General Parallel File System

Concepts, Planning, and Installation Guide

Version 3.1

GA76-0413-00

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Note:
Before using this information and the product it supports, be sure to read the general information under "Notices" on page 97.

First Edition (April 2006)

This edition applies to version 3 release 1 for the IBM General Parallel File System for Linux Multiplatform licensed program (number 5724-N94), the IBM General Parallel File System for Linux on POWER licensed program (number 5765-G67), the IBM General Parallel File System for AIX 5L licensed program (number 5765-G66) and to all subsequent versions until otherwise indicated in new editions.

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About this book

The *General Parallel File System: Concepts, Planning, and Installation Guide* describes:

- The IBM® General Parallel File System for Linux® (GPFS) on Multiplatform licensed program, 5724-N94
- The IBM General Parallel File System for Linux (GPFS) on POWER™ licensed program, 5765-G67
- The IBM General Parallel File System for AIX 5L™ (GPFS) licensed program, 5765-G66
- Introducing GPFS
- Planning concepts for GPFS
- Installing GPFS
- Migration, coexistence and compatibility
- Applying maintenance
- Configuration and tuning
- Steps to uninstall GPFS

Who should read this book

This book is intended for system administrators, analysts, installers, planners, and programmers of GPFS clusters.

It assumes that you are very experienced with and fully understand the operating systems on which your cluster is based.

Use this book if you are:

- Planning for GPFS
- Installing GPFS on a supported cluster configuration, consisting of:
  - Linux nodes
  - AIX 5L nodes
  - an interoperable cluster comprised of both operating systems

Accessibility information

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How this book is organized

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Conventions used in this book

Table 1 describes the typographic conventions used in this book.

Table 1. Typographic conventions

Typographic convention	Usage
Bold	**Bold** words or characters represent system elements that you must use literally, such as commands, flags, path names, directories, file names, values, and selected menu options.
Bold Underlined	**Bold Underlined** keywords are defaults. These take effect if you fail to specify a different keyword.
Italic	• *Italic* words or characters represent variable values that you must supply. • *Italics* are also used for book titles and for general emphasis in text.
`Constant width`	All of the following are displayed in `constant width` typeface: • Displayed information • Message text • Example text • Specified text typed by the user • Field names as displayed on the screen • Prompts from the system • References to example text
[ ]	Brackets enclose optional items in format and syntax descriptions.
{ }	Braces enclose a list from which you must choose an item in format and syntax descriptions.
|	A vertical bar separates items in a list of choices. (In other words, it means ″or″)
<>	Angle brackets (less-than and greater-than) enclose the name of a key on the keyboard. For example, **<Enter>** refers to the key on your terminal or workstation that is labeled with the word Enter.
...	An ellipsis indicates that you can repeat the preceding item one or more times.
<Ctrl-*x*>	The notation **<Ctrl-*x*>** indicates a control character sequence. For example, **<Ctrl-*c*>** means that you hold down the control key while pressing **<c>**.
\	The continuation character is used in programming examples in this book for formatting purposes.

Prerequisite and related information

For updates to this document, see publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfsbooks.html.

For the latest support information, see the GPFS Frequently Asked Questions at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

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  Include the book title and order number, and, if applicable, the specific location of the information you have comments on (for example, a page number or a table number).
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Summary of changes

The following sections summarize changes to the GPFS licensed program and the GPFS library for V3.1

Summary of changes
for GPFS 3.1
as updated, April 2006

Changes to GPFS for this release include:

- **New information:**
  - GPFS now provides for Information Lifecycle Management (ILM) with the introduction of storage pools, policy-based file management, and filesets.

    Storage pools allow you to manage your file system's storage in groups. You may now partition your storage based on such factors as performance, locality, and reliability. Files are assigned to a storage pool based on defined policies.

    Policies provide for:

    - File placement to a specific storage pool when it is created.
    - Migration of a file from one storage pool to another.
    - Deletion of a file based on characteristics of the file.

    Filesets provide a means of partitioning the namespace of a file system, allowing administrative operations at a finer granularity than the entire file system:

    - You can define per-fileset quotas on data blocks and inodes. These are analogous to existing per user and per group quotas.
    - Filesets can be specified in the policy rules used for placement and migration of file data.

    Details on these features are provided in the chapter *Policy-based data management for GPFS* of *General Parallel File System: Advanced Administration Guide*.

    New commands in support of storage pools, policies, and filesets include:

    - **mmapplypolicy**
    - **mmchfileset**
    - **mmchpolicy**
    - **mmcrfileset**
    - **mmdelfileset**
    - **mmlinkfileset**
    - **mmlsfileset**
    - **mmlspolicy**
    - **mmrestripefile**
    - **mmunlinkfileset**

    New subroutines in support of storage pools and filesets include:

    - **gpfs_igetstoragepool()**
    - **gpfs_igetfilesetname()**
  - The requirements for IP connectivity in a multi-cluster environment have been relaxed. In earlier releases of GPFS, 'all-to-all' connectivity was required. Any node mounting a given file system had to be able to open a TCP/IP connection to any other node mounting the same file system, irrespective of which cluster either of the nodes belonged to.

    In GPFS 3.1, a node mounting a file system from a remote cluster is only required to be able to open a TCP/IP connection to nodes in the cluster that owns the file system, but not any other nodes from other clusters that may be mounting the same file system.
  - Enhanced file system mounting supported by three new commands:

- The **mmmount** and **mmumount** commands are provided for cluster-wide file system management, alleviating the need for the administrator to issue the **dsh** command.
- The **mmlsmount** command displays the IP addresses and names of the nodes (local and remote) that have a particular file system mounted.

– Enhanced Network Shared Disk functions:
- An option to allow or restrict failover from local to remote access is now provided on the **mmchfs**, **mmmount**, and **mmremotefs** commands.

  In prior releases of GPFS, the only way to failback to local disk access once the connection had been repaired and access through an NSD server was no longer desired, was to remount the file system. In this release, GPFS discovers if the path has been repaired. If the path has been repaired, GPFS falls back to local disk access.
- Improved NSD access information provided by the **mmlsnsd** command:
  - The NSD identifier is now available when specifying the **-L** option.
  - The device type of the disk is now available when specifying the **-X** option.

– Enhancements to the **mmpmon** performance monitoring tool:
- Use of a named socket. The **mmpmon** command no longer uses a network connection for communication with the GPFS daemon.
- Extends support to include a list of nodes, in the local cluster, to report on instead of just the node from which the command is issued.
- A new request, **source**, that specifies an input file for requests.
- A prefix request, **once**, that directs **mmpmon** to process a request only once.

– Enhanced mount support for clusters utilizing NSD servers.

  You may now specify how long to wait for an NSD server to come online before allowing the mount to fail. The **mmchconfig** command has been enhanced allowing to specify wait time when:
- Bringing a cluster online:
  - The cluster formation time is at most **nsdServerWaitTimeWindowOnMount** seconds from the current time.
  - The number of seconds to wait for the server to come up before declaring the mount a failure as specified by the **nsdServerWaitTimeForMount** option.
- Bringing an NSD server online when client nodes are already active:
  - The last failed time is at most **nsdServerWaitTimeWindowOnMount** seconds from the current time.
  - The number of seconds to wait for the server to come up before declaring the mount a failure as specified by the **nsdServerWaitTimeForMount** option.

– You may now specify different networks for GPFS daemon communication and for GPFS administration command usage within your cluster. The node descriptor for the **mmchcluster** command now allows you to specify separate node interfaces for these uses, for each node within your cluster. You may choose to use this capability when considering cluster security or performance.

– Improved cluster network access. You may now specify the use of multiple networks for a node in your cluster allowing both the use of internal networks within a cluster and the use of external address for remote mounts. The **mmchconfig** command has been enhanced so that you may specify a list of individual subnets used to communicate between nodes in a GPFS cluster, ordered by preference (order in which operands are specified on the **subnets** option).

– GPFS now provides for the ability to distribute the token management function among multiple nodes in a cluster, reducing possible bottlenecks. This feature is enabled by default. Nodes that have been designated as **manager** nodes are used to distribute the token manager function.

  See the *General Parallel File System: Concepts, Planning, and Installation Guide* for further information on the roles of the file system manager and the *General Parallel File System: Advanced Administration Guide* for details on distributed token managers.

– An autoconfiguration tool is now provided for GPFS for Linux installations.

GPFS Linux installations require a set of kernel extensions be built to match a customer's specific hardware, Linux distribution and kernel . Prior to GPFS V3.1, this was a manual operation (see the *General Parallel File System: Concepts, Planning, and Installation Guide* and search on *The GPFS portability layer*). In addition to the manual method, there now exists an autoconfiguration tool to query your system configuration and generate a working configuration file.

– The use of a single port removing conflicts with existing network services.

  As of November 2004, port number 1191 was officially registered with InterNet Assigned Numbers Authority (IANA) for handling GPFS-specific traffic. With this release, all GPFS-related traffic has been consolidated on port number 1191.

– Improved usability and command consistency by providing the **-N** flag to indicate which nodes are to participate in processing the command. Node classes may also be used to specify nodes. Commands using this new option are:
  - **mmadddisk**
  - **mmaddnode**
  - **mmchcluster**
  - **mmchconfig**
  - **mmchdisk**
  - **mmcrcluster**
  - **mmdeldisk**
  - **mmdelnsd**
  - **mmdelnode**
  - **mmfsck**
  - **mmgetstate**
  - **mmmount**
  - **mmrestripefs**
  - **mmrpldisk**
  - **mmshutdown**
  - **mmstartup**
  - **mmumount**

– The **gpfs_getacl()** and **gpfs_putacl()** subroutines have been expanded to allow an externalized version of the ACL structure to be passed between an application and GPFS.

  Please see the GPFS FAQ for information on the latest support for GPFS interoperability.

– The **gpfs_quotactl()** subroutine has been added to allow manipulating disk quotas on file systems.

• **Changed information:**

– Improved quorum semantics when utilizing node quorum with tiebreaker disks. The maximum number of quorum nodes has been increased from two to eight.

– Enhanced quota information in support of filesets.

– Enhancements to the support of NFS V4 on AIX that includes:
  - Enhanced ACL behavior:
    • UNIX® permissions on an object no longer include a **DELETE** specification in either the **allow** or **deny** entries.
    • **DELETE** is permitted if the user has either **DELETE** on the object or **DELETE CHILD** on the parent.

– Performance and security enhancements to the **mmauth** command:
  - You may experience performance improvements as GPFS now uses a multithreaded receiver for authentication, encryption and decryption.
  - Multiple security levels, up to one for each authorized cluster, may be specified by the cluster granting access.

- The local cluster no longer needs to be shut down prior to changing security keys. This enables online management of security keys, for example:
  - In order to make connection rate performance acceptable in large clusters, the size of the security keys used for authentication cannot be very large. As a result, it may be necessary to change security keys in order to prevent a given key from being compromised while it is still in use.
  - As a matter of policy, some institutions may require security keys are changed periodically.

– Enhancement to the **mmbackup** command to permit specifying a sort directory, using the **-s** flag.
– Enhancement to the **mmlsattr** command to display additional file attributes (including the fileset, storage pool, and snapshot), using the **-L** flag.
– Enhancement to the **mmlsdisk** command to display information about how disk I/O requests are satisfied (locally or using an NSD server), with the **-M** and **-m** flags.
– Enhanced error messages reporting in the **mmfs** log. Messages previously reporting no explanation now provide the proper text.
– You may experience performance improvements when issuing either the **mmlsnsd -M** or the **mmlsnsd -m** command due to a redesign of the command.

- **Deleted information:**
  – The **mmpmon** command no longer uses a network connection for communication with the GPFS daemon.

Summary of changes for GPFS Version 3.1 library as updated, April 2006

Changes to the GPFS library for this release include:

- **New information:**
  – The *General Parallel File System: Advanced Administration Guide* has been introduced. The guide contains:
    - Shared file system access
    - Policy-based data management
    - Creating and maintaining snapshots
    - Disaster recovery
    - Monitoring GPFS I/O performance
    - Miscellaneous topics, including SANergy®
  – For the *General Parallel File System: Concepts, Planning, and Installation Guide*:
    - Information about new configuration and tuning parameters.
  – For the *General Parallel File System: Administration and Programming Reference*:
    - New information needed to administer the new GPFS functions listed previously.
    - New entries for the commands and subroutines listed previously.
  – For the *General Parallel File System: Problem Determination Guide*:
    - New messages for the new functions listed previously.
    - New problem determination sections for the new functions listed previously.
  – For the *General Parallel File System: Data Management API Guide*:
    - No new information.
- **Changed information:**
  – For the *General Parallel File System: Concepts, Planning, and Installation Guide*:
    - Quorum semantics
    - Installation instructions

- Migration instructions
- Configuration and tuning information

– For the *General Parallel File System: Administration and Programming Reference*:
- These have been moved to the *General Parallel File System: Advanced Administration Guide*:
  - Shared file system access
  - Creating and maintaining snapshots
  - Disaster recovery
  - Monitoring GPFS I/O performance
  - Miscellaneous topics, including SANergy

– For the *General Parallel File System: Problem Determination Guide*:

  Messages and problem determination information for all new and changed GPFS features, as appropriate.

- **Deleted information:**

  There has been no information deleted from the GPFS library for GPFS V3.1

Part 1. Understanding General Parallel File System

Part 1 provides planning concepts for the General Parallel File System (GPFS) licensed programs:

Chapter 1. Introducing General Parallel File System

IBM's General Parallel File System (GPFS) provides file system services to parallel and serial applications. GPFS allows parallel applications simultaneous access to the same files, or different files, from any node which has the GPFS file system mounted while managing a high level of control over all file system operations. GPFS is particularly appropriate in an environment where the aggregate peak need for data bandwidth exceeds the capability of a distributed file system server.

