. Allocations for other files in the file system will default to the file system-wide policies given in assignfs, with data allocations from rr_all, and metadata allocations using the default policy as indicated by the empty string (''). The default policy is as-given allocations from all metadata-eligible volumes.

Querying allocation policies

Querying an allocation policy displays the definition of the allocation policy.

The following example shows how to query allocation policies. The example volume set contains two volumes from different classes of storage.

To query allocation policies

◆ Query the allocation policy:

```
# fsapadm query /mnt1 bal_34
```

Assigning pattern tables to directories

A pattern table contains patterns against which a file's name and creating process' UID and GID are matched as a file is created in a specified directory. The first successful match is used to set the allocation policies of the file, taking precedence over inheriting per-file allocation policies.

See the fsapadm(1M) manual page.

The following example shows how to assign pattern tables to a directory in a volume set that contains two volumes from different classes of storage. The pattern table matches all files created in the directory dir1 with the .mp3 extension for any user or group ID and assigns the mp3data data policy and mp3meta metadata policy.

To assign pattern tables to directories

1 Define two allocation policies called mp3data and mp3meta to refer to the vol1 and vol2 volumes:

```
# fsapadm define /mnt1 mp3data vol1
# fsapadm define /mnt1 mp3meta vol2
```

2 Assign the pattern table:

```
# fsapadm assignfilepat dir1 *.mp3///mp3data/mp3meta/
```

Assigning pattern tables to file systems

A pattern table contains patterns against which a file's name and creating process' UID and GID are matched as a file is created in a directory. If the directory does not have its own pattern table or an inheritable allocation policy, the file system's pattern table takes effect. The first successful match is used to set the allocation policies of the file.

See the fsapadm(1M) manual page.

The following example shows how to assign pattern tables to a file system in a volume set that contains two volumes from different classes of storage. The pattern table is contained within the pattern file mypatternfile.

To assign pattern tables to directories

1 Define two allocation policies called mydata and mymeta to refer to the vol1 and vol2 volumes:

```
# fsapadm define /mnt1 mydata vol1
# fsapadm define /mnt1 mymeta vol2
```

2 Assign the pattern table:

```
# fsapadm assignfspat -F mypatternfile /mnt1
```

Allocating data

The following script creates a large number of files to demonstrate the benefit of allocating data:

```
i=1
while [ $i -lt 1000 ]
do
    dd if=/dev/zero of=/mnt1/$i bs=65536 count=1
    i=`expr $i + 1`
done
```

Before the script completes, vol1 runs out of space even though space is still available on the vol2 volume:

```
# fsvoladm list /mnt1
devid   size     used    avail   name
0       51200    51200   0       vol1
1       51200    221     50979   vol2
```

One possible solution is to define and assign an allocation policy that allocates user data to the least full volume.

You must have system administrator privileges to create, remove, or change policies, or to set file system or Storage Checkpoint level policies. Users can assign a pre-existing policy to their files if the policy allows that.

Policies can be inherited for new files. A file will inherit the allocation policy of the directory in which it resides if you run the fsapadm assignfile -f inherit command on the directory.

The following example defines an allocation policy that allocates data to the least full volume.

Allocating data from vol1 to vol2

1. Define an allocation policy, `lf_12`, that allocates user data to the least full volume between `vol1` and `vol2`:

   ```
   # fsapadm define -o least-full /mnt1 lf_12 vol1 vol2
   ```

2. Assign the allocation policy `lf_12` as the data allocation policy to the file system mounted at `/mnt1`:

   ```
   # fsapadm assignfs /mnt1 lf_12 ''
   ```

   Metadata allocations use the default policy, as indicated by the empty string (''). The default policy is as-given allocations from all metadata-eligible volumes.

Volume encapsulation

Multi-volume support enables the ability to encapsulate an existing raw volume and make the volume contents appear as a file in the file system.

Encapsulating a volume involves the following actions:

- Adding the volume to an existing volume set.
- Adding the volume to the file system using `fsvoladm`.

Encapsulating a volume

The following example illustrates how to encapsulate a volume.

To encapsulate a volume

1 List the volumes:

```
# vxvset -g dg1 list myvset
VOLUME    INDEX    LENGTH    STATE    CONTEXT
vol1      0        102400    ACTIVE   -
vol2      1        102400    ACTIVE   -
```

The volume set has two volumes.

2 Create a third volume and copy the passwd file to the third volume:

```
# vxassist -g dg1 make dbvol 100m
# dd if=/etc/passwd of=/dev/vx/rdsk/rootdg/dbvol count=1
1+0 records in
1+0 records out
```

The third volume will be used to demonstrate how the volume can be accessed as a file, as shown later.

3 Create a file system on the volume set:

```
# mkfs -t vxfs /dev/vx/rdsk/rootdg/myvset
version 7 layout
204800 sectors, 102400 blocks of size 1024,
log size 1024 blocks
largefiles supported
```

4 Mount the volume set:

```
# mount -t vxfs /dev/vx/dsk/rootdg/myvset /mnt1
```

5 Add the new volume to the volume set:

```
# vxvset -g dg1 addvol myvset dbvol
```

6. Encapsulate `dbvol`:

```
# fsvoladm encapsulate /mnt1/dbfile dbvol 100m
# ls -l /mnt1/dbfile
-rw------- 1 root other 104857600 May 22 11:30 /mnt1/dbfile
```

7. Examine the contents of `dbfile` to see that it can be accessed as a file:

```
# head -2 /mnt1/dbfile
root:x:0:1:Super-User:/:/sbin/sh
daemon:x:1:1::/:
```

   The passwd file that was written to the raw volume is now visible in the new file.

   Note: If the encapsulated file is changed in any way, such as if the file is extended, truncated, or moved with an allocation policy or resized volume, or the volume is encapsulated with a bias, the file cannot be de-encapsulated.

Deencapsulating a volume

The following example illustrates how to deencapsulate a volume.

To deencapsulate a volume

1. List the volumes:

```
# vxvset -g dg1 list myvset
VOLUME    INDEX    LENGTH    STATE    CONTEXT
vol1      0        102400    ACTIVE   -
vol2      1        102400    ACTIVE   -
dbvol     2        102400    ACTIVE   -
```

   The volume set has three volumes.

2. Deencapsulate `dbvol`:

```
# fsvoladm deencapsulate /mnt1/dbfile
```

Reporting file extents

MVS feature provides the capability for file-to-volume mapping and volume-to-file mapping via the `fsmap` and `fsvmap` commands. The `fsmap` command reports the volume name, logical offset, and size of data extents, or the volume name and size of indirect extents associated with a file on a multi-volume file system. The `fsvmap` command maps volumes to the files that have extents on those volumes.

See the `fsmap`(1M) and `fsvmap`(1M) manual pages.

The `fsmap` command requires `open`() permission for each file or directory specified. Root permission is required to report the list of files with extents on a particular volume.

Examples of reporting file extents

The following examples show typical uses of the `fsmap` and `fsvmap` commands.

Using the fsmap command

- Use the `find` command to descend directories recursively and run `fsmap` on the list of files:

  ```
  # find . | fsmap -
  Volume  Extent Type    File
  vol2    Data           ./file1
  vol1    Data           ./file2
  ```

Using the fsvmap command

1. Report the extents of files on multiple volumes:

   ```
   # fsvmap /dev/vx/rdsk/fstest/testvset vol1 vol2
   vol1  /.
   vol1  /ns2
   vol1  /ns3
   vol1  /file1
   vol2  /file1
   vol2  /file2
   ```

2. Report the extents of files that have either data or metadata on a single volume in all Storage Checkpoints, and indicate if the volume has file system metadata:

   ```
   # fsvmap -mvC /dev/vx/rdsk/fstest/testvset vol1
   Meta  Structural   vol1  //volume has filesystem metadata//
   Data  UNNAMED      vol1  /.
   Data  UNNAMED      vol1  /ns2
   Data  UNNAMED      vol1  /ns3
   Data  UNNAMED      vol1  /file1
   Meta  UNNAMED      vol1  /file1
   ```

Load balancing

An allocation policy with the balance allocation order can be defined and assigned to files that must have their allocations distributed at random between a set of specified volumes. Each extent associated with these files are limited to a maximum size that is defined as the required chunk size in the allocation policy. The distribution of the extents is mostly equal if none of the volumes are full or disabled.

Load balancing allocation policies can be assigned to individual files or for all files in the file system. Although intended for balancing data extents across volumes, a load balancing policy can be assigned as a metadata policy if desired, without any restrictions.

Note: If a file has both a fixed extent size set and an allocation policy for load balancing, certain behavior can be expected. If the chunk size in the allocation policy is greater than the fixed extent size, all extents for the file are limited by the chunk size. For example, if the chunk size is 16 MB and the fixed extent size is 3 MB, then the largest extent that satisfies both the conditions is 15 MB. If the fixed extent size is larger than the chunk size, all extents are limited to the fixed extent size. For example, if the chunk size is 2 MB and the fixed extent size is 3 MB, then all extents for the file are limited to 3 MB.

Defining and assigning a load balancing allocation policy

The following example defines a load balancing policy and assigns the policy to the file, `/mnt/file.db`.

To define and assign the policy

1 Define the policy by specifying the `-o balance` and `-c` options:

```
# fsapadm define -o balance -c 2m /mnt loadbal vol1 vol2 vol3 vol4
```

2 Assign the policy:

```
# fsapadm assign /mnt/filedb loadbal meta
```

Rebalancing extents

Extents can be rebalanced by strictly enforcing the allocation policy. Rebalancing is generally required when volumes are added or removed from the policy or when the chunk size is modified. When volumes are removed from the volume set, any extents on the volumes being removed are automatically relocated to other volumes within the policy.

The following example redefines a policy that has four volumes by adding two new volumes, removing an existing volume, and enforcing the policy for rebalancing.

To rebalance extents

1 Define the policy by specifying the `-o balance` and `-c` options:

```
# fsapadm define -o balance -c 2m /mnt loadbal vol1 vol2 vol4 \
vol5 vol6
```

2 Enforce the policy:

```
# fsapadm enforcefile -f strict /mnt/filedb
```

Converting a multi-volume file system to a single volume file system

Because data can be relocated among volumes in a multi-volume file system, you can convert a multi-volume file system to a traditional, single volume file system by moving all file system data onto a single volume. Such a conversion is useful to users who would like to try using a multi-volume file system or Dynamic Storage Tiering, but are not committed to using a multi-volume file system permanently.

There are three restrictions to this operation:

- The single volume must be the first volume in the volume set
- The first volume must have sufficient space to hold all of the data and file system metadata
- The volume cannot have any allocation policies that restrict the movement of data

Converting to a single volume file system

The following procedure converts an existing multi-volume file system, `/mnt1`, of the volume set `vset1`, to a single volume file system, `/mnt1`, on volume `vol1` in diskgroup `dg1`.

Note: Steps 5, 6, 7, and 8 are optional, and can be performed if you prefer to remove the wrapper of the volume set object.

Converting to a single volume file system

1 Determine if the first volume in the volume set, which is identified as device number 0, has the capacity to receive the data from the other volumes that will be removed:

```
# df /mnt1
/mnt1  (/dev/vx/dsk/dg1/vol1):16777216 blocks  3443528 files
```

2 If the first volume does not have sufficient capacity, grow the volume to a sufficient size:

```
# fsvoladm resize /mnt1 vol1 150g
```

3 Remove all existing allocation policies:

```
# fsppadm unassign /mnt1
```

4 Remove all volumes except the first volume in the volume set:

```
# fsvoladm remove /mnt1 vol2
# vxvset -g dg1 rmvol vset1 vol2
# fsvoladm remove /mnt1 vol3
# vxvset -g dg1 rmvol vset1 vol3
```

Before removing a volume, the file system attempts to relocate the files on that volume. Successful relocation requires space on another volume, and no allocation policies can be enforced that pin files to that volume. The time for the command to complete is proportional to the amount of data that must be relocated.

5 Unmount the file system:

```
# umount /mnt1
```

6 Remove the volume from the volume set:

```
# vxvset -g dg1 rmvol vset1 vol1
```

7 Edit the `/etc/fstab` file to replace the volume set name, `vset1`, with the volume device name, `vol1`.

8 Mount the file system:

```
# mount -t vxfs /dev/vx/dsk/dg1/vol1 /mnt1
```

Chapter 9

Using Veritas Extension for Oracle Disk Manager

This chapter includes the following topics:

About Oracle Disk Manager

Veritas Extension for Oracle Disk Manager is specifically designed for Oracle10g or later to enhance file management and disk I/O throughput. The features of Oracle Disk Manager are best suited for databases that reside in a file system contained in Veritas File System. Oracle Disk Manager allows Oracle10g or later users to improve database throughput for I/O intensive workloads with special I/O optimization.

Veritas Extension for Oracle Disk Manager supports Oracle Resilvering. With Oracle Resilvering, the storage layer receives information from the Oracle database as to which regions or blocks of a mirrored datafile to resync after a system crash. Oracle Resilvering avoids overhead from the VxVM DRL, which increases performance.

Oracle Disk Manager reduces administrative overhead by providing enhanced support for Oracle Managed Files. Veritas Extension for Oracle Disk Manager is transparent to the user. Files managed using Veritas Extension for Oracle Disk Manager do not require special file naming conventions. The Oracle Disk Manager interface uses regular database files.

Note: Veritas Storage Foundation 4.1 for Oracle was the last major release that supported Oracle Disk Manager for raw devices.