GPFS allows users shared file access within a single GPFS cluster and across multiple GPFS clusters. A GPFS cluster consists of:

- AIX 5L nodes, Linux nodes, or a combination thereof (see "GPFS cluster configurations" on page 8). A node may be:
  - An individual operating system image on a single computer within a cluster.
  - A system partition containing an operating system. Some System p5™ and pSeries machines allow multiple system partitions, each of which is considered to be a node within the GPFS cluster.
- Network shared disks (NSDs) created and maintained by the NSD component of GPFS
  - All disks utilized by GPFS must first be given a globally accessible NSD name.
  - The GPFS NSD component provides a method for cluster-wide disk naming and access.
  - On Linux machines running GPFS, you may give an NSD name to:
    - Physical disks
    - Logical partitions of a disk
    - Representations of physical disks (such as LUNs)
  - On AIX machines running GPFS, you may give an NSD name to:
    - Physical disks
    - Virtual shared disks
    - Representations of physical disks (such as LUNs)
- A shared network for GPFS communications allowing a single network view of the configuration. A single network, a LAN or a switch, is used for GPFS communication, including the NSD communication.

The strengths of GPFS

GPFS is a powerful file system offering:

- Shared file system access among GPFS clusters
- Improved system performance
- File consistency
- High recoverability and increased data availability
- Enhanced system flexibility
- "Simplified storage management" on page 6
- Simplified administration

Shared file system access among GPFS clusters

GPFS allows users shared access to files in either the cluster where the file system was created or other GPFS clusters. Each site in the network is managed as a separate cluster, while allowing shared file system access. When multiple clusters are configured to access the same GPFS file system, Open Secure Sockets Layer (OpenSSL) is used to authenticate and check authorization for all network connections.

Note: If you use a cipher, the data will be encrypted for transmissions. However, if you set the **cipherlist** keyword of the **mmauth** command to **AUTHONLY**, only authentication will be used for data transmissions and data will not be encrypted.

GPFS shared file system access provides for:

- The ability of the cluster granting access to specify multiple security levels, up to one for each authorized cluster.
- A highly available service as the local cluster may remain active prior to changing security keys. Periodic changing of keys is necessary for a variety of reasons, including:
  - In order to make connection rate performance acceptable in large clusters, the size of the security keys used for authentication can not be very large. As a result it may be necessary to change security keys in order to prevent a given key from being compromised while it is still in use.
  - As a matter of policy, some institutions may require security keys are changed periodically.

Note: The pair of public and private security keys provided by GPFS are similar to host based authentication mechanism provided by OpenSSH. Each GPFS cluster has a pair of these keys that identify the cluster. In addition, each cluster also has an `authorized_keys` list. Each line in the `authorized_keys` list contains the public key of one remote cluster and a list of file systems that cluster is authorized to mount. For details on shared file system access, see the *GPFS: Advanced Administration Guide*.

Improved system performance

Using GPFS to store and retrieve your files can improve system performance by:

- Allowing multiple processes or applications on all nodes in the cluster simultaneous access to the same file using standard file system calls.
- Increasing aggregate bandwidth of your file system by spreading reads and writes across multiple disks.
- Balancing the load evenly across all disks to maximize their combined throughput. One disk is no more active than another.
- Supporting very large file and file system sizes.
- Allowing concurrent reads and writes from multiple nodes. This is a key concept in parallel processing.
- Allowing for distributed token (lock) management. Distributing token management reduces system delays associated with a lockable object waiting to obtaining a token. Refer to “Managing distributed tokens” on page 25 and “High recoverability and increased data availability” on page 5 for additional information on token management.
- Allowing for the specification of different networks for GPFS daemon communication and for GPFS administration command usage within your cluster.

Achieving high throughput to a single, large file requires striping data across multiple disks and multiple disk controllers. Rather than relying on striping in a separate volume manager layer, GPFS implements striping in the file system. Managing its own striping affords GPFS the control it needs to achieve fault tolerance and to balance load across adapters, storage controllers, and disks. Large files in GPFS are divided into equal sized blocks, and consecutive blocks are placed on different disks in a round-robin fashion [1]

To exploit disk parallelism when reading a large file from a single-threaded application, whenever it can recognize a pattern, GPFS prefetches data into its buffer pool, issuing I/O requests in parallel to as many disks as necessary to achieve the bandwidth of which the switching fabric is capable. GPFS recognizes sequential, reverse sequential, and various forms of strided access patterns [1].

GPFS I/O performance may be monitored through the **mmpmon** command. See the *GPFS: Advanced Administration Guide*.

1. Dominique Heger, Gautam Shah: General Parallel File System (GPFS v1.4) for AIX Architecture and Performance, November 2001

File consistency

GPFS uses a sophisticated token management system to provide data consistency while allowing multiple independent paths to the same file by the same name from anywhere in the cluster. See “Special management functions” on page 73.

High recoverability and increased data availability

GPFS failover support allows you to organize your hardware into *failure groups*. A failure group is a set of disks that share a common point of failure that could cause them all to become simultaneously unavailable. When used in conjunction with the *replication* feature of GPFS, the creation of multiple failure groups provides for increased file availability should a group of disks fail. GPFS maintains each instance of replicated data and metadata on disks in different failure groups. Should a set of disks become unavailable, GPFS fails over to the replicated copies in another failure group.

During configuration, you assign a replication factor to indicate the total number of copies of data and metadata you wish to store. Replication allows you to set different levels of protection for each file or one level for an entire file system. Since replication uses additional disk space and requires extra write time, you might want to consider replicating only file systems that are frequently read from but seldom written to. To reduce the overhead involved with the replication of data, you may also choose to replicate only metadata as a means of providing additional file system protection. For further information on GPFS replication, see “File system recoverability parameters” on page 35.

GPFS is a logging file system that creates separate logs for each node. These logs record the allocation and modification of metadata aiding in fast recovery and the restoration of data consistency in the event of node failure. Even if you do not specify replication when creating a file system, GPFS automatically replicates recovery logs in separate failure groups, if multiple failure groups have been specified. This replication feature can be used in conjunction with other GPFS capabilities to maintain one replica in a geographically separate location which provides some capability for surviving disasters at the other location. For further information on failure groups, see “NSD creation considerations” on page 27. For further information on disaster recovery with GPFS see the *GPFS: Advanced Administration Guide*.

Once your file system is created, it can be configured to mount whenever the GPFS daemon is started. This feature assures that whenever the system and disks are up, the file system will be available. When utilizing shared file system access among GPFS clusters, to reduce overall GPFS control traffic you may indicate to mount the file system when it is first accessed. This is done through either the **mmremotefs** command or the **mmchfs** command using the **-A automount** option. GPFS mount traffic may be lessened by using automatic mounts instead of mounting at GPFS startup. Automatic mounts only produce additional control traffic at the point that the file system is first used by an application or user. Mounting at GPFS startup on the other hand produces additional control traffic at every GPFS startup. Thus startup of hundreds of nodes at once may be better served by using automatic mounts. However, when exporting the file system for Network File System (NFS) mounts, it might be useful to mount the file system when GPFS is started. For further information on shared file system access and the use of NFS with GPFS, see the *GPFS: Administration and Programming Reference*.

Enhanced system flexibility

With GPFS, your system resources are not frozen. You can add or delete disks while the file system is mounted. When the time is right and system demand is low, you can rebalance the file system across all currently configured disks. In addition, you can also add or delete nodes without having to stop and restart the GPFS daemon on all nodes.

Note: In the node quorum with tiebreaker disk configuration, GPFS has a limit of eight quorum nodes. If you add quorum nodes and exceed that limit, the GPFS daemon must be shutdown. Before you restart the daemon, you must switch quorum semantics to node quorum. For additional information, refer to “Quorum” on page 16.

In a SAN configuration where you have also defined NSD servers, if the physical connection to the disk is broken, GPFS dynamically switches disk access to the servers nodes and continues to provide data through NSD server nodes. GPFS falls back to local disk access when it has discovered the path has been repaired.

After GPFS has been configured for your system, depending on your applications, hardware, and workload, you can re-configure GPFS to increase throughput. You can set up your GPFS environment for your current applications and users, secure in the knowledge that you can expand in the future without jeopardizing your data. GPFS capacity can grow as your hardware expands.

Simplified storage management

GPFS provides storage management based on the definition and use of:

- Storage pools
- Policies
- Filesets

Storage pools

A *storage pool* is a collection of disks or RAIDs with similar properties that are managed together as a group. Storage pools provide a method to partition storage on the file system. While you plan how to configure your storage, consider factors such as:

- Improved price-performance by matching the cost of storage to the value of the data.
- Improved performance by:
  - Reducing the contention for premium storage
  - Reducing the impact of slower devices
- Improved reliability by providing for:
  - Replication based on need
  - Better failure containment

Policies

Files are assigned to a storage pool based on defined *policies*. Policies provide for:

- Placing files in a specific storage pool when the files are created
- Migrating files from one storage pool to another
- File deletion based on file characteristics

Filesets

Filesets provide a method for partitioning a file system and allow administrative operations at a finer granularity than the entire file system. For example filesets allow you to:

- Define data block and inode quotas at the fileset level
- Apply policy rules to specific filesets

For further information on storage pools, filesets, and policies see the *GPFS: Advanced Administration Guide*.

Simplified administration

GPFS offers many of the standard UNIX file system interfaces allowing most applications to execute without modification or recompiling. UNIX file system utilities are also supported by GPFS. That is, users can continue to use the UNIX commands they have always used for ordinary file operations (see Appendix C, “Considerations for GPFS applications,” on page 95). The only unique commands are those for administering the GPFS file system.

GPFS administration commands are similar in name and function to UNIX file system commands, with one important difference: *the GPFS commands operate on multiple nodes*. A single GPFS command performs a file system function across the entire cluster. See the individual commands as documented in the *GPFS: Administration and Programming Reference*.

GPFS commands save configuration and file system information in one or more files, collectively known as GPFS cluster configuration data files. The GPFS administration commands are designed to keep these files synchronized between each other and with the GPFS system files on each node in the cluster, thereby providing for accurate configuration data. See “Cluster configuration data files” on page 87.

The basic GPFS structure

GPFS is a clustered file system defined over a number of nodes. On each node in the cluster, GPFS consists of:

1. Administration commands
2. A kernel extension
3. A multithreaded daemon
4. For nodes in your cluster operating with the Linux operating system, “The GPFS open source portability layer” on page 8

For a detailed discussion of GPFS, see Appendix A, “GPFS architecture,” on page 73.

GPFS administration commands

Most GPFS administration tasks can be performed from any node running GPFS. See the individual commands as documented in the *GPFS: Administration and Programming Reference*.

The GPFS kernel extension

The GPFS kernel extension provides the interfaces to the operating system vnode and virtual file system (VFS) interfaces for adding a file system. Structurally, applications make file system calls to the operating system, which presents them to the GPFS file system kernel extension. In this way, GPFS appears to applications as just another file system. The GPFS kernel extension will either satisfy these requests using resources which are already available in the system, or send a message to the GPFS daemon to complete the request.

The GPFS daemon

The GPFS daemon performs all I/O and buffer management for GPFS. This includes read-ahead for sequential reads and write-behind for all writes not specified as synchronous. All I/O is protected by GPFS token management which honors atomicity thereby providing for data consistency of a file system on multiple nodes.

The daemon is a multithreaded process with some threads dedicated to specific functions. Dedicated threads for services requiring priority attention are not used for or blocked by routine work. The daemon also communicates with instances of the daemon on other nodes to coordinate configuration changes, recovery and parallel updates of the same data structures. Specific functions that execute on the daemon include:

1. Allocation of disk space to new files and newly extended files. This is done in coordination with the *file system manager*.
2. Management of directories including creation of new directories, insertion and removal of entries into existing directories, and searching of directories that require I/O.
3. Allocation of appropriate locks to protect the integrity of data and metadata. Locks affecting data that may be accessed from multiple nodes require interaction with the token management function.
4. Disk I/O is initiated on threads of the daemon.

5. User security and quotas are also managed by the daemon in conjunction with the file system manager.

For further information, see “Special management functions” on page 73.

The GPFS open source portability layer

For Linux nodes running GPFS, you must build custom portability modules based on your particular hardware platform and Linux distribution to enable communication between the Linux kernel and the GPFS kernel modules. See “Building your GPFS portability layer” on page 48.

GPFS cluster configurations

GPFS is designed to operate with:

The operating system kernel
Provides the basic operating system services and the routing of file system calls requiring GPFS data.

Network Shared Disk (NSD)
This GPFS component provides:

- Disk access through disk discovery

  The NSDs in your cluster may be physically attached to all nodes or serve their data through a primary and, if specified, backup NSD server, providing a virtual connection. GPFS determines if a node has physical or virtual connectivity to an underlying NSD through a sequence of commands invoked from the GPFS daemon. This determination is called *disk discovery* and occurs at both initial GPFS startup as well as whenever a file system is mounted.

  The default order of access used in disk discovery:

  1. Local **/dev** block device interfaces for virtual shared disk, SAN, SCSI or IDE disks
  2. NSD servers

  This order can be changed by use of the **useNSDserver** mount option.

  As GPFS determines the available connections to disks in the file system, it is suggested you always define NSD servers for the disks. In a SAN configuration where NSD servers have also been defined, if the physical connection is broken, GPFS dynamically switches to the servers nodes and continues to provide data. GPFS falls back to local disk access when it has discovered the path has been repaired. This is the default behavior, and can be changed with the **useNSDserver** file system mount option.

- Cluster-wide disk naming

  The cluster-wide NSD name uniquely identifies a disk, even when that disk is visible as different **/dev** entries on different nodes.

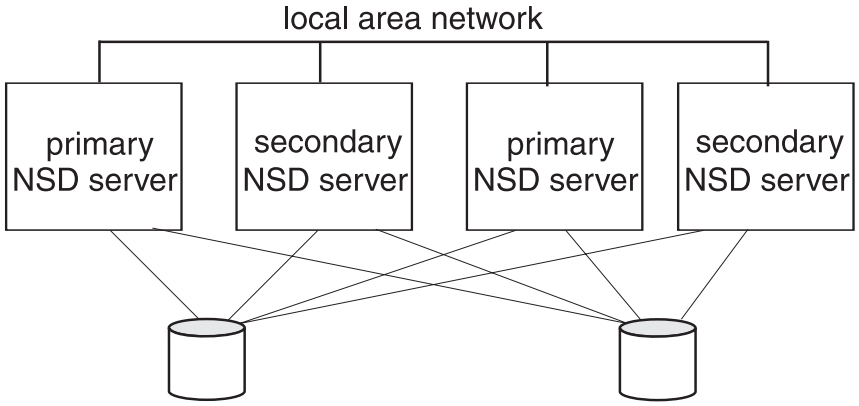


Figure 1. GPFS utilizes the network shared disk subsystem for global disk naming and access

For further information, see “Disk considerations” on page 25 and “NSD disk discovery” on page 86.