Database administrators can choose the datafile type used with the Oracle product. Historically, choosing between file system files and raw devices was based on manageability and performance. The exception to this is a database intended for use with Oracle Parallel Server, which requires raw devices on most platforms. If performance is not as important as administrative ease, file system files are typically the preferred file type. However, while an application may not have substantial I/O requirements when it is first implemented, I/O requirements may change. If an application becomes dependent upon I/O throughput, converting datafiles from file system to raw devices is often necessary.

Oracle Disk Manager was designed to work with Oracle10g or later to provide both performance and manageability. Oracle Disk Manager provides support for Oracle's file management and I/O calls for database storage on VxFS file systems and on raw volumes or partitions. This feature is provided as a dynamically-loaded shared library with which Oracle binds when it is loaded. The Oracle Disk Manager library works with an Oracle Disk Manager driver that is loaded in the kernel to perform its functions.

The benefits of using Oracle Disk Manager are as follows:

- True kernel asynchronous I/O for files and raw devices
- Reduced system call overhead
- Improved file system layout by preallocating contiguous files on a VxFS file system
- Performance on file system files that is equivalent to raw devices
- Transparent to users
- Contiguous datafile allocation

How Oracle Disk Manager improves database performance

Oracle Disk Manager improves database I/O performance to VxFS file systems by:

- Supporting kernel asynchronous I/O
- Supporting direct I/O and avoiding double buffering
- Avoiding kernel write locks on database files
- Supporting many concurrent I/Os in one system call
- Avoiding duplicate opening of files per Oracle instance
- Allocating contiguous datafiles

About kernel asynchronous I/O support

Asynchronous I/O performs non-blocking system level reads and writes, allowing the system to perform multiple I/O requests simultaneously. Kernel asynchronous I/O is better than library asynchronous I/O because the I/O is queued to the disk device drivers in the kernel, minimizing context switches to accomplish the work.

About direct I/O support and avoiding double buffering

I/O on files using read() and write() system calls typically results in data being copied twice: once between the user and kernel space, and the other between kernel space and the disk. In contrast, I/O on raw devices is copied directly between user space and disk, saving one level of copying. As with I/O on raw devices, Oracle Disk Manager I/O avoids the extra copying. Oracle Disk Manager bypasses the system cache and accesses the files with the same efficiency as raw devices. Avoiding double buffering reduces the memory overhead on the system. Eliminating the copies from kernel to user address space significantly reduces kernel mode processor utilization freeing more processor cycles to execute the application code.

About avoiding kernel write locks on database files

When database I/O is performed by way of the write() system call, each system call acquires and releases a kernel write lock on the file. This lock prevents simultaneous write operations on the same file. Because database systems usually implement their own locks for managing concurrent access to files, write locks unnecessarily serialize I/O writes. Oracle Disk Manager bypasses file system locking and lets the database server control data access.

About supporting many concurrent I/Os in one system call

When performing asynchronous I/O, an Oracle process may try to issue additional I/O requests while collecting completed I/Os, or it may try to wait for particular I/O requests synchronously, as it can do no other work until the I/O is completed. The Oracle process may also try to issue requests to different files. All this activity can be accomplished with one system call when Oracle uses the Oracle Disk Manager I/O interface. This interface reduces the number of system calls performed to accomplish the same work, reducing the number of user space/kernel space context switches.

About avoiding duplicate file opens

Oracle Disk Manager allows files to be opened once, providing a “file identifier.” This is called “identifying” the files. The same file identifiers can be used by any other processes in the Oracle instance. The file status is maintained by the Oracle Disk Manager driver in the kernel. The reduction in file open calls reduces processing overhead at process initialization and termination, and it reduces the number of file status structures required in the kernel.

About allocating contiguous datafiles

Oracle Disk Manager can improve performance for queries, such as sort and parallel queries, that use temporary tablespaces. Without Oracle Disk Manager, Oracle does not initialize the datafiles for the temporary tablespaces. Therefore, the datafiles become sparse files and are generally fragmented. Sparse or fragmented files lead to poor query performance. When using Oracle Disk Manager, the datafiles are initialized for the temporary tablespaces and are allocated in a contiguous fashion, so that they are not sparse.

About Oracle Disk Manager and Storage Foundation Cluster File System

Oracle Disk Manager supports access to clustered files in the SFCFS environment. With a Veritas Storage Foundation Cluster File System license, ODM supports SFCFS files in a serially-exclusive mode which allows access to each SFCFS file by one node at a time, but does not allow simultaneous access from multiple nodes.

See the `mount.vxodmfs`(8) man page for more information on its cluster support modes.

About Oracle Disk Manager and Oracle Managed Files

Oracle10g or later offers a feature known as Oracle Managed Files (OMF). OMF manages datafile attributes such as file names, file location, storage attributes, and whether or not the file is in use by the database. OMF is only supported for databases that reside in file systems. OMF functionality is greatly enhanced by Oracle Disk Manager.

The main requirement for OMF is that the database be placed in file system files. There are additional prerequisites imposed upon the file system itself.

OMF is a file management feature that:

- Eliminates the task of providing unique file names
- Offers dynamic space management by way of the tablespace auto-extend functionality of Oracle10g or later

OMF should only be used in file systems that reside within striped logical volumes, which support dynamic file system growth. File systems intended for OMF use must also support large, extensible files in order to facilitate tablespace auto-extension. Raw partitions cannot be used for OMF.

By default, OMF datafiles are created with auto-extend capability. This attribute reduces capacity planning associated with maintaining existing databases and implementing new applications. Due to disk fragmentation that occurs as the tablespace grows over time, database administrators have been somewhat cautious when considering auto-extensible tablespaces. Oracle Disk Manager eliminates this concern.

When Oracle Disk Manager is used in conjunction with OMF, special care is given within Veritas Extension for Disk Manager to ensure that contiguous disk space is allocated to datafiles, including space allocated to a tablespace when it is auto-extended. The table and index scan throughput does not decay as the tablespace grows.

How Oracle Disk Manager works with Oracle Managed Files

The following example illustrates the relationship between Oracle Disk Manager and Oracle Managed Files (OMF). The example shows the `init.ora` contents and the command for starting the database instance. To simplify Oracle UNDO management, the new Oracle10g or later `init.ora` parameter `UNDO_MANAGEMENT` is set to `AUTO`. This is known as System-Managed Undo.

Note: Before building an OMF database, you need the appropriate init.ora default values. These values control the location of the SYSTEM tablespace, online redo logs, and control files after the CREATE DATABASE statement is executed.

```
$ cat initPROD.ora
UNDO_MANAGEMENT = AUTO
DB_CREATE_FILE_DEST = '/PROD'
DB_CREATE_ONLINE_LOG_DEST_1 = '/PROD'
db_block_size = 4096
db_name = PROD
$ sqlplus /nolog
SQL> connect / as sysdba
SQL> startup nomount pfile= initPROD.ora
```

The Oracle instance starts.

```
Total System Global Area 93094616 bytes
Fixed Size 279256 bytes
Variable Size 41943040 bytes
Database Buffers 50331648 bytes
Redo Buffers 540672 bytes
```

To implement a layout that places files associated with the EMP_TABLE tablespace in a directory separate from the EMP_INDEX tablespace, use the ALTER SYSTEM statement. This example shows how OMF handles file names and storage clauses and paths. The layout allows you to think of the tablespaces as objects in a file system as opposed to a collection of datafiles. Since OMF uses the Oracle Disk Manager file resize function, the tablespace files are initially created with the default size of 100MB and grow as needed. Use the MAXSIZE attribute to limit growth.

The following example shows the commands for creating an OMF database and for creating the EMP_TABLE and EMP_INDEX tablespaces in their own locale.

Note: The directory must exist for OMF to work, so the SQL*Plus HOST command is used to create the directories:

```
SQL> create database PROD;
```

The database is created.

```
SQL> HOST mkdir /PROD/EMP_TABLE;
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/PROD/EMP_TABLE';
```

The system is altered.

```
SQL> create tablespace EMP_TABLE DATAFILE AUTOEXTEND ON MAXSIZE \
500M;
```

A tablespace is created.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/PROD/EMP_INDEX';
```

The system is altered.

```
SQL> create tablespace EMP_INDEX DATAFILE AUTOEXTEND ON MAXSIZE \
100M;
```

A tablespace is created.

Use the `ls` command to show the newly created database:

```
$ ls -lFR
total 638062
drwxr-xr-x 2 oracle10g dba 96 May  3 15:43 EMP_INDEX/
drwxr-xr-x 2 oracle10g dba 96 May  3 15:43 EMP_TABLE/
-rw-r--r-- 1 oracle10g dba 104858112 May 3 17:28 ora_1_BEhYgc0m.log
-rw-r--r-- 1 oracle10g dba 104858112 May 3 17:27 ora_2_BEhYu4NA.log
-rw-r--r-- 1 oracle10g dba 806912 May 3 15:43 ora_BEahlfUX.ctl
-rw-r--r-- 1 oracle10g dba 10489856 May 3 15:43 ora_sys_undo_BEajPSVq.dbf
-rw-r--r-- 1 oracle10g dba 104861696 May 3 15:4 ora_system_BEaiFE8v.dbf
-rw-r--r-- 1 oracle10g dba 186 May 3 15:03 PROD.ora

./EMP_INDEX:
total 204808
-rw-r--r-- 1 oracle10g dba 104861696 May 3 15:43
ora_emp_inde_BEakGfun.dbf

./EMP_TABLE:
total 204808
-rw-r--r-- 1 oracle10g dba 104861696 May 3 15:43
ora_emp_tabl_BEak1LqK.dbf
```

Setting up Veritas Extension for Oracle Disk Manager

Veritas Extension for Oracle Disk Manager is part of Veritas Storage Foundation Standard and Enterprise products. Veritas Extension for Oracle Disk Manager is enabled once your Veritas Storage Foundation Standard or Enterprise product and Oracle10g or later are installed. The Veritas Extension for Oracle Disk Manager library is linked to the library in the `{ORACLE_HOME}/lib` directory.

Before setting up Veritas Extension for Oracle Disk Manager, the following conditions must be met:

Prerequisites	■ Oracle10g, or later, must be installed on your system.

Linking the Veritas extension for Oracle Disk Manager library into Oracle home

To link the Veritas extension for Oracle Disk Manager library into Oracle home for Oracle 11g

◆ Use the `rm` and `ln` commands as follows.

```
# rm ${ORACLE_HOME}/lib/libodm11.so
# ln -s /opt/VRTSodm/lib64/libodm.so \
${ORACLE_HOME}/lib/libodm11.so
```

To link the Veritas extension for Oracle Disk Manager library into Oracle home for Oracle 10g

◆ Use the `rm` and `ln` commands as follows.

```
# rm ${ORACLE_HOME}/lib/libodm10.so
# ln -s /opt/VRTSodm/lib64/libodm.so \
${ORACLE_HOME}/lib/libodm10.so
```

Configuring Veritas Extension for Oracle Disk Manager

If `ORACLE_HOME` is on a shared file system, run the following commands from any node, otherwise run them on each node.

where *`ORACLE_HOME`* is the location where Oracle database binaries have been installed.

To configure Veritas Extension for Oracle Disk Manager

1. Log in as `oracle`.
2. If the Oracle database is running, then shutdown the Oracle database.
3. Verify that `/opt/VRTSodm/lib64/libodm.so` exists.

4. Link Oracle's ODM library present in `ORACLE_HOME` with Veritas Extension for Oracle Disk Manager library:

   For Oracle10g:

   - Change to the `$ORACLE_HOME/lib` directory, enter:

     ```
     # cd $ORACLE_HOME/lib
     ```

   - Take backup of `libodm10.so`, enter.

     ```
     # mv libodm10.so libodm10.so.oracle-`date '+%m_%d_%y-%H_%M_%S'`
     ```

   - Link `libodm10.so` with Veritas ODM library, enter:

     ```
     # ln -s /opt/VRTSodm/lib64/libodm.so libodm10.so
     ```

   For Oracle11g:

   - Change to the `$ORACLE_HOME/lib` directory, enter:

     ```
     # cd $ORACLE_HOME/lib
     ```

   - Take backup of `libodm11.so`, enter.

     ```
     # mv libodm11.so libodm11.so.oracle-`date '+%m_%d_%y-%H_%M_%S'`
     ```

   - Link `libodm11.so` with Veritas ODM library, enter:

     ```
     # ln -s /opt/VRTSodm/lib64/libodm.so libodm11.so
     ```

5. Start the Oracle database.

6. To confirm that the Oracle database starts with Veritas Extension for ODM, the alert log will contain the following text:

   ```
   Veritas <version> ODM Library
   ```

   where *5.1.00.00* is the ODM library version shipped with the product.

How to prepare existing database storage for Oracle Disk Manager

Files in a VxFS file system work with Oracle Disk Manager without any changes. The files are found and identified for Oracle Disk Manager I/O by default. To take full advantage of Oracle Disk Manager datafiles, files should not be fragmented.

You must be running Oracle10g or later to use Oracle Disk Manager.

Verifying that Oracle Disk Manager is configured

Before verifying that Oracle Disk Manager is configured, make sure that the following conditions are met:

Prerequisites	■ `/opt/VRTSodm/lib64/libodm.so` must exist. ■ If you are using Oracle 10g, `$ORACLE_HOME/lib/libodm10.so` is linked to `/opt/VRTSodm/lib64/libodm.so`. ■ If you are using Oracle 11g, `$ORACLE_HOME/lib/libodm11.so` is linked to `/opt/VRTSodm/lib64/libodm.so`. ■ The `VRTSdbed` license must be valid. ■ The `VRTSodm` package must be installed.

To verify that Oracle Disk Manager is configured

1 Verify that the ODM feature is included in the license:

```
# /opt/VRTS/bin/vxlicrep | grep ODM
```

The output verifies that ODM is enabled.

Note: Verify that the license key containing the ODM feature is not expired. If the license key has expired, you will not be able to use the ODM feature.

2 Check that the `VRTSodm` package is installed:

```
# rpm -qa | grep VRTSodm
VRTSodm-5.1.00.00-Axx_RHEL5

# rpm -qa | grep VRTSodm
VRTSodm-5.1.00.00-Axx_SLES11

# rpm -qa | grep VRTSodm
VRTSodm-5.1.00.00-Axx_SLES10
```

3 Check that `libodm.so` is present.

```
# ls -lL /opt/VRTSodm/lib64/libodm.so
-rwxr-xr-x 1 bin bin 49808 Sep 1 18:42
/opt/VRTSodm/lib64/libodm.so
```

To verify that Oracle Disk Manager is running

1 Start the Oracle database.

2 Check that the instance is using the Oracle Disk Manager function:

```
# cat /dev/odm/stats
# echo $?
0
```

3 Verify that the Oracle Disk Manager is loaded:

```
# lsmod | grep odm
vxodm   164480  1
fdd 78976 1 vxodm
```

4 In the alert log, verify the Oracle instance is running. The log should contain output similar to the following:

```
Oracle instance running with ODM: Veritas 5.1.00.00 ODM Library,
Version 2.0
```

Disabling the Oracle Disk Manager feature

Since the Oracle Disk Manager feature uses regular files, you can access these files as regular VxFS files as soon as the feature is disabled.

Note: Before disabling the Oracle Disk Manager feature, you may want to back up your files.

To disable the Oracle Disk Manager feature in an Oracle instance

1. Shut down the database instance.
2. Use the rm and ln commands to remove the link to the Oracle Disk Manager Library.

   For Oracle 11g, enter:

   ```
   # rm ${ORACLE_HOME}/lib/libodm11.so
   # ln -s ${ORACLE_HOME}/lib/libodmd11.so \
   ${ORACLE_HOME}/lib/libodm11.so
   ```

   For Oracle 10g, enter:

   ```
   # rm ${ORACLE_HOME}/lib/libodm10.so
   # ln -s ${ORACLE_HOME}/lib/libodmd10.so \
   ${ORACLE_HOME}/lib/libodm10.so
   ```

3. Restart the database instance.

About Cached ODM

ODM I/O normally bypasses the file system cache and directly reads from and writes to disk. Cached ODM enables some I/O to use caching and read ahead, which can improve ODM I/O performance. Cached ODM performs a conditional form of caching that is based on per-I/O hints from Oracle. The hints indicate what Oracle does with the data. ODM uses these hints to perform caching and read ahead for some reads, but ODM avoids caching other reads, even for the same file.

You can enable cached ODM only for local mount files. Cached ODM does not affect the performance of files and file systems for which you did not enable caching.

See "Enabling Cached ODM for file systems" on page 125.

Cached ODM can be configured in two ways. The primary configuration method is to turn caching on or off for all I/O on a per-file basis. The secondary configuration method is to adjust the ODM cachemap. The cachemap maps file type and I/O type combinations into caching advisories.

See "Tuning Cached ODM settings for individual files" on page 125.

See "Tuning Cached ODM settings via the cachemap" on page 126.

Enabling Cached ODM for file systems

Cached ODM is initially disabled on a file system. You enable Cached ODM for a file system by setting the `odm_cache_enable` option of the `vxtunefs` command after the file system is mounted.

See the `vxtunefs`(1M) manual page.

Note: The `vxtunefs` command enables conditional caching for all of the ODM files on the file system.

To enable Cached ODM for a file system

1 Enable Cached ODM on the VxFS file system `/database01`:

```
# vxtunefs -s -o odm_cache_enable=1 /database01
```

2 Optionally, you can make this setting persistent across mounts by adding a file system entry in the file `/etc/vx/tunefstab`:

```
/dev/vx/dsk/datadg/database01 odm_cache_enable=1
```

See the `tunefstab`(4) manual page.

Tuning Cached ODM settings for individual files

You can use the `odmadm setcachefile` command to override the cachemap for a specific file so that ODM caches either all or none of the I/O to the file. The caching state can be ON, OFF, or DEF (default). The DEF caching state is conditional caching, meaning that for each I/O, ODM consults the cachemap and determines whether the specified file type and I/O type combination should be cached. The ON caching state causes the specified file always to be cached, while the OFF caching state causes the specified file never to be cached.

See the `odmadm`(1M) manual page.

Note: The cache advisories operate only if Cached ODM is enabled for the file system. If the `odm_cache_enable` flag is zero, Cached ODM is OFF for all of the files in that file system, even if the individual file cache advisory for a file is ON.

To enable unconditional caching on a file

◆ Enable unconditional caching on the file /mnt1/file1:

```
# odmadm setcachefile /mnt1/file1=on
```

With this command, ODM caches all reads from file1.

To disable caching on a file

◆ Disable caching on the file /mnt1/file1:

```
# odmadm setcachefile /mnt1/file1=off
```

With this command, ODM does not cache reads from file1.

To check on the current cache advisory settings for a file

◆ Check the current cache advisory settings of the files /mnt1/file1 and /mnt2/file2:

```
# odmadm getcachefile /mnt1/file1 /mnt2/file2
/mnt1/file1,ON
/mnt2/file2,OFF
```

To reset all files to the default cache advisory

◆ Reset all files to the default cache advisory:

```
# odmadm resetcachefiles
```

Tuning Cached ODM settings via the cachemap

You can use the odmadm setcachemap command to configure the cachemap. The cachemap maps file type and I/O type combinations to caching advisories. ODM uses the cachemap for all files that have the default conditional cache setting. Such files are those for which caching has not been turned on or off by the odmadm setcachefile command.

See the odmadm(1M) manual page.

By default, the cachemap is empty, but you can add caching advisories by using the odmadm setcachemap command.

To add caching advisories to the cachemap

- Add a caching advisory to the cachemap:

  ```
  # odmadm setcachemap data/data_read_seq=cache,readahead
  ```

  With this example command, ODM uses caching and readahead for I/O to online log files (`data`) that have the `data_read_seq` I/O type. You can view the valid file type and I/O type values from the output of the `odmadm getcachemap` command.

  See the `odmadm`(1M) manual page.

Making the caching settings persistent across mounts

By default, the Cached ODM settings are not persistent across mounts. You can make the settings persistent by creating the `/etc/vx/odmadm` file and listing the caching advisory settings in the file

To make the caching setting persistent across mounts

- Create the `/etc/vx/odmadm` file to list files and their caching advisories. In the following example of the `/etc/vx/odmadm` file, if you mount the `/dev/vx/dsk/rootdg/vol1` device at `/mnt1`, odmadm turns off caching for `/mnt1/oradata/file1`:

  ```
  setcachemap data/read_data_header=cache
  setcachemap all/datapump=cache,readahead
  device /dev/vx/dsk/rootdg/vol1
  setcachefile oradata/file1=off
  ```

Quick Reference

This appendix includes the following topics:

Command summary

Symbolic links to all VxFS command executables are installed in the `/opt/VRTS/bin` directory. Add this directory to the end of your `PATH` environment variable to access the commands.

Table A-1 describes the VxFS-specific commands.

Table A-1 VxFS commands

Command	Description
df	Reports the number of free disk blocks and inodes for a VxFS file system.
fcladm	Administers VxFS File Change Logs.
ff	Lists file names and inode information for a VxFS file system.
fiostat	Administers file I/O statistics
fsadm	Resizes or defragments a VxFS file system.
fsapadm	Administers VxFS allocation policies.
fscat	Cats a VxFS file system.
fscdsadm	Performs online CDS operations.
fscdsconv	Performs offline CDS migration tasks on VxFS file systems.
fscdstask	Performs various CDS operations.
fsck	Checks and repairs a VxFS file system. Due to a behavioral issue with the Linux `fsck` wrapper, you must run the VxFS `fsck` command, `/opt/VRTS/bin/fsck`, when specifying any option with an equals sign (=) in it. For example: `# /opt/VRTS/bin/fsck -o zapvol=MyVolName /dev/rdsk/c0t0d1s1`
fsckpt_restore	Restores file systems from VxFS Storage Checkpoints.
fsckptadm	Administers VxFS Storage Checkpoints.
fsclustadm	Manages cluster-mounted VxFS file systems.
fsdb	Debugs VxFS file systems.
fsmap	Displays VxFS file system extent information.
fsppadm	Administers VxFS placement policies.
fsppmk	Creates placement policies.
fstag	Creates, deletes, or lists file tags.
fstyp	Returns the type of file system on a specified disk partition.
fsvmap	Maps volumes of VxFS file systems to files.

Table A-1 VxFS commands *(continued)*

Command	Description
`fsvoladm`	Administers VxFS volumes.
`glmconfig`	Configures Group Lock Managers (GLM).
`glmdump`	Reports stuck Group Lock Managers (GLM) locks in a cluster file system.
`glmstat`	Group Lock Managers (GLM) statistics gathering utility.
`mkfs`	Constructs a VxFS file system.
`mount`	Mounts a VxFS file system.
`ncheck`	Generates path names from inode numbers for a VxFS file system.
`setext`	Sets extent attributes on a file in a VxFS file system.
`vxdump`	Incrementally dumps file systems.
`vxedquota`	Edits user quotas for a VxFS file system.
`vxenable`	Enables specific VxFS features.
`vxfsconvert`	Converts an unmounted file system to VxFS or upgrades a VxFS disk layout version.
`vxfsstat`	Displays file system statistics.
`vxlsino`	Looks up VxFS reverse path names.
`vxquot`	Displays file system ownership summaries for a VxFS file system.
`vxquota`	Displays user disk quotas and usage on a VxFS file system.
`vxquotaoff` `vxquotaon`	Turns quotas on and off for a VxFS file system.
`vxrepquota`	Summarizes quotas for a VxFS file system.
`vxrestore`	Restores a file system incrementally.
`vxtunefs`	Tunes a VxFS file system.
`vxupgrade`	Upgrades the disk layout of a mounted VxFS file system.

Online manual pages

This release includes the following online manual pages as part of the VRTSvxfs package. These are installed in the appropriate directories under /opt/VRTS/man (add this to your MANPATH environment variable), but does not update the windex database. To ensure that new VxFS manual pages display correctly, update the windex database after installing VRTSvxfs.

See the catman(1M) manual page.

Table A-2 describes the VxFS-specific section 1 manual pages.

Table A-2 Section 1 manual pages

Section 1	Description
fiostat	Administers file I/O statistics.
getext	Gets extent attributes for a VxFS file system.
setext	Sets extent attributes on a file in a VxFS file system.

Table A-3 describes the VxFS-specific section 1M manual pages.

Table A-3 Section 1M manual pages

Section 1M	Description
cfscluster	Configures SFCFS clusters. This functionality is available only with the Veritas Cluster File System product.
cfsdgadm	Adds or deletes shared disk groups to/from a cluster configuration. This functionality is available only with the Veritas Cluster File System product.
cfsmntadm	Adds, deletes, modifies, and sets policy on cluster mounted file systems. This functionality is available only with the Veritas Cluster File System product.
cfsmount, cfsumount	Mounts or unmounts a cluster file system. This functionality is available only with the Veritas Cluster File System product.
df_vxfs	Reports the number of free disk blocks and inodes for a VxFS file system.
fcladm	Administers VxFS File Change Logs.
ff_vxfs	Lists file names and inode information for a VxFS file system.
fsadm_vxfs	Resizes or reorganizes a VxFS file system.
fsapadm	Administers VxFS allocation policies.

Table A-3 Section 1M manual pages *(continued)*

Section 1M	Description
`fscat_vxfs`	Cats a VxFS file system.
`fscdsadm`	Performs online CDS operations.
`fscdsconv`	Performs offline CDS migration tasks on VxFS file systems.
`fscdstask`	Performs various CDS operations.
`fsck_vxfs`	Checks and repairs a VxFS file system.
`fsckptadm`	Administers VxFS Storage Checkpoints.
`fsckpt_restore`	Restores file systems from VxFS Storage Checkpoints.
`fsclustadm`	
`fsdbencap`	Encapsulates databases.
`fsdb_vxfs`	Debugs VxFS file systems.
`fsmap`	Displays VxFS file system extent information.
`fsppadm`	Administers VxFS placement policies.
`fstyp_vxfs`	Returns the type of file system on a specified disk partition.
`fsvmap`	Maps volumes of VxFS file systems to files.
`fsvoladm`	Administers VxFS volumes.
`glmconfig`	Configures Group Lock Managers (GLM). This functionality is available only with the Veritas Cluster File System product.
`glmdump`	Reports stuck Group Lock Managers (GLM) locks in a cluster file system.
`mkfs_vxfs`	Constructs a VxFS file system.
`mount_vxfs`	Mounts a VxFS file system.
`ncheck_vxfs`	Generates path names from inode numbers for a VxFS file system.
`quot`	Summarizes ownership on a VxFS file system.
`quotacheck_vxfs`	Checks VxFS file system quota consistency.
`vxdiskusg`	Generates VxFS disk accounting data by user ID.
`vxdump`	Incrementally dumps file systems.

Table A-3 Section 1M manual pages *(continued)*

Section 1M	Description
`vxedquota`	Edits user quotas for a VxFS file system.
`vxenable`	Enables specific VxFS features.
`vxfsconvert`	Converts an unmounted file system to VxFS or upgrades a VxFS disk layout version.
`vxfsstat`	Displays file system statistics.
`vxlsino`	Looks up VxFS reverse path names.
`vxquot`	Displays file system ownership summaries for a VxFS file system.
`vxquota`	Displays user disk quotas and usage on a VxFS file system.
`vxquotaoff` `vxquotaon`	Turns quotas on and off for a VxFS file system.
`vxrepquota`	Summarizes quotas for a VxFS file system.
`vxrestore`	Restores a file system incrementally.
`vxtunefs`	Tunes a VxFS file system.
`vxupgrade`	Upgrades the disk layout of a mounted VxFS file system.

Table A-4 describes the VxFS-specific section 3 manual pages.

Table A-4 Section 3 manual pages

Section 3	Description
`vxfs_ap_alloc2`	Allocates an fsap_info2 structure.
`vxfs_ap_assign_ckpt`	Assigns an allocation policy to file data and metadata in a Storage Checkpoint.
`vxfs_ap_assign_ckptchain`	Assigns an allocation policy for all of the Storage Checkpoints of a VxFS file system.
`vxfs_ap_assign_ckptdef`	Assigns a default allocation policy for new Storage Checkpoints of a VxFS file system.
`vxfs_ap_assign_file`	Assigns an allocation policy for file data and metadata.
`vxfs_ap_assign_file_pat`	Assigns a pattern-based allocation policy for a directory.

Table A-4 Section 3 manual pages *(continued)*

Section 3	Description
`vxfs_ap_assign_fs`	Assigns an allocation policy for all file data and metadata within a specified file system.
`vxfs_ap_assign_fs_pat`	Assigns an pattern-based allocation policy for a file system.
`vxfs_ap_define`	Defines a new allocation policy.
`vxfs_ap_define2`	Defines a new allocation policy.
`vxfs_ap_enforce_ckpt`	Reorganizes blocks in a Storage Checkpoint to match a specified allocation policy.
`vxfs_ap_enforce_ckptchain`	Enforces the allocation policy for all of the Storage Checkpoints of a VxFS file system.
`vxfs_ap_enforce_file`	Ensures that all blocks in a specified file match the file allocation policy.
`vxfs_ap_enforce_file2`	Reallocates blocks in a file to match allocation policies.
`vxfs_ap_enumerate`	Returns information about all allocation policies.
`vxfs_ap_enumerate2`	Returns information about all allocation policies.
`vxf_ap_free2`	Frees one or more fsap_info2 structures.
`vxfs_ap_query`	Returns information about a specific allocation policy.
`vxfs_ap_query2`	Returns information about a specific allocation policy.
`vxfs_ap_query_ckpt`	Returns information about allocation policies for each Storage Checkpoint.
`vxfs_ap_query_ckptdef`	Retrieves the default allocation policies for new Storage Checkpoints of a VxFS file system
`vxfs_ap_query_file`	Returns information about allocation policies assigned to a specified file.
`vxfs_ap_query_file_pat`	Returns information about the pattern-based allocation policy assigned to a directory.
`vxfs_ap_query_fs`	Retrieves allocation policies assigned to a specified file system.
`vxfs_ap_query_fs_pat`	Returns information about the pattern-based allocation policy assigned to a file system.
`vxfs_ap_remove`	Deletes a specified allocation policy.

Table A-4 Section 3 manual pages *(continued)*

Section 3	Description
`vxfs_fcl_sync`	Sets a synchronization point in the VxFS File Change Log.
`vxfs_fiostats_dump`	Returns file and file range I/O statistics.
`vxfs_fiostats_getconfig`	Gets file range I/O statistics configuration values.
`vxfs_fiostats_set`	Turns on and off file range I/O statistics and resets statistics counters.
`vxfs_get_ioffsets`	Obtains VxFS inode field offsets.
`vxfs_inotopath`	Returns path names for a given inode number.
`vxfs_inostat`	Gets the file statistics based on the inode number.
`vxfs_inotofd`	Gets the file descriptor based on the inode number.
`vxfs_nattr_check` `vxfs_nattr_fcheck`	Checks for the existence of named data streams.
`vxfs_nattr_link`	Links to a named data stream.
`vxfs_nattr_open`	Opens a named data stream.
`vxfs_nattr_rename`	Renames a named data stream.
`vxfs_nattr_unlink`	Removes a named data stream.
`vxfs_nattr_utimes`	Sets access and modification times for named data streams.
`vxfs_vol_add`	Adds a volume to a multi-volume file system.
`vxfs_vol_clearflags`	Clears specified flags on volumes in a multi-volume file system.
`vxfs_vol_deencapsulate`	De-encapsulates a volume from a multi-volume file system.
`vxfs_vol_encapsulate`	Encapsulates a volume within a multi-volume file system.
`vxfs_vol_encapsulate_bias`	Encapsulates a volume within a multi-volume file system.
`vxfs_vol_enumerate`	Returns information about the volumes within a multi-volume file system.
`vxfs_vol_queryflags`	Queries flags on volumes in a multi-volume file system.
`vxfs_vol_remove`	Removes a volume from a multi-volume file system.
`vxfs_vol_resize`	Resizes a specific volume within a multi-volume file system.

Table A-4 Section 3 manual pages *(continued)*

Section 3	Description
`vxfs_vol_setflags`	Sets specified flags on volumes in a multi-volume file system.
`vxfs_vol_stat`	Returns free space information about a component volume within a multi-volume file system.

Table A-5 describes the VxFS-specific section 4 manual pages.

Table A-5 Section 4 manual pages

Section 4	Description
`fs_vxfs`	Provides the format of a VxFS file system volume.
`inode_vxfs`	Provides the format of a VxFS file system inode.
`tunefstab`	Describes the VxFS file system tuning parameters table.

Table A-6 describes the VxFS-specific section 7 manual pages.

Table A-6 Section 7 manual pages

Section 7	Description
`vxfsio`	Describes the VxFS file system control functions.

Creating a VxFS file system

The `mkfs` command creates a VxFS file system by writing to a special character device file. The special character device must be a Veritas Volume Manager (VxVM) volume. The `mkfs` command builds a file system with a root directory and a `lost+found` directory.

Before running `mkfs`, you must create the target device.

See to your operating system documentation.

If you are using a logical device (such as a VxVM volume), see the VxVM documentation.

Note: Creating a VxFS file system on a Logical Volume Manager (LVM) or Multiple Device (MD) driver volume is not supported in this release. You also must convert an underlying LVM to a VxVM volume before converting an `ext2` or `ext3` file system to a VxFS file system. See the `vxvmconvert`(1M) manual page.

See the `mkfs`(1M) and `mkfs_vxfs`(1M) manual pages.

To create a file system

- Use the `mkfs` command to create a file system:

```
mkfs [-t vxfs] [generic_options] [-o specific_options] \
special [size]
```

`-t vxfs` Specifies the VxFS file system type.

`-m` Displays the command line that was used to create the file system. The file system must already exist. This option enables you to determine the parameters used to construct the file system.

generic_options Options common to most other file system types.

`-o` *specific_options* Options specific to VxFS.

`-o N` Displays the geometry of the file system and does not write to the device.

`-o largefiles` Allows users to create files larger than two gigabytes. The default option is largefiles.

special Specifies the special device file location or character device node of a particular storage device. The device must be a Veritas Volume Manager volume.

size Specifies the number of 512-byte sectors in the file system. If *size* is not specified, `mkfs` determines the size of the special device.

Example of creating a file system

The following example creates a VxFS file system of 12288 sectors in size on a VxVM volume.

To create a VxFS file system

1 Create the file system:

```
# mkfs -t vxfs /dev/vx/rdsk/diskgroup/volume 12288
version 7 layout
12288 sectors, 6144 blocks of size 1024, log size 256 blocks
largefiles supported
```

2 Mount the newly created file system.

Converting a file system to VxFS

The `vxfsconvert` command can be used to convert a ext2 or ext3 file system to a VxFS file system.

See the `vxfsconvert`(1M) manual page.

To convert a ext2 or ext3 file system to a VxFS file system

◆ Use the `vxfsconvert` command to convert a ext2 or ext3 file system to VxFS:

```
vxfsconvert [-l logsize] [-s size] [-efnNvyY] special
```

`-e`	Estimates the amount of space required to complete the conversion.
`-f`	Displays the list of supported file system types.
`-l` *logsize*	Specifies the size of the file system intent log.
`-n|N`	Assumes a no response to all questions asked by `vxfsconvert`.
`-s` *siz*	Directs `vxfsconvert` to use free disk space past the current end of the file system to store VxFS metadata.
`-v`	Specifies verbose mode.
`-y|Y`	Assumes a yes response to all questions asked by `vxfsconvert`.
special	Specifies the name of the character (raw) device that contains the file system to convert.

Example of converting a file system

The following example converts a ext2 or ext3 file system to a VxFS file system with an intent log size of 4096 blocks.

To convert an ext2 or ext3 file system to a VxFS file system

- Convert the file system:

```
# vxfsconvert -l 4096 /dev/vx/rdsk/diskgroup/volume
```

Mounting a file system

You can mount a VxFS file system by using the `mount` command. When you enter the `mount` command, the generic `mount` command parses the arguments and the `-t FSType` option executes the `mount` command specific to that file system type. If the `-t` option is not supplied, the command searches the file `/etc/fstab` for a file system and an FSType matching the special file or mount point provided. If no file system type is specified, `mount` uses the default file system.

To mount a file system

- Use the `mount` command to mount a file system:

```
mount [-t vxfs] [generic_options] [-r] [-o specific_options] \
special mount_point
```

`vxfs`	File system type.
generic_options	Options common to most other file system types.
specific_options	Options specific to VxFS.
`-o ckpt=`*`ckpt_name`*	Mounts a Storage Checkpoint.
`-o cluster`	Mounts a file system in shared mode. Available only with the VxFS cluster file system feature.
special	A VxFS block special device.
mount_point	Directory on which to mount the file system.
`-r`	Mounts the file system as read-only.

Mount options

The `mount` command has numerous options to tailor a file system for various functions and environments.

The following table lists some of the *specific_options*:

Security feature

If security is important, use blkclear to ensure that deleted files are completely erased before the space is reused.

Support for large files

If you specify the largefiles option, you can create files larger than two gigabytes on the file system. The default option is largefiles.

Using Storage Checkpoints

The ckpt=*checkpoint_name* option mounts a Storage Checkpoint of a mounted file system that was previously created by the fsckptadm command.

News file systems

If you are using cnews, use delaylog (or tmplog),mincache=closesync because cnews does an fsync() on each news file before marking it received. The fsync() is performed synchronously as required, but other options are delayed.

Temporary file systems

For a temporary file system such as /tmp, where performance is more important than data integrity, use tmplog,mincache=tmpcache.

Locking a file system

If you specify the mntlock option, you can lock a file system to disallow unmounting the file system except if the mntunlock option is specified. The mntlock is useful for applications for which you do not want the file systems that the applications are monitoring to be improperly unmounted by other applications or administrators.

See “Mounting a VxFS file system” on page 30.

See the fsckptadm(1M), mount_vxfs(1M), fstab(5), and mount(8) manual pages.

Example of mounting a file system

The following example mounts the file system /dev/vx/dsk/fsvol/vol1 on the /ext directory with read/write access and delayed logging.

To mount the file system

◆ Mount the file system:

```
# mount -t vxfs -o delaylog /dev/vx/dsk/fsvol/vol1 /ext
```

Editing the fstab file

You can edit the /etc/fstab file to mount a file system automatically at boot time.

You must specify the following:

- The special block device name to `mount`
- The mount point
- The file system type (vxfs)
- The `mount` options
- Which file systems need to be dumped (by default a file system is not dumped)
- Which `fsck` pass looks at the file system

Each entry must be on a single line.

See the `fstab`(5) manual page.

The following is a typical `fstab` file with the new file system on the last line:

```
LABEL=/                 /            ext3          defaults           1 1
LABEL=/boot             /boot        ext3          defaults           1 2
none                    /dev/pts     devpts        gid=5,mode=620     0 0
none                    /proc        proc          defaults           0 0
/dev/sdc1               swap         swap          defaults           0 0
/dev/cdrom              /mnt/cdrom   udf,iso9660   noauto,owner,ro    0 0
/dev/fd0                /mnt/floppy  auto          noauto,owner       0 0
/dev/vx/dsk/fsvol/vol1  /mnt1        vxfs          defaults           0 2
```

Unmounting a file system

Use the `umount` command to unmount a currently mounted file system.

See the `vxumount`(1M) manual page.

To unmount a file system

◆ Use the `umount` command to unmount a file system:

Specify the file system to be unmounted as a *mount_point* or *special*. *special* is the VxFS block special device on which the file system resides.

Example of unmounting a file system

The following are examples of unmounting file systems.

To unmount the file system /dev/vx/dsk/fsvol/vol1

◆ Unmount the file system:

```
# umount /dev/vx/dsk/fsvol/vol1
```

To unmount all file systems not required by the system

- Unmount the file system mounted at /mnt1:

```
# vxumount /mnt1
```

Displaying information on mounted file systems

Use the mount command to display a list of currently mounted file systems.

See the mount_vxfs(1M) and mount(8) manual pages.

To view the status of mounted file systems

- Use the mount command to view the status of mounted file systems:

```
mount
```

  This shows the file system type and mount options for all mounted file systems.

Example of displaying information on mounted file systems

The following example shows the result of invoking the mount command without options.

To display information on mounted file systems

- Invoke the mount command without options:

```
# mount
/dev/sda3 on / type ext3 (rw)
none on /proc type proc (rw)
none on /dev/pts type devpts (rw,gid=5,mode=620)
```

Identifying file system types

Use the fstyp command to determine the file system type for a specified file system. This is useful when a file system was created elsewhere and you want to know its type.

See the fstyp_vxfs(1M) manual page.

To determine a file system's type

- Use the fstyp command to determine a file system's type:

```
fstyp -v special
```

special The block or character (raw) device.

`-v` Specifies verbose mode.

Example of determining a file system's type

The following example uses the `fstyp` command to determine a the file system type of the `/dev/vx/dsk/fsvol/vol1` device.

To determine the file system's type

- Use the `fstyp` command to determine the file system type of the device

  ```
  # fstyp -v /dev/vx/dsk/fsvol/vol1
  ```

  The output indicates that the file system type is vxfs, and displays file system information similar to the following:

  ```
  vxfs
  magic a501fcf5 version 7 ctime Tue Jun 23 18:29:39 2004
  logstart 17  logend 1040
  bsize  1024 size  1048576 dsize  1047255  ninode 0  nau 8
  defiextsize 64  ilbsize 0  immedlen 96  ndaddr 10
  aufirst 1049  emap 2  imap 0  iextop 0  istart 0
  bstart 34  femap 1051  fimap 0  fiextop 0  fistart 0  fbstart

  1083
  nindir 2048  aulen 131106  auimlen 0  auemlen 32
  auilen 0  aupad 0  aublocks 131072  maxtier 17
  inopb 4  inopau 0  ndiripau 0  iaddrlen 8   bshift 10
  inoshift 2  bmask fffffc00  boffmask 3ff  checksum d7938aa1
  oltext1 9  oltext2 1041  oltsize 8  checksum2 52a
  free 382614  ifree 0
  efree  676 413 426 466 612 462 226 112 85 35 14 3 6 5 4 4 0 0
  ```

Resizing a file system

You can extend or shrink mounted VxFS file systems using the `fsadm` command. Use the `extendfs` command to extend the size of an unmounted file system. A file system using the Version 6 or 7 disk layout can be up to 8 exabytes in size. The size to which a Version 6 or 7 disk layout file system can be increased depends on the file system block size.

See “About disk layouts” on page 201.

See the fsadm_vxfs(1M) and fdisk(8) manual pages.

Extending a file system using fsadm

If a VxFS file system is not large enough, you can increase its size. The size of the file system is specified in units of 1024-byte blocks (or sectors).

Note: If a file system is full, busy, or too fragmented, the resize operation may fail.

The device must have enough space to contain the larger file system.

See the fdisk(8) manual page.

See the *Veritas Volume Manager Administrator's Guide*.

To extend a VxFS file system

◆ Use the fsadm command to extend a VxFS file system:

```
fsadm  [-b newsize] [-r rawdev] \
mount_point
```

newsize	The size (in sectors) to which the file system will increase.
mount_point	The file system's mount point.
-r *rawdev*	Specifies the path name of the raw device if there is no entry in /etc/fstab and fsadm cannot determine the raw device.

Example of extending a file system

The following is an example of extending a file system with the fsadm command.

To extend a file system

◆ Extend the VxFS file system mounted on /ext to 22528 sectors:

```
# fsadm -b 22528 /ext
```

Shrinking a file system

You can decrease the size of the file system using fsadm, even while the file system is mounted.

Note: If a file system is full, busy, or too fragmented, the resize operation may fail.

To decrease the size of a VxFS file system

- Use the `fsadm` command to decrease the size of a VxFS file system:

```
fsadm  [-t vxfs] [-b newsize] [-r rawdev] mount_point
```

`vxfs`	The file system type.
newsize	The size (in sectors) to which the file system will shrink.
mount_point	The file system's mount point.
`-r` *`rawdev`*	Specifies the path name of the raw device if there is no entry in `/etc/fstab` and `fsadm` cannot determine the raw device.

Example of shrinking a file system

The following example shrinks a VxFS file system mounted at `/ext` to 20480 sectors.

To shrink a VxFS file system

- Shrink a VxFS file system mounted at `/ext` to 20480 sectors:

```
# fsadm -t vxfs -b 20480 /ext
```

Warning: After this operation, there is unused space at the end of the device. You can then resize the device, but be careful not to make the device smaller than the new size of the file system.

Reorganizing a file system

You can reorganize or compact a fragmented file system using `fsadm`, even while the file system is mounted. This may help shrink a file system that could not previously be decreased.

Note: If a file system is full or busy, the reorg operation may fail.

To reorganize a VxFS file system

- Use the fsadm command to reorganize a VxFS file system:

```
fsadm [-t vxfs] [-e] [-d] [-E] [-D] [-r rawdev] mount_point
```

vxfs	The file system type.
-d	Reorders directory entries to put subdirectory entries first, then all other entries in decreasing order of time of last access. Also compacts directories to remove free space.
-D	Reports on directory fragmentation.
-e	Minimizes file system fragmentation. Files are reorganized to have the minimum number of extents.
-E	Reports on extent fragmentation.
mount_point	The file system's mount point.
-r *rawdev*	Specifies the path name of the raw device if there is no entry in /etc/fstab and fsadm cannot determine the raw device.

Example of reorganizing a file system

The following example reorganizes the file system mounted at /ext.

To reorganize a VxFS file system

- Reorganize the VxFS file system mounted at /ext:

```
# fsadm -t vxfs -EeDd /ext
```

Backing up and restoring a file system

To back up a VxFS file system, you first create a read-only snapshot file system, then back up the snapshot. This procedure lets you keep the main file system on line. The snapshot is a copy of the snapped file system that is frozen at the moment the snapshot is created.

See "About snapshot file systems" on page 69.

See the mount_vxfs(1M), vxdump(1M), vxrestore(1M), and mount(8) manual pages.

Creating and mounting a snapshot file system

The first step in backing up a VxFS file system is to create and mount a snapshot file system.

To create and mount a snapshot of a VxFS file system

- Use the `mount` command to create and mount a snapshot of a VxFS file system:

```
mount [-t vxfs] -o ro,snapof=source,[snapsize=size] \
destination snap_mount_point
```

source	The mount point of the file system to copy.
destination	The name of the special device on which to create the snapshot.
size	The size of the snapshot file system in sectors.
snap_mount_point	Location where to mount the snapshot; *snap_mount_point*must exist before you enter this command.

Example of creating and mounting a snapshot of a VxFS file system

The following example creates a snapshot file system of the file system at `/home` on `/dev/vx/dsk/fsvol/vol1`, and mounts it at `/snapmount`.

To create and mount a snapshot file system of a file system

- Create a snapshot file system of the file system at `/home` on `/dev/vx/dsk/fsvol/vol1` and mount it at `/snapmount`:

```
# mount -t vxfs -o ro,snapof=/home, \
snapsize=32768 /dev/vx/dsk/fsvol/vol1 /snapmount
```

You can now back up the file system.

Backing up a file system

After creating a snapshot file system, you can use `vxdump` to back it up.

To back up a VxFS snapshot file system

- Use the `vxdump` command to back up a VxFS snapshot file system:

```
vxdump [-c] [-f backupdev] snap_mount_point
```

`-c`	Specifies using a cartridge tape device.
backupdev	The device on which to back up the file system.
snap_mount_point	The snapshot file system's mount point.

Example of backing up a file system

The following example backs up the VxFS snapshot file system mounted at `/snapmount` to the tape drive with device name `/dev/st1/`.

To back up a VxFS snapshot file system

◆ Back up the VxFS snapshot file system mounted at `/snapmount` to the tape drive with device name `/dev/st1`:

```
# vxdump -cf /dev/st1 /snapmount
```

Restoring a file system

After backing up the file system, you can restore it using the `vxrestore` command. First, create and mount an empty file system.

To restore a VxFS snapshot file system

◆ Use the `vxrestore` command to restore a VxFS snapshot file system:

```
vxrestore [-v] [-x] [filename]
```

`-v`	Specifies verbose mode.
`-x`	Extracts the named files from the tape.
filename	The file or directory to restore. If filename is omitted, the root directory, and thus the entire tape, is extracted.

Example of restoring a file system

The following example restores a VxFS snapshot file system from the tape:

To restore a VxFS snapshot file system

◆ Restore a VxFS snapshot file system from the tape `/dev/st1` into the mount point `/restore`:

```
# cd /restore
# vxrestore -v -x -f /dev/st1
```

Using quotas

You can use quotas to allocate per-user and per-group quotas on VxFS file systems.

See "Using quotas" on page 80.

See the `vxquota`(1M), `vxquotaon`(1M), `vxquotaoff`(1M), and `vxedquota`(1M) manual pages.

Turning on quotas

You can enable quotas at mount time or after a file system is mounted. The root directory of the file system must contain a file named quotas that is owned by root.

To turn on quotas

1 Turn on quotas for a mounted file system:

```
vxquotaon mount_point
```

2 Mount a file system and turn on quotas at the same time:

```
mount -t vxfs -o quota special
mount_point
```

If the root directory does not contain a quotas file, the `mount` command succeeds, but quotas are not turned on.

Example of turning on quotas for a mounted file system

The following example creates a quoatas file and turns on quotas for a VxFS file system mounted at `/mnt`.

To turn on quotas for a mounted file system

- Create a quotas file if it does not already exist and turn on quotas for a VxFS file system mounted at `/mnt`:

```
# touch /mnt/quotas
# vxquotaon /mnt
```

Example of turning on quotas at mount time

The following example turns on quotas when the `/dev/vx/dsk/fsvol/vol1` file system is mounted.

To turn on quotas for a file system at mount time

- Turn on quotas at mount time by specifying the `-o quota` option:

  ```
  # mount -t vxfs -o quota /dev/vx/dsk/fsvol/vol1 /mnt
  ```

Setting up user quotas

You can set user quotas with the `vxedquota` command if you have superuser privileges. User quotas can have a soft limit and hard limit. You can modify the limits or assign them specific values. Users are allowed to exceed the soft limit, but only for a specified time. Disk usage can never exceed the hard limit. The default time limit for exceeding the soft limit is seven days on VxFS file systems.

`vxedquota` creates a temporary file for a specified user. This file contains on-disk quotas for each mounted VxFS file system that has a quotas file. The temporary file has one or more lines similar to the following:

```
fs /mnt blocks (soft = 0, hard = 0) inodes (soft=0, hard=0)
fs /mnt1 blocks (soft = 100, hard = 200) inodes (soft=10, hard=20)
```

Quotas do not need to be turned on for `vxedquota` to work. However, the quota limits apply only after quotas are turned on for a given file system.

`vxedquota` has an option to modify time limits. Modified time limits apply to the entire file system; you cannot set time limits for an individual user.

To set up user quotas

1. Invoke the quota editor:

   ```
   vxedquota username
   ```

2. Modify the time limit:

   ```
   vxedquota -t
   ```

Viewing quotas

The superuser or individual user can view disk quotas and usage on VxFS file systems using the `vxquota` command. This command displays the user's quotas and disk usage on all mounted VxFS file systems where the quotas file exists. You will see all established quotas regardless of whether or not the quotas are actually turned on.

To view quotas for a specific user

- Use the `vxquota` command to view quotas for a specific user:

```
vxquota -v username
```

Turning off quotas

You can turn off quotas for a mounted file system using the `vxquotaoff` command.

To turn off quotas for a file system

- Turn off quotas for a file system:

```
vxquotaoff mount_point
```

Example of turning off quotas

The following example turns off quotas for a VxFS file system mounted at `/mnt`.

To turn off quotas

- Turn off quotas for a VxFS file system mounted at `/mnt`:

```
# vxquotaoff /mnt
```

Appendix B

Diagnostic messages

This appendix includes the following topics:

File system response to problems

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

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 does not 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 a 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.

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 the `fsck_vxfs`(1M) manual page.

To execute a full structural check

◆ Use the `fsck` command to execute a full structural check:

```
# fsck -t vxfs -o full -y /dev/vx/rdsk/diskgroup/volume
```

Warning: Be careful when running this command. By specifying the `-y` option, all `fsck` user prompts are answered with a "yes", which can make irreversible changes if it performs a full file system check.

About kernel messages

Kernel messages are diagnostic or error messages generated by the Veritas File System (VxFS) kernel. Each message has a description and a suggestion on how to handle or correct the underlying problem.

About global message IDs

When a VxFS kernel message displays on the system console, it is preceded by a numerical ID shown in the msgcnt field. This ID number increases with each instance of the message to guarantee that the sequence of events is known when analyzing file system problems.

Each message is also written to an internal kernel buffer that you can view in the file /var/log/messages.

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/log/messages and obtain the additional information.

Kernel messages

Some commonly encountered kernel messages are described on the following table:

Table B-1 Kernel messages

Message Number	Message and Definition
001	NOTICE: msgcnt *x*: mesg 001: V-2-1: vx_nospace - *mount_point* file system full (n block extent) ■ Description 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 the fsadm command. See the fsadm_vxfs(1M) manual page.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
002	WARNING: msgcnt *x*: mesg 002: V-2-2: vx_snap_strategy - *mount_point* file system write attempt to read-only file system WARNING: msgcnt x: mesg 002: V-2-2: vx_snap_copyblk - *mount_point* file system write attempt to read-only file system ■ Description 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.
003, 004, 005	WARNING: msgcnt *x*: mesg 003: V-2-3: vx_mapbad - *mount_point* file system free extent bitmap in au *aun* marked bad WARNING: msgcnt *x*: mesg 004: V-2-4: vx_mapbad - *mount_point* file system free inode bitmap in au *aun* marked bad WARNING: msgcnt x: mesg 005: V-2-5: vx_mapbad - *mount_point* file system inode extended operation bitmap in au *aun* marked bad ■ Description 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 cannot 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
006, 007	WARNING: msgcnt *x*: mesg 006: V-2-6: vx_sumupd - *mount_point* file system summary update in au *aun* failed WARNING: msgcnt *x*: mesg 007: V-2-7: vx_sumupd - *mount_point* file system summary update in inode au *iaun* failed ■ Description 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 cannot 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.
008, 009	WARNING: msgcnt *x*: mesg 008: V-2-8: vx_direrr: function - *mount_point* file system dir inode *dir_inumber* dev/block *device_ID/block* dirent inode *dirent_inumber* error *errno* WARNING: msgcnt *x*: mesg 009: V-2-9: vx_direrr: function - *mount_point* file system dir inode *dir_inumber* dirent inode *dirent_inumber* immediate directory error *errno* ■ Description A directory operation failed in an unexpected manner. 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
010	WARNING: msgcnt *x*: mesg 010: V-2-10: vx_ialloc - *mount_point* file system inode *inumber* not free ■ Description 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.
011	NOTICE: msgcnt *x*: mesg 011: V-2-11: vx_noinode - *mount_point* file system out of inodes ■ Description 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. See the `fsadm_vxfs`(1M) online manual page.
012	WARNING: msgcnt *x*: mesg 012: V-2-12: vx_iget - *mount_point* file system invalid inode number *inumber* ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
013	WARNING: msgcnt *x*: mesg 013: V-2-13: vx_iposition - *mount_point* file system inode *inumber* invalid inode list extent - Description 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 cannot 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.
014	WARNING: msgcnt *x*: mesg 014: V-2-14: vx_iget - inode table overflow - Description 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 *vxfs_ninode* parameter in the kernel. See "Tuning the VxFS file system" on page 40.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
015	WARNING: msgcnt *x*: mesg 015: V-2-15: vx_ibadinactive - *mount_point* file system cannot mark inode *inumber* bad WARNING: msgcnt *x*: mesg 015: V-2-15: vx_ilisterr - *mount_point* file system cannot mark inode *inumber* bad ■ Description 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.
016	WARNING: msgcnt *x*: mesg 016: V-2-16: vx_ilisterr - *mount_point* file system error reading inode *inumber* ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
017	

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
	WARNING: msgcnt *x*: mesg 017: V-2-17: vx_attr_getblk - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_attr_iget - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_attr_indadd - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_attr_indtrunc - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_attr_iremove - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_bmap - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_bmap_indirect_ext4 - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_delbuf_flush - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_dio_iovec - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_dirbread - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_dircreate - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_dirlook - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_doextop_iau - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_doextop_now - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_do_getpage - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_enter_ext4 - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_exttrunc - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_get_alloc - *mount_point*

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
	file system inode *inumber* marked bad in core
017 (continued)	WARNING: msgcnt *x*: mesg 017: V-2-17: vx_ilisterr - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_indtrunc - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_iread - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_iremove - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_iremove_attr - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_logwrite_flush - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_oltmount_iget - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_overlay_bmap - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_readnomap - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_reorg_trunc - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_stablestore - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_tranitimes - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_trunc - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_write_alloc2 - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_write_default - *mount_point* file system inode *inumber* marked bad in core WARNING: msgcnt *x*: mesg 017: V-2-17: vx_zero_alloc - *mount_point* file system inode *inumber* marked bad in core

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
017 (continued)	■ Description When inode information is no longer dependable, the kernel marks it bad in memory. This is followed by a message to mark it bad on disk as well unless the mount command ioerror option is set to disable, or there is subsequent I/O failure when updating the inode on disk. No further operations can be performed on the inode. 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. The file system can be remounted without a full `fsck` unless the `VX_FULLFSCK` flag is set for the file system.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
019	WARNING: msgcnt *x*: mesg 019: V-2-19: vx_log_add - *mount_point* file system log overflow ■ Description 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.
020	WARNING: msgcnt *x*: mesg 020: V-2-20: vx_logerr - *mount_point* file system log error *errno* ■ Description 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 cannot 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
021	WARNING: msgcnt *x*: mesg 021: V-2-21: vx_fs_init - *mount_point* file system validation failure - Description 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 is not 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.
024	WARNING: msgcnt *x*: mesg 024: V-2-24: vx_cutwait - *mount_point* file system current usage table update error - Description 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 cannot be written, the file system is disabled. - Action Unmount the file system and use `fsck` to run a full structural check.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
025	WARNING: msgcnt *x*: mesg 025: V-2-25: vx_wsuper - *mount_point* file system super-block update failed - Description 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.
026	WARNING: msgcnt *x*: mesg 026: V-2-26: vx_snap_copyblk - *mount_point* primary file system read error - Description 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.
027	WARNING: msgcnt *x*: mesg 027: V-2-27: vx_snap_bpcopy - *mount_point* snapshot file system write error - Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
028	WARNING: msgcnt *x*: mesg 028: V-2-28: vx_snap_alloc - *mount_point* snapshot file system out of space ■ Description 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.
029, 030	WARNING: msgcnt *x*: mesg 029: V-2-29: vx_snap_getbp - *mount_point* snapshot file system block map write error WARNING: msgcnt *x*: mesg 030: V-2-30: vx_snap_getbp - *mount_point* snapshot file system block map read error ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
031	WARNING: msgcnt *x*: mesg 031: V-2-31: vx_disable - *mount_point* file system disabled - Description 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.
032	WARNING: msgcnt *x*: mesg 032: V-2-32: vx_disable - *mount_point* snapshot file system disabled - Description 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.
033	WARNING: msgcnt *x*: mesg 033: V-2-33: vx_check_badblock - *mount_point* file system had an I/O error, setting `VX_FULLFSCK` - Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
034	WARNING: msgcnt *x*: mesg 034: V-2-34: vx_resetlog - *mount_point* file system cannot reset log - Description 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.
035	WARNING: msgcnt *x*: mesg 035: V-2-35: vx_inactive - *mount_point* file system inactive of locked inode *inumber* - Description 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.
036	WARNING: msgcnt *x*: mesg 036: V-2-36: vx_lctbad - *mount_point* file system link count table *lctnumber* bad - Description 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 cannot be written, the file system is disabled. - Action Unmount the file system and use `fsck` to run a full structural check.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
037	WARNING: msgcnt *x*: mesg 037: V-2-37: vx_metaioerr - function - *volume_name* file system meta data [read|write] error in dev/block *device_ID/block* ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
038	WARNING: msgcnt *x*: mesg 038: V-2-38: vx_dataioerr - *volume_name* file system file data [read|write] error in dev/block *device_ID/block* ■ Description 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 the ncheck(1M) manual page. 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
039	WARNING: msgcnt *x*: mesg 039: V-2-39: vx_writesuper - file system super-block write error ■ Description 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.
040	WARNING: msgcnt *x*: mesg 040: V-2-40: vx_dqbad - *mount_point* file system user|group quota file update error for id *id* ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
041	WARNING: msgcnt *x*: mesg 041: V-2-41: vx_dqget - *mount_point* file system user|group quota file cannot read quota for id *id* ■ Description 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.
042	WARNING: msgcnt *x*: mesg 042: V-2-42: vx_bsdquotaupdate - *mount_point* file system *user|group_id* disk limit reached ■ Description 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.
043	WARNING: msgcnt *x*: mesg 043: V-2-43: vx_bsdquotaupdate - *mount_point* file system *user|group_id* disk quota exceeded too long ■ Description 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.
044	WARNING: msgcnt *x*: mesg 044: V-2-44: vx_bsdquotaupdate - *mount_point* file system *user|group_id* disk quota exceeded ■ Description The soft limit on blocks is exceeded. Users can exceed the soft limit for a limited amount of time before allocations begin to fail. After the soft quota time limit has expired, subsequent attempts to allocate blocks for files fail. ■ Action Remove some files to free up space.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
045	WARNING: msgcnt *x*: mesg 045: V-2-45: vx_bsdiquotaupdate - *mount_point* file system *user|group_id* inode limit reached ■ Description 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.
046	WARNING: msgcnt *x*: mesg 046: V-2-46: vx_bsdiquotaupdate - *mount_point* file system *user|group_id* inode quota exceeded too long ■ Description 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.
047	WARNING: msgcnt *x*: mesg 047: V-2-47: vx_bsdiquotaupdate - warning: *mount_point* file system *user|group_id* inode quota exceeded ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
048, 049	WARNING: msgcnt *x*: mesg 048: V-2-48: vx_dqread - warning: *mount_point* file system external user|group quota file read failed WARNING: msgcnt *x*: mesg 049: V-2-49: vx_dqwrite - warning: *mount_point* file system external user|group quota file write failed ■ Description To maintain reliable usage counts, VxFS maintains the user quotas file as a structural file 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
056	WARNING: msgcnt *x*: mesg 056: V-2-56: vx_mapbad - *mount_point* file system extent allocation unit state bitmap number *number* marked bad ■ Description 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 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.
057	WARNING: msgcnt *x*: mesg 057: V-2-57: vx_esum_bad - *mount_point* file system extent allocation unit summary number *number* marked bad ■ Description An I/O error occurred reading or writing an extent 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
058	WARNING: msgcnt *x*: mesg 058: V-2-58: vx_isum_bad - *mount_point* file system inode allocation unit summary number *number* marked bad - Description 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.
059	WARNING: msgcnt *x*: mesg 059: V-2-59: vx_snap_getbitbp - *mount_point* snapshot file system bitmap write error - Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
060	WARNING: msgcnt *x*: mesg 060: V-2-60: vx_snap_getbitbp - *mount_point* snapshot file system bitmap read error ■ Description 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.
061	WARNING: msgcnt *x*: mesg 061: V-2-61: vx_resize - *mount_point* file system remount failed ■ Description 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.
062	NOTICE: msgcnt *x*: mesg 062: V-2-62: vx_attr_creatop - invalid disposition returned by attribute driver ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
063	WARNING: msgcnt *x*: mesg 063: V-2-63: vx_fset_markbad - *mount_point* file system *mount_point* fileset (index *number*) marked bad ■ Description An error occurred while reading or writing a fileset structure. `VX_FULLFSCK` flag is set. If the `VX_FULLFSCK` flag cannot be set, the file system is disabled. ■ Action Unmount the file system and use `fsck` to run a full structural check.
064	WARNING: msgcnt *x*: mesg 064: V-2-64: vx_ivalidate - *mount_point* file system inode number version number exceeds fileset's ■ Description 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 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 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.
066	NOTICE: msgcnt *x*: mesg 066: V-2-66: DMAPI mount event - buffer ■ Description 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.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
067	WARNING: msgcnt *x*: mesg 067: V-2-67: mount of *device_path* requires HSM agent - Description 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.
069	WARNING: msgcnt *x*: mesg 069: V-2-69: memory usage specified by the vxfs:vxfs_ninode and vxfs:vx_bc_bufhwm parameters exceeds available memory; the system may hang under heavy load - Description The value of the system tunable parameters—`vxfs_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. See "Tuning the VxFS file system" on page 40.
070	WARNING: msgcnt *x*: mesg 070: V-2-70: checkpoint *checkpoint_name* removed from file system *mount_point* - Description The file system ran out of space while updating a Storage Checkpoint. The Storage 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 Storage Checkpoints. Monitor capacity of the file system closely to ensure it does not run out of space. See the `fsadm_vxfs`(1M) manual page.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
071	NOTICE: msgcnt *x*: mesg 071: V-2-71: cleared data I/O error flag in *mount_point* file system ■ Description The user data I/O error flag was reset when the file system was mounted. This message indicates that a read or write error occurred while the file system was previously mounted. See Message Number 038. ■ Action Informational only, no action required.