GPFS has several cluster configurations. A subset of these configurations includes:

1. Configurations where all disks are SAN-attached to all nodes in the cluster and the nodes in the cluster are either all Linux or all AIX (refer to Figure 2). For the latest hardware that GPFS has been tested with, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html

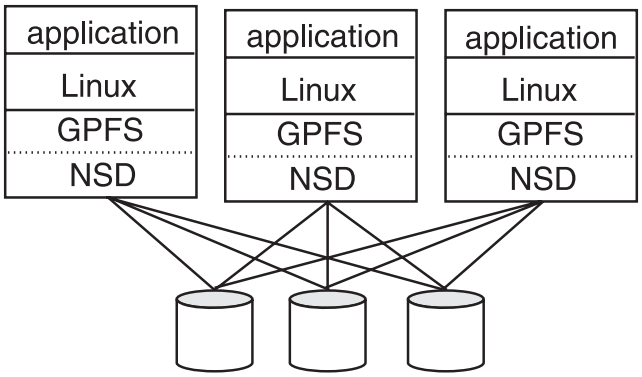


Figure 2. A Linux-only cluster with disks that are SAN-attached to all nodes

2. A Linux-only cluster consisting of xSeries®, System p5, pSeries, or @server™ machines with an NSD server attached to the disk (refer to Figure 3 on page 10). Nodes not directly attached to the disk have remote data access over the local area network (either Ethernet or Myrinet) to the NSD server. A backup NSD server having direct Fibre Channel access to the disks may also be defined. Any nodes directly attached to the disk will not access data through the NSD server. This is the default behavior and can be changed with the **useNSDserver** file system mount option.

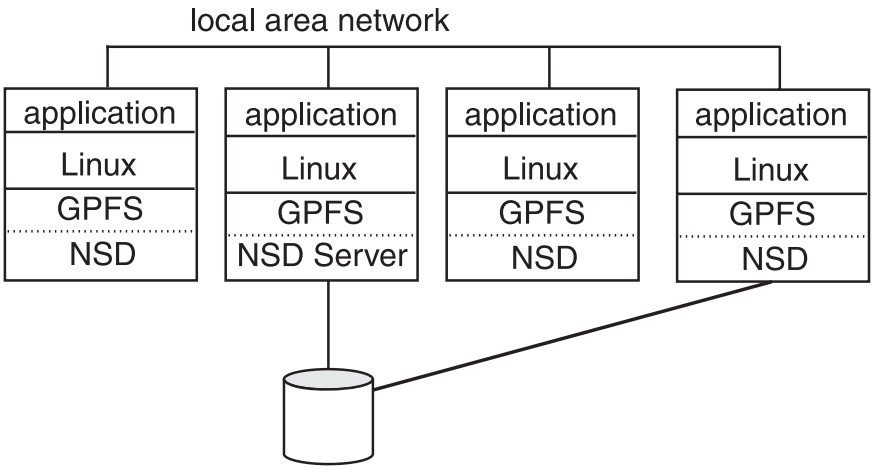


Figure 3. A Linux-only cluster with an NSD server

3. An AIX and Linux cluster with an NSD server (refer to Figure 4). Nodes not directly attached to the disk have remote access over the local area network (Ethernet only) to the NSD server.

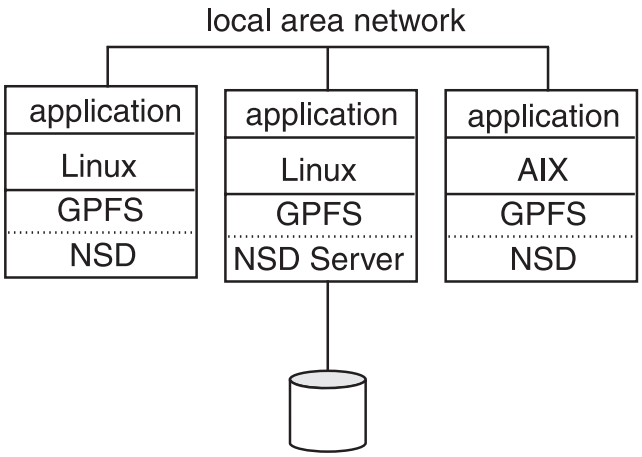


Figure 4. An AIX and Linux cluster with an NSD server

4. An AIX and Linux cluster with an NSD server (refer to Figure 5 on page 11). AIX nodes having Recoverable Virtual Shared Disk (RVSD) and IBM @server High Performance Switch (HPS) connections to the disk server access data through that path. Linux or other AIX nodes having no RVSD switch access, have remote data access over the LAN (Ethernet only) to the NSD server. A backup NSD server having access to the disk through RVSD and the switch may also be defined.

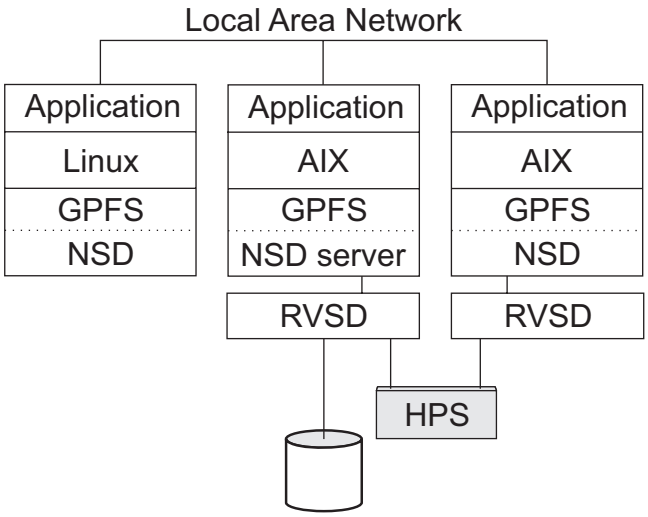


Figure 5. An AIX and Linux cluster providing remote access to disks through the High Performance Switch (HPS) for the AIX nodes and a LAN connection for the Linux nodes

5. An AIX and Linux cluster that provides remote access to disks through primary and backup NSD servers (refer to Figure 6). In this configuration:
   - Internode communication uses the LAN
   - All disk access passes through NSD servers
     - NSD servers connect the disk to the Linux nodes
     - NSD servers use RVSD to connect the disk to the AIX nodes

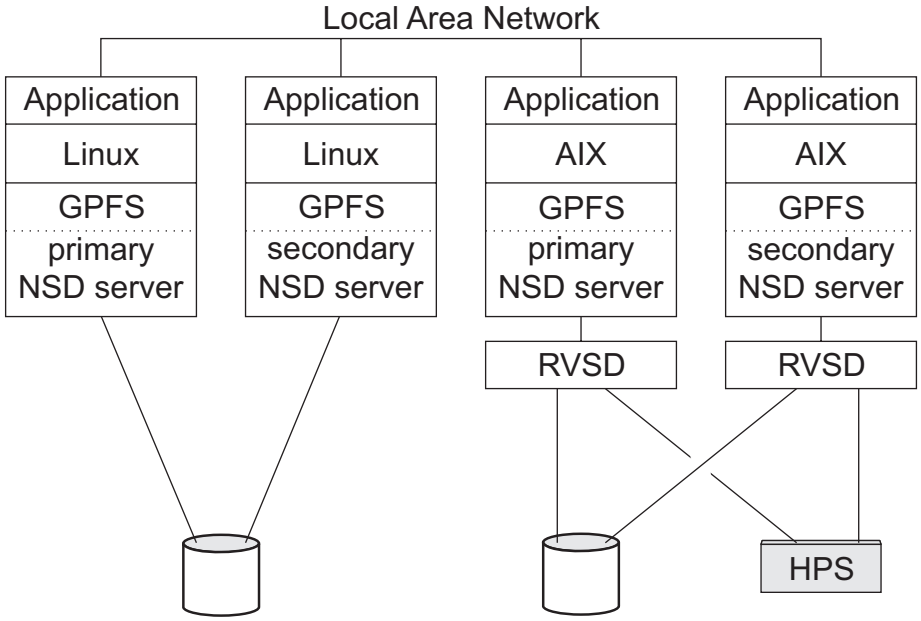


Figure 6. An AIX and Linux cluster that provides remote access to disks through primary and backup NSD servers

6. An AIX cluster with an NSD server (refer to Figure 7 on page 12). Nodes not directly attached to the disk have remote access over the HPS to the NSD server.

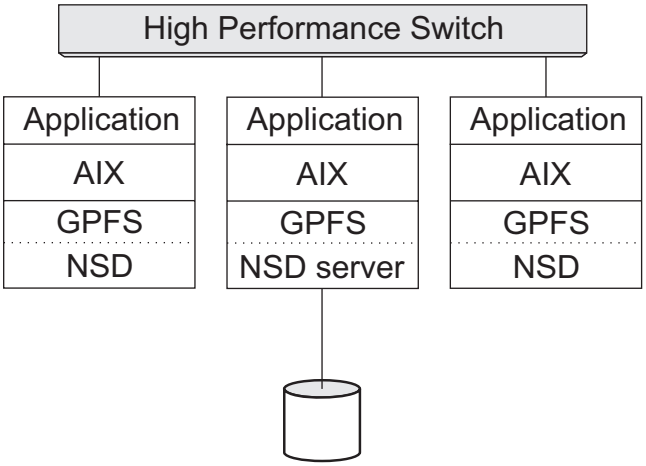


Figure 7. An AIX cluster with an NSD server

7. Shared file system access among multiple GPFS clusters (refer to Figure 8). The GPFS clusters sharing file system access may be any supported configuration.

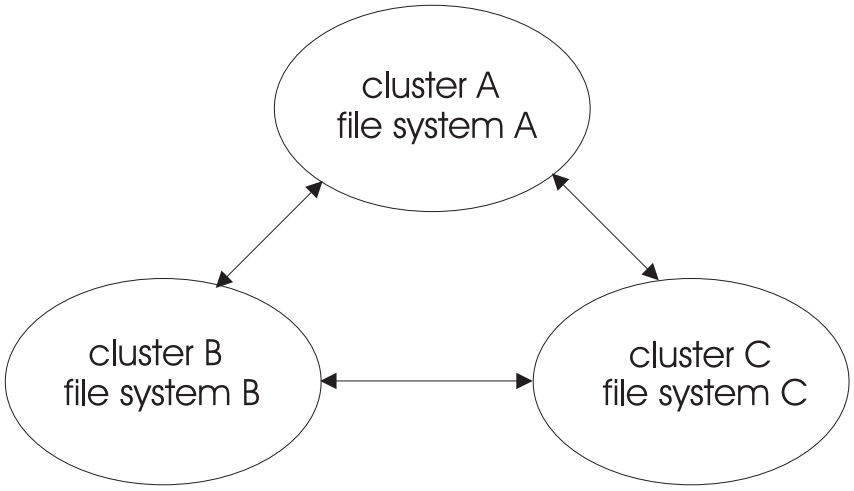


Figure 8. GPFS clusters providing shared file system access

For the latest list of supported cluster configurations, please see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Interoperable cluster requirements

Consult the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for any changes to requirements and currently tested:

1. Hardware configurations
2. Software configurations
3. Cluster configurations

These software requirements apply to an interoperable GPFS cluster:

- All nodes must have GPFS 3.1 and the latest service level installed.

These configuration requirements apply to an interoperable GPFS cluster:

- All file systems defined on versions of GPFS prior to version 2.3 must be exported from their old cluster definition and re-imported into a newly created 3.1 cluster. Cluster configuration dependencies and setup changed significantly in GPFS version 2.3. See “Migrating to GPFS 3.1 from GPFS 2.2 or earlier releases of GPFS” on page 53.
- The NSD primary and backup servers for each disk device must be defined on a homogenous set of Linux or AIX nodes. They may not be split between operating system types. See Figure 6 on page 11.
- For most disk subsystems, all nodes accessing a SAN-attached disk (LUN) must use the same operating system. Most disk subsystems do not allow you to have Linux nodes and AIX nodes attached to the same LUN. Refer to the information supplied with your specific disk subsystem for details about supported configurations.

Chapter 2. Planning for GPFS

Planning for GPFS includes:

- "Hardware requirements"
- "Software requirements"
- "Recoverability considerations" on page 16
- "GPFS cluster creation considerations" on page 21
- "Disk considerations" on page 25
- "File system creation considerations" on page 31

Although you can modify your GPFS configuration after it has been set, a little consideration before installation and initial setup will reward you with a more efficient and immediately useful file system. During configuration, GPFS requires you to specify several operational parameters that reflect your hardware resources and operating environment. During file system creation, you have the opportunity to specify parameters based on the expected size of the files or allow the default values to take effect. These parameters define the disks for the file system and how data will be written to them.

Hardware requirements

1. Please consult the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for latest list of:
   - Supported hardware
   - Tested disk configurations
   - Maximum cluster size
2. Enough disks to contain the file system. Disks can be:
   - SAN-attached to each node in the cluster
   - Attached to the primary and, if specified, backup NSD server
   - A mixture of direct attached and primary and secondary NSDs
   - Refer to "NSD creation considerations" on page 27 for additional information
3. Since GPFS passes a large amount of data between its daemons, it is suggested that you configure a dedicated high speed network supporting the IP protocol when you are using GPFS:
   - With NSD disks configured with servers providing remote disk capability
   - Multiple GPFS clusters providing remote mounting of and access to GPFS file systems
   - Refer to the *GPFS: Advanced Administration Guide* for additional information

GPFS communications require invariant static IP addresses for each specific GPFS node. Any IP address takeover operations which transfer the address to another computer are not allowed for the GPFS network. Other IP addresses within the same computer which are not used by GPFS can participate in IP takeover. GPFS can use virtual IP addresses created by aggregating several network adapters using techniques such as EtherChannel or channel bonding.

Software requirements

Please consult the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for latest list of:

- Linux distributions
- Linux kernel versions
- AIX environments
- OpenSSL levels

Note: When multiple clusters are configured to access the same GPFS file system OpenSSL is used to authenticate and check authorization for all network connections. In addition, if you use a cipher, data will be encrypted for transmissions. However, if you set the **cipherlist** keyword of the **mmauth** command to **AUTHONLY**, only authentication will be used for data transmissions and data will not be encrypted.

Recoverability considerations

Sound file system planning requires several decisions about recoverability. After you make these decisions, GPFS parameters enable you to create a highly available file system with fast recoverability from failures:

- At the file system level, consider replication through the metadata and data replication parameters. See "File system recoverability parameters" on page 35.
- At the disk level, consider preparing disks for use with your file system by specifying failure groups that are associated with each disk. With this configuration, information is not vulnerable to a single point of failure. See "NSD creation considerations" on page 27.

Additionally, GPFS provides several layers of protection against failures of various types:

1. "Node failure"
2. "Network Shared Disk server and disk failure" on page 19

Node failure

In the event of a node failure, GPFS:

- Prevents the continuation of I/O from the failing node
- Replays the file system metadata log for the failing node

GPFS prevents the continuation of I/O from a failing node through a GPFS-specific fencing mechanism called *disk leasing*. When a node has access to file systems, it obtains disk leases that allow it to submit I/O. However, when a node fails, that node cannot obtain or renew a disk lease. When GPFS selects another node to perform recovery for the failing node, it first waits until the disk lease for the failing node expires. This allows for the completion of previously submitted I/O and provides for a consistent file system metadata log. Waiting for the disk lease to expire also avoids data corruption in the subsequent recovery step. For further information on recovery from node failure, see the *GPFS: Problem Determination Guide*.

File system recovery from node failure should not be noticeable to applications running on other nodes. The only noticeable effect may be a delay in accessing objects being modified on the failing node. Recovery involves rebuilding metadata structures which may have been under modification at the time of the failure. If the failing node is the file system manager for the file system, the delay will be longer and proportional to the activity on the file system at the time of failure. However, administrative intervention will not be needed.

During node failure situations, quorum needs to be maintained in order to recover the failing nodes. If quorum is not maintained due to node failure, GPFS unmounts local file systems on the remaining nodes and attempts to reestablish quorum, at which point file system recovery occurs. For this reason it is important that the set of quorum nodes be carefully considered.

Quorum

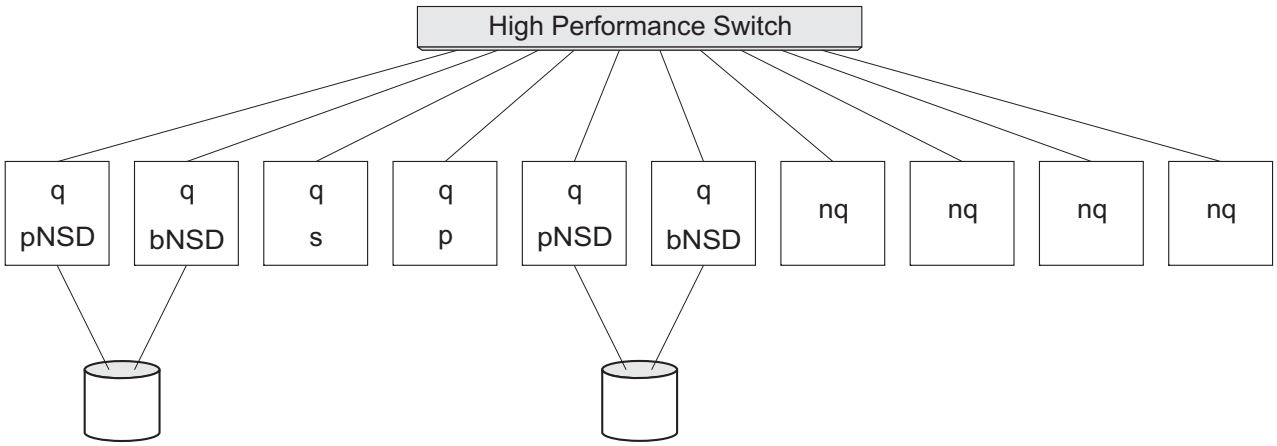
GPFS quorum must be maintained within the cluster for GPFS to remain active. If the quorum semantics are broken, GPFS performs recovery in an attempt to achieve quorum again. GPFS can use one of two methods for determining quorum:

- Node quorum
- Node quorum with tiebreaker disks.

Node quorum: Node quorum is the default quorum algorithm for GPFS. With node quorum:

- Quorum is defined as one plus half of the *explicitly defined* quorum nodes in the GPFS cluster.
- There are no default quorum nodes, you must specify which nodes have this role.
- GPFS does not limit the number of quorum nodes.

For example, in Figure 9, there are six quorum nodes. In this configuration, GPFS remains active as long as there are four quorum nodes available.



q - quorum node

pNSD - primary NSD server

bNSD - backup NSD server

s - secondary cluster configuration server

p - primary cluster configuration server

nq - non-quorum node

Figure 9. GPFS configuration utilizing node quorum

Node quorum with tiebreaker disks: Node quorum with tiebreaker disks allows you to run with as little as one quorum node available as long as you have access to a majority of the quorum disks (refer to Figure 10 on page 18). Switching to quorum with tiebreaker disks is accomplished by indicating a list of one to three disks to use on the **tiebreakerDisks** parameter on the **mmchconfig** command.

When utilizing node quorum with tiebreaker disks, there are specific rules for cluster nodes and for tiebreaker disks.

Cluster node rules

1. There is a maximum of eight quorum nodes.
2. You should include the primary and secondary cluster configuration servers as quorum nodes.
3. You may have an unlimited number of non-quorum nodes.

Changing quorum semantics::

1. If you exceed eight quorum nodes, you must disable node quorum with tiebreaker disks and restart GPFS daemon using the default node quorum configuration. To disable node quorum with tiebreaker disks:
   a. Shutdown the GPFS daemon by issuing **mmshutdown -a** on all nodes.
   b. Change quorum semantics by issuing **mmchconfig tiebreakerdisks=no**.
   c. Add quorum nodes.

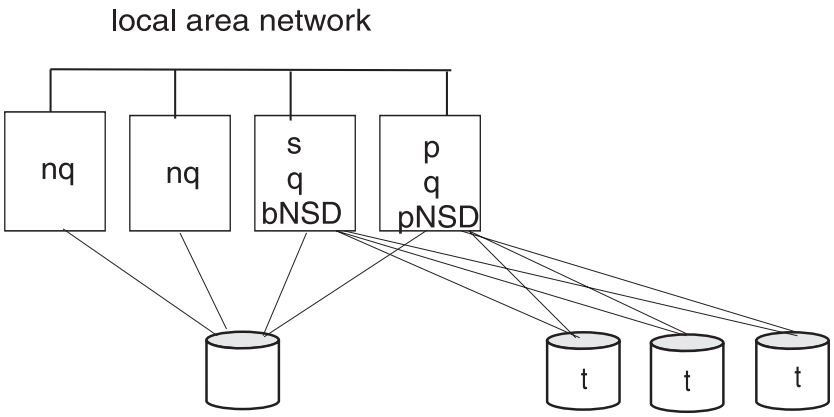
d. Restart the GPFS daemon by issuing **mmstartup -a** on all nodes.

2. If you remove quorum nodes and the new configuration has less than eight quorum nodes, you can change the configuration to node quorum with tiebreaker disks. To enable quorum with tiebreaker disks:
   a. Shutdown the GPFS daemon by issuing **mmshutdown -a** on all nodes.
   b. Delete the quorum nodes.
   c. Change quorum semantics by issuing the **mmchconfig tiebreakerdisks=***"diskList"* command.
      - The *diskList* contains the names of the tiebreaker disks.
      - The list contains the NSD names of the disks, preferably one or three disks, separated by a semicolon (;) and enclosed by quotes.
   d. Restart the GPFS daemon by issuing **mmstartup -a** on all nodes.

Tiebreaker disk rules

- You may have one, two, or three tiebreaker disks. However, you should use an odd number of tiebreaker disks.
- Tiebreaker disks must have a cluster-wide NSD name defined through the **mmcrnsd** command.
- Tiebreaker disks must use one of following attachments to the quorum nodes:
  – fibre-channel SAN
  – IP SAN
  – virtual shared disks

In Figure 10 GPFS remains active with the minimum of a single available quorum node and two available tiebreaker disks.



p - primary cluster configuration server
s - secondary cluster configuration server
q - quorum node
nq - non-quorum node
pNSD - primary NSD server
bNSD - backup NSD server
t - tiebreaker disk

Figure 10. GPFS configuration utilizing node quorum with tiebreaker disks

Selecting quorum nodes

To configure a system with efficient quorum nodes, follow these rules:

- Select nodes that are likely to remain active

  - If a node is likely to be rebooted or require maintenance, do not select that node as a quorum node.
- Select nodes that have different failure points such as:
  - Nodes located in different racks
  - Nodes connected to different power panels
- You should select nodes that GPFS administrative and serving functions rely on such as:
  - Primary configuration servers
  - Secondary configuration servers
  - Primary Network Shared Disk servers
  - Backup NSD servers
- Select an odd number of nodes as quorum nodes
  - The suggested maximum is seven quorum nodes.
- Having a large number of quorum nodes may increase the time required for startup and failure recovery.
  - Having more than seven quorum nodes does not guarantee higher availability.

Network Shared Disk server and disk failure

The three most common reasons why data becomes unavailable are:

- Disk failure
- Disk server failure with no redundancy
- Failure of a path to the disk

In the event of a disk failure where GPFS can no longer read or write to the disk, GPFS will discontinue use of the disk until it returns to an available state. You can guard against loss of data availability from disk failure by:

- Utilizing hardware data replication as provided by a Redundant Array of Independent Disks (RAID) device

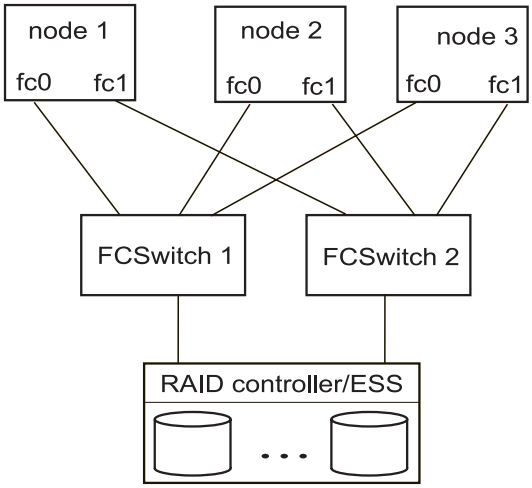


Figure 11. RAID/ESS Controller twin-tailed in a SAN configuration

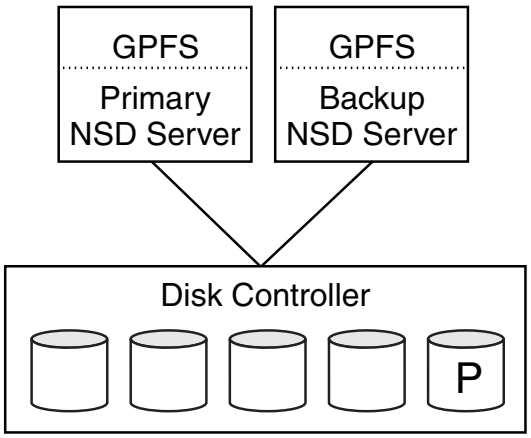


Figure 12. GPFS configuration specifying both primary and backup NSD servers connected to a common disk controller utilizing RAID5 with four data disks and one parity disk

- Utilizing the GPFS data and metadata replication features (see "High recoverability and increased data availability" on page 5) along with the designation of failure groups (see "NSD creation considerations" on page 27)

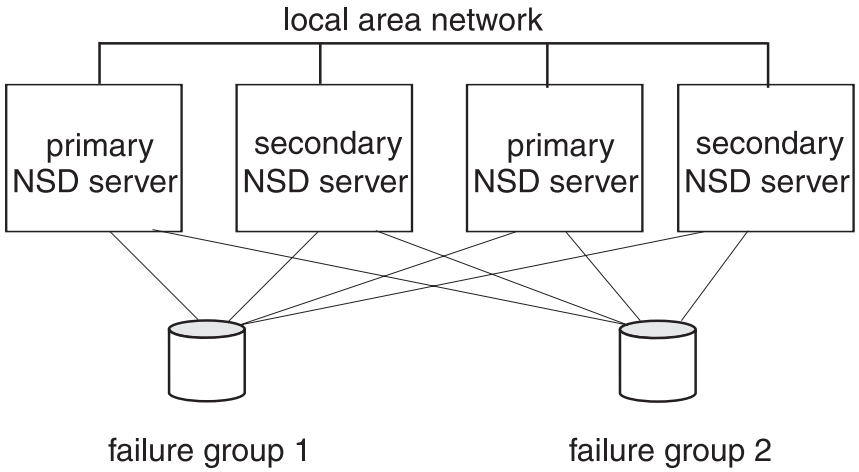


Figure 13. GPFS utilizes failure groups to minimize the probability of a service disruption due to a single component failure

In general, it is suggested that you consider RAID as the first level of redundancy for your data and add GPFS replication if you desire additional protection.

In the event of a disk server failure where GPFS can no longer contact the node providing remote access to a disk, GPFS will again discontinue use of the disk. You can guard against loss of disk server availability by utilizing common disk connectivity at multiple nodes and specifying a backup Network Shared Disk server for the common disk.

In the event of failure of a path to the disk:

- If a virtual shared disk server goes down and GPFS reports a disk failure, follow the instructions in the *RSCT for AIX 5L Managing Shared Disks* manual for the level of your system to check the state of the virtual shared disk path to the disk.
- If a SAN failure removes the path to the disk and GPFS reports a disk failure, follow the directions supplied by your storage vendor to distinguish a SAN failure from a disk failure.