072	WARNING: msgcnt *x*: vxfs: mesg 072: could not failover for *volume_name* file system ■ Description This message is specific to the cluster file system. The message indicates a problem in a scenario where a node failure has occurred in the cluster and the newly selected primary node encounters a failure. ■ Action Save the system logs and core dump of the node along with the disk image (metasave) and contact your customer support organization. The node can be rebooted to join the cluster.
075	WARNING: msgcnt *x*: mesg 075: V-2-75: replay fsck failed for *mount_point* file system ■ Description The log replay failed during a failover or while migrating the CFS primary-ship to one of the secondary cluster nodes. The file system was disabled. ■ Action Unmount the file system from the cluster. Use `fsck` to run a full structural check and mount the file system again.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
076	NOTICE: msgcnt *x*: mesg 076: V-2-76: checkpoint asynchronous operation on *mount_point* file system still in progress ■ Description An EBUSY message was received while trying to unmount a file system. The unmount failure was caused by a pending asynchronous fileset operation, such as a fileset removal or fileset conversion to a nodata Storage Checkpoint. ■ Action The operation may take a considerable length of time. Wait for the operation to complete so file system can be unmounted cleanly.
077	WARNING: msgcnt *x*: mesg 077: V-2-77: vx_fshdchange - *mount_point* file system number fileset, fileset header: checksum failed ■ Description Disk corruption was detected while changing fileset headers. This can occur when writing a new inode allocation unit, preventing the allocation of new inodes in the fileset. ■ Action Unmount the file system and use `fsck` to run a full structural check.
078	WARNING: msgcnt *x*: mesg 078: V-2-78: vx_ilealloc - *mount_point* file system *mount_point* fileset (index number) ilist corrupt ■ Description The inode list for the fileset was corrupted and the corruption was detected while allocating new inodes. The failed system call returns an ENOSPC error. Any subsequent inode allocations will fail unless a sufficient number of files are removed. ■ Action Unmount the file system and use `fsck` to run a full structural check.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
079	

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
	WARNING: msgcnt *x*: mesg 017: V-2-79: vx_attr_getblk - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_attr_iget - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_attr_indadd - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_attr_indtrunc - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_attr_iremove - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_bmap - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_bmap_indirect_ext4 - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_delbuf_flush - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_dio_iovec - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_dirbread - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_dircreate - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_dirlook - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_doextop_iau - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_doextop_now - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_do_getpage - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_enter_ext4 - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_exttrunc - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_get_alloc - *mount_point*

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
	file system inode *inumber* marked bad on disk
079 (continued)	WARNING: msgcnt *x*: mesg 017: V-2-79: vx_ilisterr - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_indtrunc - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_iread - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_iremove - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_iremove_attr - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_logwrite_flush - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_oltmount_iget - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_overlay_bmap - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_readnomap - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_reorg_trunc - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_stablestore - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_tranitimes - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_trunc - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_write_alloc2 - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_write_default - *mount_point* file system inode *inumber* marked bad on disk WARNING: msgcnt *x*: mesg 017: V-2-79: vx_zero_alloc - *mount_point* file system inode *inumber* marked bad on disk

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
079 (continued)	■ Description 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.
081	WARNING: msgcnt *x*: mesg 081: V-2-81: possible network partition detected ■ Description This message displays when CFS detects a possible network partition and disables the file system locally, that is, on the node where the message appears. ■ Action There are one or more private network links for communication between the nodes in a cluster. At least one link must be active to maintain the integrity of the cluster. If all the links go down, after the last network link is broken, the node can no longer communicate with other nodes in the cluster. Check the network connections. After verifying that the network connections is operating correctly, unmount the disabled file system and mount it again.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
082	WARNING: msgcnt *x*: mesg 082: V-2-82: *volume_name* file system is on shared volume. It may get damaged if cluster is in partitioned state. ■ Description If a cluster node is in a partitioned state, and if the file system is on a shared VxVM volume, this volume may become corrupted by accidental access from another node in the cluster. ■ Action These shared disks can also be seen by nodes in a different partition, so they can inadvertently be corrupted. So the second message 082 tells that the device mentioned is on shared volume and damage can happen only if it is a real partition problem. Do not use it on any other node until the file system is unmounted from the mounted nodes.
083	WARNING: msgcnt *x*: mesg 083: V-2-83: *mount_point* file system log is not compatible with the specified intent log I/O size ■ Description Either the specified `mount` logiosize size is not compatible with the file system layout, or the file system is corrupted. ■ Action Mount the file system again without specifying the logiosize option, or use a logiosize value compatible with the intent log specified when the file system was created. If the error persists, unmount the file system and use `fsck` to run a full structural check.
084	WARNING: msgcnt *x*: mesg 084: V-2-84: in *volume_name* quota on failed during assumption. (stage *stage_number*) ■ Description In a cluster file system, when the primary of the file system fails, a secondary file system is chosen to assume the role of the primary. The assuming node will be able to enforce quotas after becoming the primary. If the new primary is unable to enforce quotas this message will be displayed. ■ Action Issue the quotaon command from any of the nodes that have the file system mounted.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
085	WARNING: msgcnt *x*: mesg 085: V-2-85: Checkpoint quota - warning: *file_system* file system fileset quota hard limit exceeded ■ Description The system administrator sets the quotas for Storage Checkpoints in the form of a soft limit and hard limit. This message displays when the hard limit is exceeded. ■ Action Delete Storage Checkpoints or increase the hard limit.
086	WARNING: msgcnt *x*: mesg 086: V-2-86: Checkpoint quota - warning: *file_system* file system fileset quota soft limit exceeded ■ Description The system administrator sets the quotas for Storage Checkpoints in the form of a soft limit and hard limit. This message displays when the soft limit is exceeded. ■ Action Delete Storage Checkpoints or increase the soft limit. This is not a mandatory action, but is recommended.
087	WARNING: msgcnt *x*: mesg 087: V-2-87: vx_dotdot_manipulate: *file_system* file system *inumber* inode *ddnumber* dotdot inode error ■ Description When performing an operation that changes an inode entry, if the inode is incorrect, this message will display. ■ Action Run a full file system check using `fsck` to correct the errors.
088	WARNING: msgcnt *x*: mesg 088: V-2-88: quotaon on *file_system* failed; limits exceed limit ■ Description The external quota file, quotas, contains the quota values, which range from 0 up to 2147483647. When quotas are turned on by the `quotaon` command, this message displays when a user exceeds the quota limit. ■ Action Correct the quota values in the quotas file.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
089	WARNING: msgcnt *x*: mesg 089: V-2-89: quotaon on *file_system* invalid; disk usage for group/user id *uid* exceeds sectors sectors - Description The supported quota limit is up to 2147483647 sectors. When quotas are turned on by the `quotaon` command, this message displays when a user exceeds the supported quota limit. - Action Ask the user to delete files to lower the quota below the limit.
090	WARNING: msgcnt *x*: mesg 090: V-2-90: quota on *file_system* failed; soft limits greater than hard limits - Description One or more users or groups has a soft limit set greater than the hard limit, preventing the BSD quota from being turned on. - Action Check the soft limit and hard limit for every user and group and confirm that the soft limit is not set greater than the hard limit.
091	WARNING: msgcnt *x*: mesg 091: V-2-91: vx_fcl_truncate - failure to punch hole at offset *offset* for *bytes* bytes in File Change Log file; error *error_number* - Description The vxfs kernel has experienced an error while trying to manage the space consumed by the File Change Log file. Because the space cannot be actively managed at this time, the FCL has been deactivated and has been truncated to 1 file system block, which contains the FCL superblock. - Action Re-activate the FCL.
092	WARNING: msgcnt *x*: mesg 092: V-2-92: vx_mkfcltran - failure to map offset *offset* in File Change Log file - Description The vxfs kernel was unable to map actual storage to the next offset in the File Change Log file. This is mostly likely caused by a problem with allocating to the FCL file. Because no new FCL records can be written to the FCL file, the FCL has been deactivated. - Action Re-activate the FCL.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
094	WARNING: msgcnt *x*: mesg 094: V-2-94: Unable to mount the primary file system *file_system* because it is still mounted on secondary nodes. ■ Description An attempt to unmount a secondary node failed and hung, preventing the primary file system from being mounted. ■ Action Wait until the file system is ready to be mounted, make a secondary node eligible to become the primary file system, or unmount all secondary nodes.
096	WARNING: msgcnt *x*: mesg 096: V-2-96: *file_system* file system fullfsck flag set - *function_name*. ■ Description The next time the file system is mounted, a full `fsck` must be performed. ■ Action No immediate action required. When the file system is unmounted, run a full file system check using `fsck` before mounting it again.
097	WARNING: msgcnt *x*: mesg 097: V-2-97: VxFS failed to create new thread (*error_number*, *function_address*:*argument_address*) ■ Description VxFS failed to create a kernel thread due to resource constraints, which is often a memory shortage. ■ Action VxFS will retry the thread creation until it succeeds; no immediate action is required. Kernel resources, such as kernel memory, might be overcommitted. If so, reconfigure the system accordingly.
098	WARNING: msgcnt *x*: mesg 098: V-2-98: VxFS failed to initialize File Change Log for fileset fileset (index number) of *mount_point* file system ■ Description VxFS mount failed to initialize FCL structures for the current fileset mount. As a result, FCL could not be turned on. The FCL file will have no logging records. ■ Action Reactivate the FCL.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
099	WARNING: msgcnt *x*: mesg 099: V-2-99: The specified value for *vx_ninode* is less than the recommended minimum value of *min_value* ■ Description Auto-tuning or the value specified by the system administrator resulted in a value lower than the recommended minimum for the total number of inodes that can be present in the inode cache. VxFS will ignore the newly tuned value and will keep the value specified in the message (`VX_MINNINODE`). ■ Action Informational only; no action required.
100	WARNING: msgcnt *x*: mesg 100: V-2-100: Inode *inumber* can not be accessed: file size exceeds OS limitations. ■ Description The specified inode's size is larger than the file size limit of the current operating system. The file cannot be opened on the current platform. This can happen when a file is created on one OS and the filesystem is then moved to a machine running an OS with a smaller file size limit. ■ Action If the file system is moved to the platform on which the file was created, the file can be accessed from there. It can then be converted to multiple smaller files in a manner appropriate to the application and the file's format, or simply be deleted if it is no longer required.
101	WARNING: msgcnt *x*: mesg 101: V-2-101: File Change Log on *mount_point* for file set *index* approaching max file size supported. File Change Log will be reactivated when its size hits max file size supported. ■ Description The size of the FCL file is approching the maximum file size supported. This size is platform specific. When the FCL file is reaches the maximum file size, the FCL will be deactivated and reactivated. All logging information gathered so far will be lost. ■ Action Take any corrective action possible to restrict the loss due to the FCL being deactivated and reactivated.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
102	WARNING: msgcnt *x*: mesg 102: V-2-102: File Change Log of *mount_point* for file set *index* has been reactivated. ■ Description The size of FCL file reached the maximum supported file size and the FCL has been reactivated. All records stored in the FCL file, starting from the current *fc_loff* up to the maximum file size, have been purged. New records will be recorded in the FCL file starting from offset *fs_bsize*. The activation time in the FCL is reset to the time of reactivation. The impact is equivalent to File Change Log being deactivated and activated. ■ Action Informational only; no action required.
103	WARNING: msgcnt *x*: mesg 103: V-2-103: File Change Log merge on *mount_point* for file set *index* failed. ■ Description The VxFS kernel has experienced an error while merging internal per-node File Change Log files into the external File Change Log file. Since the File Change Log cannot be maintained correctly without this, the File Change Log has been deactivated. ■ Action Re-activate the File Change Log.
104	WARNING: msgcnt *x*: mesg 104: V-2-104: File System *mount_point* device *volume_name* disabled ■ Description The volume manager detected that the specified volume has failed, and the volume manager has disabled the volume. No further I/O requests are sent to the disabled volume. ■ Action The volume must be repaired.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
105	WARNING: msgcnt *x*: mesg 105: V-2-105: File System *mount_point* device *volume_name* re-enabled ■ Description The volume manager detected that a previously disabled volume is now operational, and the volume manager has re-enabled the volume. ■ Action Informational only; no action required.
106	WARNING: msgcnt *x*: mesg 106: V-2-106: File System *mount_point* device *volume_name* has BAD label ■ Description A file system's label does not match the label that the multi-volume support feature expects the file system to have. The file system's volume is effectively disabled. ■ Action If the label is bad because the volume does not match the assigned label, use the `vxvset` command to fix the label. Otherwise, the label might have been overwritten and the volume's contents may be lost. Call technical support so that the issue can be investigated.
107	WARNING: msgcnt *x*: mesg 107: V-2-107: File System *mount_point* device *volume_name* valid label found ■ Description The label of a file system that had a bad label was somehow restored. The underlying volume is functional. ■ Action Informational only; no action required.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
108	WARNING: msgcnt *x*: mesg 108: V-2-108: vx_dexh_error - *error*: fileset *fileset*, directory inode number *dir_inumber*, bad hash inode *hash_inode*, seg *segment* bno *block_number* ■ Description The supplemental hash for a directory is corrupt. ■ Action If the file system is mounted read/write, the hash for the directory will be automatically removed and recreated. If the removal or recreation fails, subsequent messages indicate the type of prolem. If there are no further messages, the removal and recreation of the hash succeeded.