You can guard against loss of data availability from failure of a path to a disk by:

- Creating primary and backup NSD servers for all disks. As GPFS determines the available connections to disks in the file system, it is suggested you always define NSD servers for the disks. In a SAN configuration where NSD servers have also been defined, if the physical connection is broken, GPFS dynamically switches to the primary NSD server and continues to provide data. When GPFS discovers the path has been repaired, it falls back to local disk access. This is the default behavior, and can be changed with the **-o useNSDserver** file system mount option on the **mmmount**, **mount**, **mmchfs**, and **mmremotefs** commands.
- Utilizing the Multiple Path I/O (MPIO) feature of AIX to define alternate paths to a device for failover purposes. Failover is a path-management algorithm that improves the reliability and availability of a device because the system automatically detects when one I/O path fails and reroutes I/O through an alternate path. All Small Computer System Interface (SCSI) Self Configured SCSI Drive (SCSD) disk drives are automatically configured as MPIO devices. Other devices can be supported, providing the device driver is compatible with the MPIO implementation in AIX. For more information about MPIO, see the:
  - *AIX 5L Version 5.3 System Management Concepts: Operating System and Devices* book and search on *Multi-path I/O*.
  - *AIX 5L Version 5.3 System Management Guide: Operating System and Devices* book and search on *Multi-path I/O*.
- Use Subsystem Device Driver (SDD) or Subsystem Device Driver Path Control Module (SDDPCM) to give the AIX host the ability to access multiple paths to a single LUN within an Enterprise Storage Server® (ESS). This ability to access a single logical unit number (LUN) on multiple paths allows for a higher degree of data availability in the event of a path failure. Data can continue to be accessed within the ESS as long as there is at least one available path. Without one of these installed, you will lose access to the LUN in the event of a path failure.

GPFS cluster creation considerations

You create GPFS clusters by issuing the **mmcrcluster** command. Table 2 details:

- The GPFS cluster creation options provided by the **mmcrcluster** command
- How to change the options
- The default values are for each option

Note: Refer to the*GPFS: Advanced Administration Guide* for information on accessing GPFS file systems in remote clusters and large cluster administration.

Table 2. GPFS cluster creation options

Cluster option	Command to change the option	Default value
"Nodes in your GPFS cluster" on page 22	Add nodes through the **mmaddnode** command	None
	Delete nodes through the **mmdelnode** command	
Node designation: Manager or client, see "Nodes in your GPFS cluster" on page 22	**mmchconfig**	Client
Node designation: Quorum or non-quorum, see "Nodes in your GPFS cluster" on page 22		Non-quorum
Primary cluster configuration server, see "GPFS cluster configuration servers" on page 23	**mmchcluster**	None

Table 2. GPFS cluster creation options (continued)

Cluster option	Command to change the option	Default value
Secondary cluster configuration server, see “GPFS cluster configuration servers” on page 23	**mmchcluster**	None
“Remote shell command” on page 24	**mmchcluster**	**/usr/bin/rsh**
“Remote file copy command” on page 24	**mmchcluster**	**/usr/bin/rcp**
“Cluster name” on page 24	**mmchcluster**	The node name of the primary GPFS cluster configuration server
GPFS administration adapter port name, see “GPFS node adapter interface names”	**mmchcluster -N**	Same as the GPFS communications adapter port name
GPFS communications adapter port name, see “GPFS node adapter interface names”	**mmchcluster -N**	None
“User ID domain for the cluster” on page 24	**mmchconfig**	The name of the GPFS cluster
“Starting GPFS automatically” on page 25	**mmchconfig**	No
“Cluster configuration file” on page 25	**mmchconfig**	None
“Managing distributed tokens” on page 25	**mmchconfig**	Yes

GPFS node adapter interface names

An adapter interface name refers to the hostname or IP address that GPFS uses to communicate with a node. Specifically, the hostname or IP address identifies the communications adapter over which the GPFS daemons or GPFS administration commands communicate. GPFS permits the administrator to specify two node adapter interface names for each node in the cluster:

GPFS node name
: Specifies the name of the node adapter interface to be used by the GPFS daemons for internode communication.

GPFS admin node name
: Specifies the name of the node adapter interface to be used by GPFS administration commands when communicating between nodes. If not specified, the GPFS administration commands use the same node adapter interface used by the GPFS daemons.

These names can be specified by means of the node descriptors passed to the **mmcrcluster**, **mmaddnode**, or **mmchcluster -N** commands.

Nodes in your GPFS cluster

When you create your GPFS cluster you must provide a file containing a list of node descriptors, one per line, for each node to be included in the cluster. GPFS stores this information on the GPFS cluster configuration servers. Each descriptor must be specified in the form:

```
NodeName:NodeDesignations:AdminNodeName
```

NodeName
: The hostname or IP address of the node for GPFS daemon-to-daemon communication.

The hostname or IP address used for a node must refer to the communications adapter over which the GPFS daemons communicate. Alias interfaces are not allowed. Use the original address or a name that is resolved by the **host** command to that original address. You may specify a node using any of these forms:

Format	Example
Short hostname	h135n01
Long hostname	h135n01.frf.ibm.com
IP address	7.111.12.102

NodeDesignations
An optional, "-" separated list of node roles.

- **manager** | **client** – Indicates whether a node is part of the node pool from which configuration managers, file system managers, and token manager can be selected. The special functions of the file system manager consume extra processing time. See "The file system manager" on page 73. The default is to *not* have the node included in the pool.

  In general, small systems do not need multiple nodes dedicated for the file system manager. However, if you are running large parallel jobs, threads scheduled to a node performing these functions may run slower. As a guide, in a large system there should be a different file system manager node for each GPFS file system.
- **quorum** | **nonquorum** – This designation specifies whether or not the node should be included in the pool of nodes from which quorum is derived. The default is non-quorum. You must designate at least one node as a quorum node. It is strongly suggested that you designate the primary and secondary cluster configuration servers and any primary and secondary NSD servers as quorum nodes.

  How many quorum nodes you designate depends upon whether you use node quorum or node quorum with tiebreaker disks. See "Quorum" on page 16.

AdminNodeName
Specifies an optional field that consists of a node name to be used by the administration commands to communicate between nodes.

If *AdminNodeName* is not specified, the *NodeName* value is used.

You must follow these rules when creating your GPFS cluster:

- While a node may mount file systems from multiple clusters, the node itself may only be added to a single cluster through either the **mmcrcluster** command or the **mmaddnode** command.
- The default quorum type is node quorum. To enable node quorum with tiebreaker disks, you must issue the **mmchconfig** command.
- The node must be available for the command to be successful. If any of the nodes listed are not available when the command is issued, a message listing those nodes is displayed. You must correct the problem on each node, create a new input file containing the failed nodes only, and issue the **mmaddnode** command to add those nodes.

GPFS cluster configuration servers

You must designate one of the nodes in your GPFS cluster as the primary GPFS cluster configuration server, where GPFS configuration information is maintained. It is strongly suggested that you also specify a secondary GPFS cluster configuration server.

Attention: If your primary server fails and you have not designated a secondary server, the GPFS cluster configuration data files are inaccessible and any GPFS administration commands that are issued, fail. Similarly, when the GPFS daemon starts up, at least one of the two GPFS cluster configuration servers must be accessible. See "Cluster configuration data files" on page 87.

Private IP addresses

GPFS uses private IP addresses among cluster nodes that are connected with communications adapters. To define private IP addresses, use the **subnets** operand of the **mmchconfig** command. For more information and an example, see *Using remote access with public and private IP addresses* in *General Parallel File System: Advanced Administration*.

Note: Standard private IP addresses are located on these subnets:

- 10.0.0.0
- 172.16.0.0
- 192.168.0.0

Remote shell command

The default remote shell command is **rsh**. This requires that a properly configured **.rhosts** file exist in the root user's home directory on each node in the GPFS cluster.

If you choose to designate the use of a different remote shell command on either the **mmcrcluster** or the **mmchcluster** command, you must specify the fully qualified pathname for the program to be used by GPFS. You must also ensure:

1. Proper authorization is granted to all nodes in the GPFS cluster.
2. The nodes in the GPFS cluster can communicate without the use of a password.

The remote shell command must adhere to the same syntax as **rsh** but may implement an alternate authentication mechanism.

Remote file copy command

The default remote file copy program is **rcp**. This requires that a properly configured **.rhosts** file exist in the root user's home directory on each node in the GPFS cluster.

If you choose to designate the use of a different remote file copy command on either the **mmcrcluster** or the **mmchcluster** command, you must specify the fully-qualified pathname for the program to be used by GPFS. You must also ensure:

1. Proper authorization is granted to all nodes in the GPFS cluster.
2. The nodes in the GPFS cluster can communicate without the use of a password.

The remote copy command must adhere to the same syntax as **rcp** but may implement an alternate authentication mechanism.

Cluster name

Provide a name for the cluster by issuing the **-C** option on the **mmcrcluster** command. If the user-provided name contains dots, it is assumed to be a fully qualified domain name. Otherwise, to make the cluster name unique in a multiple cluster environment, GPFS appends the domain name of the primary cluster configuration server. If the **-C** option is not specified, the cluster name defaults to the hostname of the primary cluster configuration server. The name of the cluster may be changed at a later time by issuing the **-C** option on the **mmchcluster** command.

The cluster name is applicable when GPFS file systems are mounted by nodes belonging to other GPFS clusters. See the **mmauth** and the **mmremotecluster** commands.

User ID domain for the cluster

The user ID domain for a cluster when accessing a file system remotely. This option is further explained in the *GPFS: Advanced Administration Guide* and the white paper entitled *UID Mapping for GPFS in a Multi-Cluster Environment* at www.ibm.com/servers/eserver/clusters/library/wp_aix_lit.html

Starting GPFS automatically

Specify whether to start GPFS automatically on all nodes in the cluster whenever they come up with the **autoload** attribute. The default is for GPFS to *not* automatically start GPFS on all nodes. You may change this by specifying the **autoload=yes** on the **mmchconfig** command. This eliminates the need to start GPFS by issuing the **mmstartup** command when a node comes back up.

Cluster configuration file

GPFS provides you with default configuration options that may generically apply to most systems. You may:

- Accept the system defaults at cluster creation time and tune your system after the cluster is created by issuing the **mmchconfig** command (see Chapter 7, "Configuring and tuning your system for GPFS," on page 61). This is the suggested method.
- Experienced users may use a customized cluster configuration file on the **mmcrcluster** command. For detailed information, please see the *GPFS: Administration and Programming Reference*.

Managing distributed tokens

GPFS implements distributed locking using token-based lock management. In GPFS, the **distributedTokenServer** option of the **mmchconfig** command allows you to distribute the token server workload over multiple token manager nodes in a cluster. Distributing token management among file system manager nodes reduces system delays associated with a lockable object waiting to obtaining a token.

When the file system is initially mounted with **distributedTokenServer** in the default state (**yes**), the file system manager is the only token server. However, when the number of external mounts reaches a threshold, the file system manager appoints additional manager nodes as token servers. You can disable the distributed token manager feature by setting **distributedTokenServer** to **no**. If set to **no**, the file system manager continues to act as the only token server no matter how many nodes mount the file system.

Notes:

1. The total number of token manager nodes depends on the number of manager nodes you defined in the cluster.
2. If you only designated one node as a manager node, you can only have one token server regardless of the **distributedTokenServer** setting.
3. Once the token state has been distributed, it remains distributed until all external mounts have gone away.
4. The **maxFilesToCache** and **maxStatCache** parameters are indirectly affected by multiple token manager nodes as distributing tokens across multiple nodes could allow more tokens than if you only had one token server.
5. Refer to the *General Parallel File System: Advanced Administration Guide* for details on distributed token managers.

Disk considerations

Proper planning for your GPFS installation includes:

- Ensuring you have sufficient disks to meet the expected I/O load. In GPFS terminology, a disk may be a physical disk or a RAID device. With GPFS 2.3 or later, you may have up to 268 million disks in the file system. However, to achieve this maximum limit, you must recompile GPFS.

  Notes:

  1. The actual number of disks in your system may be constrained by products other than the version of GPFS installed on your system.

2. With file systems created with GPFS 2.3 or later, the theoretical limit on the maximum number of disks in a file system has been increased from 4096 to approximately 268 million. However, the actual limit enforced by the current version of GPFS is 2048. It can be increased if necessary (please contact IBM to discuss increasing the limit).

- Ensuring you have sufficient free disk space.

  If your system contains AIX nodes with NSDs created on existing virtual shared disks, sufficient free disk space needs to be kept in **/var** for the correct operation of the IBM Recoverable Virtual Shared Disk component. While GPFS does not use large amounts of **/var**, this component requires several megabytes to correctly support GPFS recovery. Failure to supply this space on all nodes may appear as a hang in your GPFS file system when recovering failed nodes.
- Ensuring you have sufficient connectivity (adapters and buses) between disks and network shared disk servers.
- Deciding how your disks will be connected. Supported types of disk connectivity include:
  1. All disks are SAN-attached to all nodes in all clusters which access the file.

     In this configuration, every node sees the same disk simultaneously and has a corresponding disk device entry in **/dev**.
  2. Each disk is connected to a single primary NSD server node and, if specified, a single backup NSD server node.

     In this configuration, a single node with connectivity to a disk performs data shipping to all other nodes. This node is called a primary NSD server. Additionally, it is suggested that you define a backup NSD server to guard against the loss of the primary disk server. When using a backup NSD server, both primary and backup disk servers must have connectivity to the same disks. Note that in this configuration, all other nodes will receive their data over the local area network from the primary and, if specified, backup NSD server.
  3. A combination of SAN-attached and an NSD server configuration.

  Configuration consideration:

  – If the node has a physical or virtual attachment to the disk and that connection fails, the node switches to utilizing any specified NSD server to perform I/O. For this reason it is suggested that NSDs be defined with primary and backup servers, even if all nodes have physical attachments to the disk.

  – Configuring GPFS disks without an NSD server stops the serving of data when the direct path to the disk is lost. This may be a preferable option for nodes requiring a higher speed data connection provided through a SAN as opposed to a lower speed network NSD server connection. Parallel jobs using MPI often have this characteristic.

  – The **-o useNSDserver** file system mount option on the **mmmount**, **mount**, **mmchfs**, and **mmremotefs** commands can be used to specify the disk discovery, and limit or eliminate switching from local access to NSD server access, or the other way around.
- Deciding if you will use storage pools to manage your disks.

  Storage pools allow you to manage your file system's storage in groups. You may now partition your storage based on such factors as performance, locality, and reliability. Files are assigned to a storage pool based on defined policies.

  Policies provide for:

  – Placing files in a specific storage pool when the files are created

  – Migrating files from one storage pool to another

  – File deletion based on file characteristics

  See the *GPFS: Advanced Administration Guide*.

Disk considerations include:

1. "NSD creation considerations" on page 27
2. "NSD server considerations" on page 29

3. “File system descriptor quorum” on page 30

NSD creation considerations

You must prepare each physical disk you intend to use with GPFS as an NSD through the **mmcrnsd** command. NSDs may be created on:

- Physical disks
  - An hdisk or vpath on AIX
  - A block disk device or a disk partition on Linux
- Virtual shared disks:
  - An RSCT peer domain virtual shared disk, see *Reliable Scalable Cluster Technology: Managing Shared Disks*

Note: When you are using the High Performance Switch (HPS) in your configuration it is suggested you process your disks in two steps:

1. Create virtual shared disks on each physical disk through the **mmcrvsd** command.
2. Using the rewritten disk descriptors from the **mmcrvsd** command, create NSDs through the **mmcrnsd** command.

The **mmcrnsd** command expects as input a file, *DescFile*, containing a disk descriptor, one per line, for each of the disks to be processed. Disk descriptors have the format:

```
DiskName:PrimaryServer:BackupServer:DiskUsage:FailureGroup:DesiredName:StoragePool
```

DiskName

The block device name appearing in **/dev** for the disk you want to define as an NSD. Examples of disks accessible through a block device are SAN-attached disks or virtual shared disks. If a *PrimaryServer* node is specified, *DiskName* must be the **/dev** name for the disk device on the primary NSD server node. See the Frequently Asked Questions at publib.boulder.ibm.com/ infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/ gpfs_faqs/gpfsclustersfaq.html for the latest supported disk types.

In the AIX environment, GPFS provides the **mmcrvsd** command to ease configuration of virtual shared disks. This command allows you to configure a virtual shared disk and make it accessible to nodes connected over a High Performance Switch. In addition, you can use the output disk descriptor file from the **mmcrvsd** command as input to the **mmcrnsd** command.

Note: The virtual shared disk names listed in output disk descriptor file appear as **/dev** block devices on switch attached nodes.

PrimaryServer

The name of the primary NSD server node.

If this field is omitted, the disk is assumed to be SAN-attached to all nodes in the cluster. If not all nodes in the cluster have access to the disk, or if the file system to which the disk belongs is to be accessed by other GPFS clusters, *PrimaryServer* must be specified.

BackupServer

The name of the backup NSD server node.

If the *PrimaryServer* has been specified and this field is omitted, it is assumed you do not want failover in the event that the *PrimaryServer* fails. If *BackupServer* is specified and the *PrimaryServer* has not been specified, the command fails.

The hostname or IP address must refer to the communications adapter over which the GPFS daemons communicate. Alias interfaces are not allowed. Use the original address or a name that is resolved by the **host** command to that original address. You may specify a node using any of these forms:

Format	Example
Short hostname	h125n01
Long hostname	h125n01.frn.ibm.com
IP address	8.112.11.113

DiskUsage

Specify a disk usage or accept the default. This field is ignored by the **mmcrnsd** command, and is passed unchanged to the output descriptor file produced by the **mmcrnsd** command. Possible values are:

- **dataAndMetadata** Indicates that the disk contains both data and metadata. This is the default.
- **dataOnly** Indicates that the disk contains data and does not contain metadata.
- **metadataOnly** Indicates that the disk contains metadata and does not contain data.
- **descOnly** Indicates that the disk contains no data and no metadata. Such a disk is used solely to keep a copy of the file system descriptor, and can be used as a third failure group in certain disaster recovery configurations.

FailureGroup

A number identifying the failure group to which this disk belongs. You can specify any value from -1 (where -1 indicates that the disk has no point of failure in common with any other disk) to 4000. If you do not specify a failure group, the value defaults to the NSD primary server node number plus 4000. If an NSD server node is not specified, the value defaults to -1. GPFS uses this information during data and metadata placement to assure that no two replicas of the same block are written in such a way as to become unavailable due to a single failure. All disks that are attached to the same NSD server or adapter should be placed in the same failure group.

This field is ignored and passed unchanged to the output descriptor file written by either the **mmcrvsd** command or the **mmcrnsd** command.

DesiredName

Specify the name you desire for the NSD to be created. This name must not already be used as another GPFS disk name, and it must not begin with the reserved string 'gpfs'.

Note: This name can contain only the characters: 'A' through 'Z', 'a' through 'z', '0' through '9', or '_' (the underscore). All other characters are not valid.

If a desired name is not specified, the NSD is assigned a name according to the convention:

gpfs*NN***nsd** where *NN* is a unique nonnegative integer not used in any prior NSD.

StoragePool

Specifies the name of the storage pool that the NSD is assigned to. Storage pool names:

- Must be unique within a file system, but not across file systems
- Should not be larger than 255 alphanumeric characters
- Are case sensitive
  - MYpool and myPool are distinct storage pools

If this name is not provided, the default is **system**. Only the **system** pool may contain **metadataOnly**, **dataAndMetadata**, or **descOnly** disks.

Upon successful completion of the **mmcrnsd** command the disk descriptors in the input file are rewritten:

- The original descriptor line is copied and commented out.
- The physical device name is replaced with the assigned unique global name.
- The primary and backup server names are omitted.
- The *DiskUsage*, *FailureGroup*, and *StoragePool* fields, when provided by the user, are not changed. If the those values are not provided, the appropriate default values are inserted.

The rewritten disk descriptor file, *DescFile*, can then be used as input to the **mmcrfs**, **mmadddisk**, or the **mmrpldisk** commands. The *Disk Usage* and *FailureGroup* specifications in the disk descriptor are only preserved in the *DescFile* file rewritten by the **mmcrnsd** command. If you do not use this file, you must accept the default values or specify these values when creating disk descriptors for subsequent **mmcrfs**, **mmadddisk**, or **mmrpldisk** commands.

If necessary, the primary and backup NSD server nodes associated with an existing NSD can be changed later with the **mmchnsd** command. Similarly the *DiskUsage* and *FailureGroup* values for a disk can be changed with the **mmchdisk** command. *StoragePools* can be changed by deleting a disk and adding it back in with the changed pool name. The global NSD name cannot be changed.

Table 3 details the use of disk descriptor information by the GPFS disk commands:

Table 3. Disk descriptor usage for the GPFS disk commands

	mmcrnsd	mmcrvsd	mmchnsd	mmchdisk	mmcrfs	default value
"Disk name" on page 27	X	X	X	X	X	none
"Primary server" on page 27	X	X	X			none
"Backup server" on page 27	X	X	X			none
"Disk usage" on page 28	X	X		X	X	dataAndMetadata
"Failure group" on page 28	X	X		X	X	-1 for disks directly attached to all nodes in the cluster Otherwise, the primary NSD server node number plus 4000
"Desired name" on page 28	X	X				**gpfs***NN***nsd** where *NN* is a unique nonnegative integer not used in any prior NSD.
"Storage pool" on page 28	X	X			X	system

Notes:

1. X – indicates the option is processed by the command
2. an empty cell – indicates the option is not processed by the command

NSD server considerations

If you plan on using NSD servers to remotely serve disk data to other nodes, as opposed to having disks SAN-attached to all nodes, you should consider the total computing and I/O load on these nodes:

- Will your Network Shared Disk servers be dedicated servers or will you also be using them to run applications? If you will have non-dedicated servers, consider running less time-critical applications on these nodes. If you run time-critical applications on a Network Shared Disk server, servicing disk requests from other nodes might conflict with the demands of these applications.
- The special functions of the file system manager consume extra processing time. If possible, avoid using a Network Shared Disk server as the file system manager. The Network Shared Disk server

consumes both memory and processor cycles that could impact the operation of the file system manager. See “The file system manager” on page 73.

- The actual processing capability required for Network Shared Disk service is a function of the application I/O access patterns, the type of node, the type of disk, and the disk connection. You can later run **iostat** on the server to determine how much of a load your access pattern will place on a Network Shared Disk server.
- Providing sufficient disks and adapters on the system to yield the required I/O bandwidth. Dedicated Network Shared Disk servers should have sufficient disks and adapters to drive the I/O load you expect them to handle.
- Knowing approximately how much storage capacity you will need for your data.

You should consider what you want as the default behavior for switching between local access and NSD server access in the event of a failure. To set this configuration, use the **-o useNSDserver** file system mount option of the **mmmount**, **mount**, **mmchfs**, and **mmremotefs** commands to:

- Specify the disk discovery behavior
- Limit or eliminate switching from either:
  - Local access to NSD server access
  - NSD server access to local access

You should consider specifying how long to wait for an NSD server to come online before allowing a file system mount to fail because the server is not available. The **mmchconfig** command has these options:

nsdServerWaitTimeForMount
: When a node is trying to mount a file system whose disks depend on NSD servers, this option specifies the number of seconds to wait for those servers to come up. If a server recovery is taking place, the wait time you are specifying with this option starts after recovery completes.

  Note: The decision to wait for servers is controlled by the **nsdServerWaitTimeWindowOnMount** option.

nsdServerWaitTimeWindowOnMount
: Specifies a window of time (in seconds) during which a mount can wait for NSD servers as described for the **nsdServerWaitTimeForMount** option. The window begins when quorum is established (at cluster startup or subsequently), or at the last known failure times of the NSD servers required to perform the mount.

  Notes:

  1. When a node rejoins a cluster, it resets all the failure times it knew about within that cluster.
  2. Because a node that rejoins a cluster resets its failure times within that cluster, the NSD server failure times are also reset.
  3. When a node attempts to mount a file system, the GPFS code checks the cluster formation criteria first. If that check falls outside the window, it will then check for NSD server fail times being in the window.

File system descriptor quorum

There is a structure in GPFS called the *file system descriptor* that is initially written to every disk in the file system, but is replicated on a subset of the disks as changes to the file system occur, such as adding or deleting disks. Based on the number of failure groups and disks, GPFS creates between one and five replicas of the descriptor:

- If there are at least five different failure groups, five replicas are created.
- If there are at least three different disks, three replicas are created.
- If there are only one or two disks, a replica is created on each disk.

Once it is decided how many replicas to create, GPFS picks disks to hold the replicas, so that all replicas will be in different failure groups, if possible, to reduce the risk of multiple failures. In picking replica locations, the current state of the disks is taken into account. Stopped or suspended disks are avoided. Similarly, when a failed disk is brought back online, GPFS may modify the subset to rebalance the file system descriptors across the failure groups. The subset can be found by issuing the**mmlsdisk -L** command.

GPFS requires a majority of the replicas on the subset of disks to remain available to sustain file system operations:

- If there are at least five different failure groups, GPFS will be able to tolerate a loss of two of the five groups. If disks out of three different failure groups are lost, the file system descriptor may become inaccessible due to the loss of the majority of the replicas.
- If there are at least three different failure groups, GPFS will be able to tolerate a loss of one of the three groups. If disks out of two different failure groups are lost, the file system descriptor may become inaccessible due to the loss of the majority of the replicas.
- If there are fewer than three failure groups, a loss of one failure group may make the descriptor inaccessible.

  If the subset consists of three disks and there are only two failure groups, one failure group must have two disks and the other failure group has one. In a scenario that causes one entire failure group to disappear all at once, if the half of the disks that are unavailable contain the single disk that is part of the subset, everything stays up. The file system descriptor is moved to a new subset by updating the remaining two copies and writing the update to a new disk added to the subset. But if the downed failure group contains a majority of the subset, the file system descriptor cannot be updated and the file system has to be force unmounted.

  Introducing a third failure group consisting of a single disk that is used solely for the purpose of maintaining a copy of the file system descriptor can help prevent such a scenario. You can designate this disk by using the **descOnly** designation for disk usage on the disk descriptor. With the **descOnly** designation, the disk does not hold any of the other file system data or metadata and can be as small as 4 MB. See *NSD creation considerations* in *GPFS: Concepts, Planning, and Installation Guide* and *Establishing disaster recovery for your GPFS cluster* in *GPFS: Advanced Administration Guide*.

File system creation considerations

File system creation involves anticipating usage within the file system and considering your hardware configurations. Before creating a file system, consider how much data will be stored and how great the demand for the files in the system will be. Each of these factors can help you to determine how much disk resource to devote to the file system, which block size to choose, where to store data and metadata, and how many replicas to maintain. For the latest supported file system size, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Your GPFS file system is created by issuing the **mmcrfs** command. Table 4 details the file system creation options specified on the **mmcrfs** command, which options can be changed later with the **mmchfs** command, and what the default values are.

To move an existing file system into a new GPFS cluster, see *Exporting file system definitions between clusters* in the *GPFS: Administration and Programming Reference*.