109	WARNING: msgcnt *x*: mesg 109: V-2-109: failed to tune down *tunable_name* to *tunable_value* possibly due to *tunable_object* in use, could free up only up to *suggested_tunable_value* ■ Description When the value of a tunable, such as *ninode* or *bufhwm*, is modified, sometimes the tunable cannot be tuned down to the specified value because of the current system usage. The minimum value to which the tunable can be tuned is also provided as part of the warning message. ■ Action Tune down the tunable to the minimum possible value indicated by the warning message. See "Tuning the VxFS file system" on page 40.
110	WARNING: msgcnt *x*: mesg 110: V-2-110: The specified value for *vx_bc_bufhwm* is less than the recommended minimum value of *recommended_minimum_value*. ■ Description Setting the *vx_bc_bufhwm* tunable to restrict the memory used by the VxFS buffer cache to a value that is too low has a degrading effect on the system performance on a wide range of applications. Symantec does not recommend setting *vx_bc_bufhwm* to a value less than the recommended minimum value, which is provided as part of the warning message. ■ Action Tune the *vx_bc_bufhwm* tunable to a value greater than the recommended minimum indicated by the warning message.

Table B-1 Kernel messages *(continued)*

Message Number	Message and Definition
111	WARNING: msgcnt *x*: mesg 111: V-2-111: You have exceeded the authorized usage (maximum *maxfs* unique mounted user-data file systems) for this product and are out of compliance with your License Agreement. Please email **sales_mail@symantec.com** or contact your Symantec sales representative for information on how to obtain additional licenses for this product. ■ Description As per your Storage Foundation Basic license agreement, you are allowed to have only a limited number of VxFS file systems, and you have exceeded this number. ■ Action Email **sales_mail@symantec.com** or contact your Symantec sales representative for information on how to obtain additional licenses for this product.

About unique message identifiers

VxFS generates diagnostic or error messages for issues not related to the kernel, which are displayed along with a unique message identifier (UMI). Each message has a description and a suggestion on how to handle or correct the underlying problem. The UMI is used to identify the issue should you need to call Technical Support for assistance.

Unique message identifiers

Some commonly encountered UMIs and the associated messages are described on the following table:

Table B-2 Unique message identifiers and messages

Message Number	Message and Definition
20002	UX:vxfs *command*: ERROR: V-3-20002: *message* ■ Description The command attempted to call `stat()` on a device path to ensure that the path refers to a character device before opening the device, but the `stat()` call failed. The error message will include the platform-specific message for the particular error that was encountered, such as "Access denied" or "No such file or directory". ■ Action The corrective action depends on the particular error.
20003	UX:vxfs *command*: ERROR: V-3-20003: *message* ■ Description The command attempted to open a disk device, but the `open()` call failed. The error message includes the platform-specific message for the particular error that was encountered, such as "Access denied" or "No such file or directory". ■ Action The corrective action depends on the particular error.
20005	UX:vxfs *command*: ERROR: V-3-20005: *message* ■ Description The command attempted to read the superblock from a device, but the `read()` call failed. The error message will include the platform-specific message for the particular error that was encountered, such as "Access denied" or "No such file or directory". ■ Action The corrective action depends on the particular error.
20012	UX:vxfs *command*: ERROR: V-3-20012: *message* ■ Description The command was invoked on a device that did not contain a valid VxFS file system. ■ Action Check that the path specified is what was intended.

Table B-2 Unique message identifiers and messages *(continued)*

Message Number	Message and Definition
20076	UX:vxfs *command*: ERROR: V-3-20076: *message* ■ Description The command called `stat`() on a file, which is usually a file system mount point, but the call failed. ■ Action Check that the path specified is what was intended and that the user has permission to access that path.
21256	UX:vxfs *command*: ERROR: V-3-21256: *message* ■ Description The attempt to mount the file system failed because either the request was to mount a particular Storage Checkpoint that does not exist, or the file system is managed by an HSM and the HSM is not running. ■ Action In the first case, use the `fsckptadm list` command to see which Storage Checkpoints exist and mount the appropriate Storage Checkpoint. In the second case, make sure the HSM is running. If the HSM is not running, start and mount the file system again.

Table B-2 Unique message identifiers and messages *(continued)*

Message Number	Message and Definition
21264	UX:vxfs *command*: ERROR: V-3-21264: *message* ■ Description The attempt to mount a VxFS file system has failed because either the volume being mounted or the directory which is to be the mount point is busy. The reason that a VxVM volume could be busy is if the volume is in a shared disk group and the volume is currently being accessed by a VxFS command, such as `fsck`, on a node in the cluster. One reason that the mount point could be busy is if a process has the directory open or has the directory as its current directory. Another reason that the mount point could be busy is if the directory is NFS-exported. ■ Action For a busy mount point, if a process has the directory open or has the directory as its current directory, use the `fuser` command to locate the processes and either get them to release their references to the directory or kill the processes. Afterward, attempt to mount the file system again. If the directory is NFS-exported, unexport the directory, such as by using the `unshare mntpt` command on the Solaris operating environment. Afterward, attempt to mount the file system again.
21268	UX:vxfs *command*: ERROR: V-3-21268: *message* ■ Description This message is printed by two different commands: `fsckpt_restore` and `mount`. In both cases, the kernel's attempt to mount the file system failed because of I/O errors or corruption of the VxFS metadata. ■ Action Check the console log for I/O errors and fix any problems reported there. Run a full `fsck`.

Table B-2 Unique message identifiers and messages *(continued)*

Message Number	Message and Definition
21272	UX:vxfs *command*: ERROR: V-3-21272: *message* ■ Description The mount options specified contain mutually-exclusive options, or in the case of a remount, the new mount options differed from the existing mount options in a way that is not allowed to change in a remount. ■ Action Change the requested mount options so that they are all mutually compatible and retry the mount.
23729	UX:vxfs *command*: ERROR: V-3-23729: *message* ■ Description Cluster mounts require the `vxfsckd` daemon to be running, which is controlled by VCS. ■ Action Check the VCS status to see why this service is not running. After starting the daemon via VCS, try the mount again.
24996	UX:vxfs *command*: ERROR: V-3-24996: *message* ■ Description In some releases of VxFS, before the VxFS `mount` command attempts to mount a file system, `mount` tries to read the VxFS superblock to determine the disk layout version of the file system being mounted so that `mount` can check if that disk layout version is supported by the installed release of VxFS. If the attempt to read the superblock fails for any reason, this message is displayed. This message will usually be preceded by another error message that gives more information as to why the superblock could not be read. ■ Action The corrective action depends on the preceding error, if any.

Appendix C

Disk layout

This appendix includes the following topics:

About disk layouts

The disk layout is the way file system information is stored on disk. On VxFS, seven different disk layout versions were created to take advantage of evolving technological developments.

The disk layout versions used on VxFS are:

Version 1	Version 1 disk layout is the original VxFS disk layout provided with pre-2.0 versions of VxFS.	Not Supported
Version 2	Version 2 disk layout supports features such as filesets, dynamic inode allocation, and enhanced security. The Version 2 layout is available with and without quotas support.	Not Supported
Version 3	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.	Not Supported

Version 4	Version 4 disk layout encompasses all file system structural information in files, rather than at fixed locations on disk, allowing for greater scalability. Version 4 supports files and file systems up to one terabyte in size.	Not Supported
Version 5	Version 5 enables the creation of file system sizes up to 32 terabytes. File sizes can be a maximum of 4 billion file system blocks. File systems larger than 1TB must be created on a Veritas Volume Manager volume.	Not Supported
Version 6	Version 6 disk layout enables features such as multi-volume support, cross-platform data sharing, named data streams, and File Change Log.	Supported
Version 7	Version 7 disk layout enables support for variable and large size history log records, more than 2048 volumes, large directory hash, and Dynamic Storage Tiering.	Supported

Some of the disk layout versions were not supported on all UNIX operating systems. Currently, only the Version 6 and 7 disk layouts are supported and can be created and mounted. Version 1, 2, 3, 4, and 5 disk layout file systems cannot be created nor mounted. Version 7 is the default disk layout version.

The `vxupgrade` command is provided to upgrade an existing VxFS file system to the Version 7 layout while the file system remains online.

See the `vxupgrade`(1M) manual page.

The `vxfsconvert` command is provided to upgrade ext2 and ext3 file systems to the Version 7 disk layout while the file system is not mounted.

See the `vxfsconvert`(1M) manual page.

VxFS Version 4 disk layout

The Version 4 disk layout allows the file system to scale easily to accommodate large files and large file systems.

The original 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 4 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.

The Version 4 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 previous layouts.

All Version 4 structural files reside in the structural fileset.

The structural files in the Version 4 disk layout are:

File	Description
object location table file	Contains the object location table (OLT). 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.

File	Description
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 files	Contains quota information in records. Each record contains resources allocated either per user or per group.

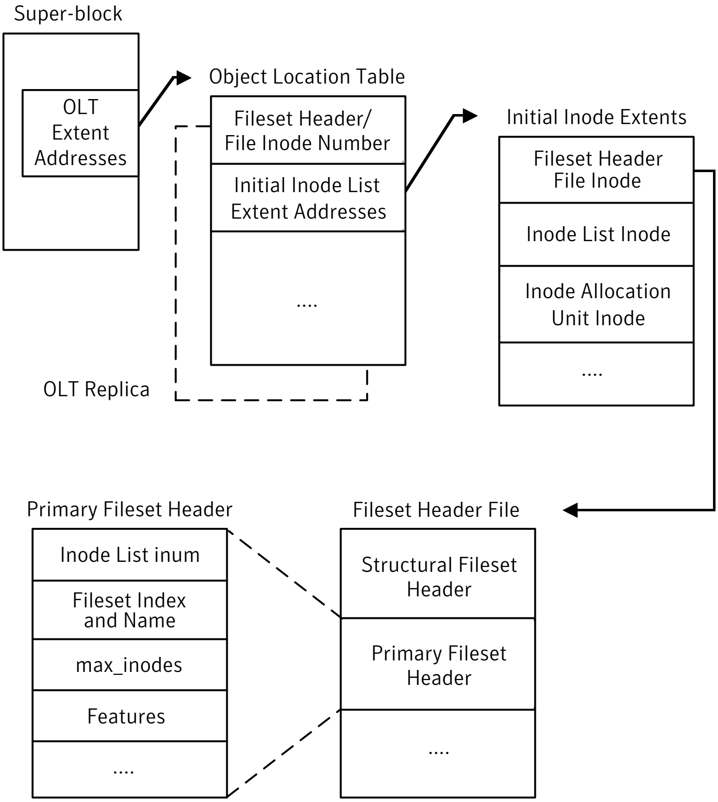
The Version 4 disk layout supports Block-Level Incremental (BLI) Backup. BLI Backup is a backup method that stores and retrieves only the data blocks changed since the previous backup, not entire files. This saves times, storage space, and computing resources required to backup large databases.

Figure C-1 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.

Figure C-1 VxFS Version 4 disk layout



VxFS Version 6 disk layout

Disk layout Version 6 enables features such as multi-volume support, cross-platform data sharing, named data streams, and File Change Log.The Version 6 disk layout can theoretically support files and file systems up to 8 exabytes (2^{63}). The maximum file system size that can be created is currently restricted to 2^{35} blocks. For a file system to take advantage of greater than 1 terabyte support, it must be created on a Veritas Volume Manager volume. For 64-bit kernels, the maximum size of the file system you can create depends on the block size:

Block Size	Currently-Supported Theoretical Maximum File System Size
1024 bytes	68,719,472,624 sectors (≈32 TB)

Block Size	Currently-Supported Theoretical Maximum File System Size
2048 bytes	137,438,945,248 sectors (≈64 TB)
4096 bytes	274,877,890,496 sectors (≈128 TB)
8192 bytes	549,755,780,992 sectors (≈256 TB)

The Version 6 disk layout also supports group quotas.

See “About quota files on Veritas File System” on page 78.

VxFS Version 7 disk layout

Disk layout Version 7 enables support for variable and large size history log records, more than 2048 volumes, large directory hash, and Dynamic Storage Tiering. The Version 7 disk layout can theoretically support files and file systems up to 8 exabytes (2^{63}). The maximum file system size that can be created is currently restricted to 2^{35} blocks. For a file system to take advantage of greater than 1 terabyte support, it must be created on a Veritas Volume Manager volume. For 64-bit kernels, the maximum size of the file system you can create depends on the block size:

Block Size	Currently-Supported Theoretical Maximum File System Size
1024 bytes	68,719,472,624 sectors (≈32 TB)
2048 bytes	137,438,945,248 sectors (≈64 TB)
4096 bytes	274,877,890,496 sectors (≈128 TB)
8192 bytes	549,755,780,992 sectors (≈256 TB)

The Version 7 disk layout supports group quotas.

See “About quota files on Veritas File System” on page 78.

Glossary

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

agent A process that manages predefined Veritas Cluster Server (VCS) resource types. Agents bring resources online, take resources offline, and monitor resources to report any state changes to VCS. When an agent is started, it obtains configuration information from VCS and periodically monitors the resources and updates VCS with the resource status.

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.

API Application Programming Interface.

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.

atomic operation An operation that either succeeds completely or fails and leaves everything as it was before the operation was started. If the operation succeeds, all aspects of the operation take effect at once and the intermediate states of change are invisible. If any aspect of the operation fails, then the operation aborts without leaving partial changes.

Block-Level Incremental Backup (BLI Backup) A Symantec backup capability that does not store and retrieve entire files. Instead, only the data blocks that have changed since the previous backup are backed up.

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.

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.

encapsulation A process that converts existing partitions on a specified disk to volumes. If any partitions contain file systems, /etc/filesystems entries are modified so that the file systems are mounted on volumes instead. Encapsulation is not applicable on some systems.

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 fragment size on some UNIX file systems.

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.

fragmentation The on-going process on an active file system in which the file system is spread further and further along the disk, leaving unused gaps or fragments between areas that are in use. This leads to degraded performance because the file system has fewer options when assigning a file to an extent.

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.

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 indices used by each user. See quotas and external quotas file.

K
Kilobyte (210 bytes or 1024 bytes).

large file
A file larger than two one terabyte. VxFS supports files up to 8 exabytes in size.

large file system
A file system larger than one terabytes. VxFS supports file systems up to 8 exabytes 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 (220 bytes or 1024 kilobytes).

mirror
A duplicate copy of a volume and the data therein (in the form of an ordered collection of subdisks). Each mirror is one copy of the volume with which the mirror is associated.

multi-volume file system
A single file system that has been created over multiple volumes, with each volume having its own properties.

MVS
Multi-volume support.

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.

root disk group A special private disk group that always exists on the system. The root disk group is named rootdg.

shared disk group A disk group in which the disks are shared by multiple hosts (also referred to as a cluster-shareable disk group).

shared volume A volume that belongs to a shared disk group and is open on more than one node at the same time.

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 quotas.

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 Storage 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.

unbuffered 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.

volume set A container for multiple different volumes. Each volume can have its own geometry.

vxfs The Veritas File System type. Used as a parameter in some commands.

VxFS Veritas File System.

VxVM Veritas Volume Manager.

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