Table 4. File system creation options

	mmcrfs	mmchfs	default value
Mountpoint directory of the file system	X	Use the **-T** option.	none
Device name of the file system	X	X	none

Table 4. File system creation options (continued)

	mmcrfs	mmchfs	default value
-D {**nfs4** | **posix**} semantics for a 'deny-write open lock'	X	X	**posix**
-F *DiskDesc* for each disk in your file system	X	Issue the **mmadddisk** and **mmdeldisk** commands respectively to add or delete disks from the file system	none
-A {**yes** | **no** | **automount**} when to mount the file system	X	X	yes
-B *BlockSize* **16K**, **64K**, **256K**, **512K**, **1024K**, or **1M** data block size	X	this value cannot be changed without recreating the file system	**256K**
-E {**yes** | **no**} to report exact mtime values	X	X	yes
-k {**posix** | **nfs4** |**all**} authorization types supported by the file system	X	X	**posix**
-m *DefaultMetadataReplicas*	X	X	1
- M *MaxMetadataReplicas*	X	this value cannot be changed	1
-N *NumInodes* determine the maximum number of files in the file system	X	Use the **-F** option.	file system size/1 MB
-n *NumNodes* that will mount the file system	X	this value cannot be changed after the file system has been created	32
-o *MountOptions* to be passed to the **mount** command		X	none
-Q {**yes** | **no** } to activate quota	X	X	no
-r *DefaultDataReplicas*	X	X	1
-R*MaxDataReplicas*	X	this value cannot be changed	1
-S {**yes** | **no**} to suppress periodic updating of atime values	X	X	no
-V to migrate file system format to latest level		X	none
-v {**yes** | **no**} to verify disk usage	X		yes
-W *NewDeviceName* to assign a new device name to the file system		X	none
-z **yes** | **no** to enable DMAPI	X	X	no

Notes:

1. X – indicates the option is available on the command
2. an empty cell – indicates the option is not available on the command

Mountpoint directory

GPFS does not have a default mountpoint directory for the file system. You must specify the directory when creating a file system. Creating filesets is part of the process of laying out the namespace for the file system. While filesets can be created at any time, partitioning an existing file system into filesets or reorganizing the fileset structure of a file system can be time-consuming. Since filesets have quota and policy implications, it is useful to give some thought to filesets when establishing the hierarchy of a new file system.

Filesets can be used for any reasonably independent subtree of the file system such as the home directories belonging to a user, project trees, and installation directories for large applications. Generally, subtrees with characteristic uses or purposes can be beneficially assigned to filesets so that policy statements can be concisely applied to them. When sharing a pool of storage between various uses that are aligned by hierarchy, rather than by user or group, the fileset quota can be useful; user and project directories are a common example of this situation.

Note: When using the **mmchfs** command, the **-T** option can be used to change the file system mountpoint.

Device name of the file system

File system names must be unique within a GPFS clusters. However, two different clusters can have two distinct file systems with the same name. The device name of the file system does not need to be fully qualified. **fs0** is as acceptable as **/dev/fs0**. Do not specify an existing entry in **/dev**.

NFS V4 'deny-write open lock'

Specify whether a 'deny-write open lock' blocks writes, which is expected and required by NFS V4. See *Managing GPFS access control lists and NFS export* in the *GPFS: Administration and Programming Reference*

nfs4 Must be specified for file systems supporting NFS V4.

posix Specified for file systems supporting NFS V3 or ones which are not NFS exported. This is the default.

posix allows NFS writes even in the presence of a **deny-write** open lock.

Disks for your file system

Prior to issuing the **mmcrfs** command you must decide if you will:

1. Create new disks through the **mmcrnsd** command.
2. Select NSDs no longer in use by another GPFS file system. Issue the **mmlsnsd -F** command to display the available disks.

See "Disk considerations" on page 25.

Deciding how the file system is mounted

Specify when the file system is to be mounted:

yes When the GPFS daemon starts. This is the default.

no Manual mount.

automount When the file system is first accessed.

This can be changed at a later time by using the **-A** option on the **mmchfs** command.

Considerations:

1. GPFS mount traffic may be lessened by using the automount feature to mount the file system when it is first accessed instead of at GPFS startup. Automatic mounts only produce additional control traffic at the point that the file system is first used by an application or user. Mounts at GPFS startup on the other hand produce additional control traffic at every GPFS startup. Thus startup of hundreds of nodes at once may be better served by using automatic mounts.
2. Automatic mounts will fail if the node does not have the operating systems automount support enabled for the file system.
3. When exporting file systems for NFS mounts, it may be useful to mount the file system when GPFS starts.

Block size

The size of data blocks in a file system may be specified at file system creation by using the **-B** option on the **mmcrfs** command or allowed to default to 256 KB. This value *cannot* be changed without recreating the file system.

GPFS offers five block sizes for file systems: 16 KB, 64 KB, 256 KB, 512 KB, and 1024 KB or 1 MB. This value should be specified with the character **K** or **M** as appropriate. For example `512K`. You should choose the block size based on the application set that you plan to support and if you are using RAID hardware:

- The 256 KB block size is the default block size and normally is the best block size for file systems that contain large files accessed in large reads and writes.
- The 16 KB block size optimizes use of disk storage at the expense of large data transfers.
- The 64 KB block size offers a compromise if there are a mix of many files of approximately 64K or less in size. It makes more efficient use of disk space than 256 KB while allowing faster I/O operations than 16 KB.
- The 1024 KB or 1 MB block sizes are more efficient if the dominant I/O pattern is sequential access to large files (1 MB or more).

  If you plan to use RAID devices in your file system, a larger block size may be more effective and help avoid the penalties involved in small block write operations to RAID devices. For example, in a RAID configuration utilizing 4 data disks and 1 parity disk (a 4+P configuration), which utilizes a 64 KB stripe size, the optimal file system block size would be an integral multiple of 256 KB (4 data disks $\times$ 64 KB stripe size = 256 KB). A block size of an integral multiple of 256 KB results in a single data **write** that encompasses the 4 data disks and a parity-write to the parity disk. If a block size smaller than 256 KB, such as 64 KB, is used, **write** performance is degraded by the read-modify-write behavior. A 64 KB block size results in a single disk writing 64 KB and a subsequent **read** from the three remaining disks in order to compute the parity that is then written to the parity disk. The extra **read** degrades performance.

  The choice of block size also affects the performance of certain metadata operations, in particular, block allocation performance. GPFS block allocation map is stored in blocks, similar to regular files. When block size is small:

  – It takes more blocks to store a given amount of data resulting in additional work to allocate those blocks

  – One block of allocation map data contains less information

  Note: The choice of block size is particularly important for large file systems. For file systems larger than 100 TB, you should use a block size of at least 256 KB.

Fragments and subblocks

GPFS divides each block into 32 *subblocks*. Files smaller than one block size are stored in *fragments*, which are made up of one or more subblocks. Large files are stored in a number of full blocks plus zero or more subblocks to hold the data at the end of the file.

The block size is the largest contiguous amount of disk space allocated to a file and therefore the largest amount of data that can be accessed in a single I/O operation. The subblock is the smallest unit of disk space that can be allocated. For a block size of 256 KB, GPFS reads as much as 256 KB of data in a single I/O operation and small files can occupy as little as 8 KB of disk space. With a block size of 16 KB, small files occupy as little as 512 bytes of disk space (not counting the inode), but GPFS is unable to read more than 16 KB in a single I/O operation.

atime values

atime represents the time when the file was last accessed. The **-S** parameter controls the updating of the **atime** value. The default is **-S no**, which results in updating **atime** locally in memory whenever a file is read, but the value is not visible to other nodes until after the file is closed. If an accurate **atime** is needed,

the application must use the GPFS calls **gpfs_stat()** and **gpfs_fstat()**. When **-S yes** is specified, or the file system is mounted **read-only**, the updating of the **atime** value is suppressed. See “Exceptions to Open Group technical standards” on page 95.

mtime values

mtime represents the time when the file was last modified. The **-E** parameter controls the frequency of updating of the **mtime** value. The default is **-E yes**, which results in the **stat()** and **fstat()** calls reporting exact **mtime** values. Specifying **-E no** results in the **stat()** and **fstat()** calls reporting the **mtime** value available at the completion of the last sync period. This may result in the calls not always reporting the exact **mtime** value. Note that regardless of the **-E** setting, the GPFS calls **gpfs_stat()** and **gpfs_fstat()** always report the exact mtime. See “Exceptions to Open Group technical standards” on page 95.

File system authorization

The type of authorization for the file system is specified on the **-k** option on the **mmcrfs** command or changed at a later time by using the **-k** option on the **mmchfs** command:

posix Traditional GPFS access control lists (ACLs) only (NFS V4 ACLs are not allowed).

nfs4 Support for NFS V4 ACLs only. Users are not allowed to assign traditional ACLs to any file system objects. This should not be specified unless the file system is going to be exported to NFS V4 clients.

all Allows for the coexistence of POSIX and NFS V4 ACLs within a file system. This should not be specified unless at least one file within the file system is going to be exported to NFS V4 clients.

File system recoverability parameters

The metadata (inodes, directories, and indirect blocks) and data replication parameters are set at the file system level and apply to all files. They are initially set for the file system when issuing the **mmcrfs** command. They can be changed for an existing file system using the **mmchfs** command, but modifications only apply to files subsequently created. To apply the new replication values to existing files in a file system, issue the **mmrestripefs** command.

Metadata and data replication are specified independently. Each has a default replication factor of 1 (no replication) and a maximum replication factor. Although replication of metadata is less costly in terms of disk space than replication of file data, excessive replication of metadata also affects GPFS efficiency because all metadata replicas must be written. In general, more replication uses more space. When considering data replication for files accessible to Tivoli® SANergy, see SANergy export considerations in *General Parallel File System: Advanced Administration Guide*.

Default metadata Replicas

The default number of copies of metadata for all files in the file system may be specified at file system creation by using the **-m** option on the **mmcrfs** command or changed at a later time by using the **-m** option on the **mmchfs** command. This value must be equal to or less than *MaxMetadataReplicas*, and cannot exceed the number of failure groups with disks that can store metadata. The allowable values are 1 or 2, with a default of 1.

Maximum metadata replicas

The maximum number of copies of metadata for all files in the file system may be specified at file system creation by using the **-M** option on the **mmcrfs** command or allowed to default to 1. The allowable values are 1 or 2, but it cannot be lower than *DefaultMetadataReplicas*. This value cannot be changed.

Default data replicas

The default replication factor for data blocks may be specified at file system creation by using the **-r** option on the **mmcrfs** command or changed at a later time by using the **-r** option on the **mmchfs** command. This value must be equal to or less than *MaxDataReplicas*, and the value cannot exceed the number of failure groups with disks that can store data. The allowable values are 1 and 2, with a default of 1.

If you want to change the data replication factor for the entire file system, the data disk in each storage pool must have a failure group that is equal to or greater than the replication factor. For example, you will get a failure with error messages if you try to change the replication factor for a file system to 2 but the storage pool only has one failure group.

This is an example of a successful update to the data replication factor:

```
mmlsdisk fs2
disk         driver   sector failure holds    holds storage
name         type     size   group   metadata data  status        availability pool
------------ -------- ------ ------- -------- ----- ------------- ------------ ------------
gpfs1005nsd  nsd      512    2       no       yes   ready         up           sp4
gpfs2nsd     nsd      512    2       no       yes   ready         up           sp3
gpfs1004nsd  nsd      512    4001    yes      yes   ready         up           system
gpfs1006nsd  nsd      512    4001    no       yes   ready         up           sp3
gpfs1007nsd  nsd      512    4001    no       yes   ready         up           sp4
gpfs1008nsd  nsd      512    2       yes      yes   ready         up           system
gpfs3nsd     nsd      512    3       no       yes   ready         up           sp1
gpfs1002nsd  nsd      512    4001    no       yes   ready         up           sp1
GPFS: 6027-741 Attention: Due to an earlier configuration change the file system
may contain data that is at risk of being lost.
mmchfs fs2 -r 2
mmlsfs fs2 -r
flag value          description
---- -------------- -----------------------------------------------------
-r 2 Default        number of data replicas
```

Maximum data replicas

The maximum number of copies of data blocks for a file may be specified at file system creation by using the **-R** option on the **mmcrfs** command or allowed to default to 1. The allowable values are 1 and 2, but cannot be lower than *DefaultDataReplicas*. This value cannot be changed.

Number of nodes mounting the file system

The estimated number of nodes that will mount the file system may be specified at file system creation by using the **-n** option on the **mmcrfs** command or allowed to default to 32.

When creating a GPFS file system, over estimate the number of nodes that will mount the file system. This input is used in the creation of GPFS data structures that are essential for achieving the maximum degree of parallelism in file system operations (see Appendix A, “GPFS architecture,” on page 73). Although a larger estimate consumes a bit more memory, insufficient allocation of these data structures can limit node ability to process certain parallel requests efficiently, such as the allotment of disk space to a file. If you cannot predict the number of nodes, allow the default value to be applied. Specify a larger number if you expect to add nodes, but avoid wildly overestimating as this can affect buffer operations.

Note: *This value cannot be changed later.*

Maximum number of files

The maximum number of files in a file system may be specified at file system creation by using the **-N** option on the **mmcrfs** command or changed at a later time by using the **-F** option on the **mmchfs** command. This value defaults to the size of the file system at creation divided by 1 MB and cannot exceed the architectural limit of 2,147,483,647.

These options limit the maximum number of files that may actively exist within the file system. However, the maximum number of files in the file system may be restricted by GPFS so the control structures associated with each file do not consume all of the file system space.

Notes:

1. For file systems that will be doing parallel file creates, if the total number of free inodes is not greater than 5% of the total number of inodes there is the potential for slowdown in file system access. Take this into consideration when creating or changing your file system. Use the **mmdf** command to display the number of free inodes.
2. Excessively increasing the value for the maximum number of files will cause the allocation of too much disk space for control structures.

Assign mount command options

Options may be passed to the file system **mount** command using the **-o** option on the **mmchfs** command.

Automatic quota activation

Whether or not to automatically activate quotas when the file system is mounted may be specified at file system creation by using the **-Q** option on the **mmcrfs** command or changed at a later time by using the **-Q** option on the **mmchfs** command. After the file system has been mounted, quota values are established by issuing the **mmedquota** command and activated by issuing the **mmquotaon** command. The default is to *not* have quotas activated.

The GPFS quota system helps you control the allocation of files and data blocks in a file system. GPFS quotas can be defined for individual users, groups of users, or filesets. Quotas should be installed by the system administrator if control over the amount of space used by the individual users, groups of users, or filesets is desired. When setting quota limits for a file system, the system administrator should consider the replication factors of the file system. GPFS quota management takes replication into account when reporting on and determining if quota limits have been exceeded for both block and file usage. In a file system that has either type of replication (data replication or metadata replication) set to a value of two, the values reported on by both the **mmlsquota** and the **mmrepquota** commands are double the value reported by the **ls** command.

GPFS quotas operate with three parameters that you can explicitly set using the **mmedquota** and **mmdefedquota** commands:

1. Soft limit
2. Hard limit
3. Grace period

The soft limits define levels of disk space and files below which the user, group of users, or fileset can safely operate. The hard limits define the maximum disk space and files the user, group of users, or fileset can accumulate. Specify hard and soft limits for disk space in units of kilobytes (k or K), megabytes (m or M), or gigabytes (g or G). If no suffix is provided, the number is assumed to be in bytes.

The grace period allows the user, group of users, or fileset to exceed the soft limit for a specified period of time (the default period is one week). If usage is not reduced to a level below the soft limit during that time, the quota system interprets the soft limit as the hard limit and no further allocation is allowed. The user, group of users, or fileset can reset this condition by reducing usage enough to fall below the soft limit.

Default quotas

Applying default quotas provides all new users of the file system, groups of users of the file system, or a fileset with established minimum quota limits. If default quota values are not enabled, a new user, a new group, or a new fileset has a quota value of zero, which establishes no limit to the amount of space that can be used.

Default quotas may be set for a file system only if the file system was created with the **-Q yes** option on the **mmcrfs** command, or updated with the **-Q** option on the **mmchfs** command. Default quotas may then be enabled for the file system by issuing the **mmdefquotaon** command. Default values are established by issuing the **mmdefedquota** command.

Quota system files

The GPFS quota system maintains three separate files that contain data about usage and limits. These files reside in the root directory of the GPFS file systems:

- **user.quota**
- **group.quota**
- **fileset.quota**

All three **.quota** files are:

- Built with the information provided in the **mmedquota** and **mmdefedquota** commands.
- Updated through normal allocation operations throughout the file system and when the **mmcheckquota** command is issued.
- Readable by the **mmlsquota** and **mmrepquota** commands.

The **.quota** files are read from the root directory when mounting a file system with quotas enabled. When these files are read, one of three possible actions take place:

- The files contain quota information and the user wants these files to be used.
- The files contain quota information, however, the user wants different files to be used.

  To specify the use of different files, the **mmcheckquota** command *must* be issued prior to the **mount** of the file system.
- The files do not contain quota information. In this case the **mount** fails and appropriate error messages are issued. See the *GPFS: Problem Determination Guide* for further information regarding **mount** failures.

Notes:

1. If these files are not available when mounting the file system, new quota files are created.
2. A fileset quota behaves the same way as a user or group quota.
3. The result of an online quota check may be incomplete when files are being accessed through SANergy at the time of the file system quota check. See *SANergy export considerations* in the *GPFS: Advanced Administration Guide*. To get an accurate online quota check result, rerun the **mmcheckquota** command when SANergy is not active.

Migrate file system format to latest level

Attention: Changing file system format causes the file system to become permanently incompatible with prior releases of GPFS.

GPFS Version 3.1 supports filesets and storage pools. When you migrate an existing GPFS file system to the latest version, the migration process automatically creates a "root" fileset and "system" storage pool.

Root filesets

During migration, all existing files and directories are assigned to the root fileset. After migration, you can:

- Create new filesets with **mmcrfileset**
- Link filesets into the namespace with **mmlinkfileset**
- Copy data into the filesets using ordinary file system tools such as **cp** or **tar**

Note: Upgrading a file system with quotas enabled will not enable fileset quota. This must be explicitly enabled using the **mmchfs -Q yes** command. That command will automatically create the **fileset.quota** file in the root directory of the file system.

System storage pools

During migration, all of the disks belonging to an existing file system are assigned to the system storage pool. When you add new disks, you can assign them to other storage pools. Adding new disks automatically creates the storage pool named in the disk description. To move a disk already belonging to the file system to a new storage pool use **mmdeldisk** followed by **mmadddisk**.

Notes:

1. After GPFS migration, you may need to change the file system format to the latest format supported by the currently installed level of GPFS. To change the file system format, use the **-V** option on the **mmchfs** command. Refer to File system format changes for additional information.
2. The migration process does not create an initial policy file. If you are going to use a policy file, you must create one and install it with the **mmchpolicy** command.

Disk usage verification

When you create your file system, you may check whether or not the disks you are specifying do not already belong to an existing file system by using the **-v** option on the **mmcrfs** command. The default is to verify disk usage. You should only specify **no** when you want to reuse disks that are no longer needed for an existing GPFS file system. To determine which disks are no longer in use by any file system, issue the **mmlsnsd -F** command.

Assign a new device name to the file system

The device name of a file system may be changed using the **-W** option on the **mmchfs** command.

Enable DMAPI

Whether or not the file system can be monitored and managed by the GPFS Data Management API (DMAPI) may be specified at file system creation by using the **-z** option on the **mmcrfs** command or changed at a later time by using the **-z** option on the **mmchfs** command. The default is *not* to enable DMAPI for the file system. For further information on DMAPI for GPFS, see the *GPFS: Data Management API Guide*.

A sample file system creation

To create a file system called **gpfs2** with the properties:

- the disks for the file system listed in the file **/tmp/gpfs2dsk**
- automatically mount the file system when the GPFS daemon starts (**-A yes**)
- a block size of 256 KB (**-B 256K**)
- mount it on 32 nodes (**-n 32**)
- both default replication and the maximum replication for metadata set to two (**-m 2 -M 2**)
- default replication for data set to one and the maximum replication for data set to two (**-r 1 -R 2**)

Enter:

```
mmcrfs /gpfs2 gpfs2 -F /tmp/gpfs2dsk -A yes -B 512K -n 24 -m 2 -M 2 -r 1 -R 2
```

The system displays information similar to:

```
The following disks of gpfs2 will be formatted on node k194p03.tes.nnn.com:
    hd25n09: size 17796014 KB
    hd24n09: size 17796014 KB
    hd23n09: size 17796014 KB
Formatting file system ...
Disks up to size 59 GB can be added to storage pool system.
Creating Inode File
  56 % complete on Mon Mar  6 15:10:08 2006
 100 % complete on Mon Mar  6 15:10:11 2006
Creating Allocation Maps
```

```
Clearing Inode Allocation Map
Clearing Block Allocation Map
  44 % complete on Mon Mar  6 15:11:32 2006
  90 % complete on Mon Mar  6 15:11:37 2006
 100 % complete on Mon Mar  6 15:11:38 2006
Completed creation of file system /dev/gpfs2.
mmcrfs: Propagating the cluster configuration data to all
  affected nodes.  This is an asynchronous process.
```

To confirm the file system configuration, issue the command:

```
mmlsfs gpfs2
```

The system displays information similar to:

```
flag value          description
---- -------------- ------------------------------------------------------
 -s  roundRobin     Stripe method
 -f  8192           Minimum fragment size in bytes
 -i  512            Inode size in bytes
 -I  32768          Indirect block size in bytes
 -m  2              Default number of metadata replicas
 -M  2              Maximum number of metadata replicas
 -r  1              Default number of data replicas
 -R  2              Maximum number of data replicas
 -j  scatter        Block allocation type
 -D  posix          File locking semantics in effect
 -k  posix          ACL semantics in effect
 -a  1048576        Estimated average file size
 -n  32             Estimated number of nodes that will mount file system
 -B  262144         Block size
 -Q  user;group;fileset Quotas enforced
     user;group     Default quotas enabled
 -F  2998272        Maximum number of inodes
 -V  9.03           File system version. Highest supported version: 9.03
 -u  yes            Support for large LUNs?
 -z  no             Is DMAPI enabled?
 -E  yes            Exact mtime mount option
 -S  yes            Suppress atime mount option
 -P  system;sp1     Disk storage pools in file system
 -d  gpfs33nsd;gpfs34nsd;gpfs35nsd Disks in file system
 -A  no             Automatic mount option
 -o  none           Additional mount options
 -T  /gpfs2         Default mount point
```

Part 2. Establishing GPFS on your system

Chapter 3. Steps to establishing and starting your GPFS cluster

Follow these steps to establish your GPFS cluster:

1. See the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for the latest recommendations on establishing a GPFS cluster.
2. Place the GPFS code on your system:
   - For existing systems, see Chapter 6, "Migration, coexistence and compatibility," on page 53.
   - For new systems:
     - For your Linux nodes, see Chapter 4, "Installing GPFS on Linux nodes," on page 45.
     - For your AIX nodes, see Chapter 5, "Installing GPFS on AIX 5L nodes," on page 49.
3. Decide which nodes in your system will be quorum nodes (see "Quorum" on page 16) .
4. Create your GPFS cluster by issuing the **mmcrcluster** command. See "GPFS cluster creation considerations" on page 21.

After your GPFS cluster has been established:

1. Ensure you have configured and tuned your system according to the values suggested in *Configuring and tuning your system for GPFS*.
2. Start GPFS by issuing the **mmstartup** command. See the *GPFS: Administration and Programming Reference*.
3. Create new disks for use in your file systems by issuing the **mmcrnsd** command. See "NSD creation considerations" on page 27.
4. Create new file systems by issuing the **mmcrfs** command. See "File system creation considerations" on page 31.
5. If any existing files systems have not already been moved to the new GPFS cluster, do so. For file systems created prior to GPFS version 2 release 3, see Chapter 6, "Migration, coexistence and compatibility," on page 53. For file systems already migrated to or created on a GPFS version 2 release 3 system, see the section on *Exporting file system definitions between clusters* in the *GPFS: Administration and Programming Reference*.
6. Mount your file systems.
7. As an optional step, you can also create a temporary directory (**/tmp/mmfs**) to collect problem determination data. If you decide to do so, the **/tmp/mmfs** directory should *not* be placed in a GPFS file system as it might not be available should GPFS fail. However, the **/tmp/mmfs** directory can be a symbolic link to another location if more space can be found there.

   If a problem should occur, GPFS may write 200 MB or more of problem determination data into **/tmp/mmfs**. These files must be manually removed when any problem determination is complete. This should be done promptly so that a **NOSPACE** condition is not encountered during the next failure. An alternate path may be specified through the **mmchconfig** command.

Chapter 4. Installing GPFS on Linux nodes

It is suggested you read Chapter 2, “Planning for GPFS,” on page 15 and the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Do not attempt to install GPFS if you do not have the prerequisites listed in “Hardware requirements” on page 15 and “Software requirements” on page 15.

Ensure that the **PATH** environment variable on each node includes **/usr/lpp/mmfs/bin**.

The installation process includes:

1. “Files to ease the installation process”
2. “Verifying the level of prerequisite software”
3. “Installation procedures”
4. “Building your GPFS portability layer” on page 48

Files to ease the installation process

To ease the installation process, it is suggested that you create a file listing all of the nodes in your GPFS cluster using either host names or IP addresses.

For example, create the file **/tmp/gpfs.allnodes**, listing the nodes one per line:

```
k145n01.dpd.ibm.com
k145n02.dpd.ibm.com
k145n03.dpd.ibm.com
k145n04.dpd.ibm.com
k145n05.dpd.ibm.com
k145n06.dpd.ibm.com
k145n07.dpd.ibm.com
k145n08.dpd.ibm.com
```

Verifying the level of prerequisite software

Before you install GPFS, it is necessary to verify you have the correct levels of the prerequisite software installed on each node in the cluster. If the correct level of prerequisite software is *not* installed, see the appropriate installation manual before proceeding with your GPFS installation.

See the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for the latest:

- Linux distributions
- RPM levels
- Software recommendations
- Configuration information

Installation procedures

Follow these steps in the specified order to install the GPFS software using the **rpm** command. This procedure installs GPFS on one node at a time:

1. “Setting the remote command environment” on page 46
2. “Electronic license agreement” on page 46
3. “Creating the GPFS directory” on page 46
4. “Installing the GPFS man pages” on page 47

5. “Installing GPFS over a network” on page 47
6. “Verifying the GPFS installation” on page 47

Setting the remote command environment

Configure your remote command environment to use either:

- **rsh** and **rcp**
  - This is the GPFS default
  - Are specified on the **mmcrcluster** command
- An alternative form of remote shell and remote copy commands. These commands:
  - Must adhere to the same syntax form as **rsh** and **rcp**
  - May implement alternate authentication mechanism
  - Must be specified on the **mmcrcluster** command

Regardless of whether you use rsh and rcp or alternative commands, you must make certain that:

- You grant proper authorization to all nodes in the GPFS cluster.
- The nodes in the GPFS cluster can communicate without the use of a password.

For additional information, refer to “GPFS cluster creation considerations” on page 21.

Electronic license agreement

The GPFS software license agreement is shipped and viewable electronically. The electronic license agreement must be accepted before software installation can continue. See “Creating the GPFS directory.”

Creating the GPFS directory

To create the GPFS directory:

1. On any node create a temporary subdirectory where GPFS installation images will be extracted. For example:

   ```
   mkdir  /tmp/gpfslpp
   ```

2. Copy the self-extracting product image, **gpfs_install-3.1***, from the CD-ROM to the new directory (where * is the correct version of the product for your hardware platform and Linux distribution).

   The image contains:

   - The GPFS product installation images
   - The License Acceptance Process (LAP) Tool

     The LAP Tool is invoked for acceptance of the GPFS license agreements. The license agreements must be accepted to obtain access to the GPFS product installation images.
   - A version of the Java™ Runtime Environment (JRE) necessary to run the LAP Tool
3. Verify that the self-extracting program has executable permissions.
4. Invoke the self extracting image that you copied from the CD-ROM and accept the license agreement:
   a. By default, the LAP Tool, JRE and GPFS installation images will be extracted to the target directory **/usr/lpp/mmfs/3.1*** .
   b. The license agreement files on the media may be viewed in either graphics or text-only modes.

      To view in graphics mode, simply invoke gpfs_install-3.1*. To view the license agreements in text only mode, use the **--text-only** option.
   c. Use the **--silent** option to accept the license agreements.
   d. Use the **--help** option to obtain usage information from the self extracting archive.

   ```
   gpfs_install-3.1.* --silent
   ```

5. Either copy or move the install images from the extraction target directory (default of **/usr/lpp/mmfs/3.1***) to the **/tmp/gpfslpp** directory. All subsequent install command examples expect the images to reside in the **/tmp/gpfslpp** directory.

Upon license agreement acceptance, the GPFS product installation images will reside in the extraction target directory. Copy these images to the **/tmp/gpfslpp** directory:

1. gpfs.base-3.1*.rpm
2. gpfs.gpl-3.1*.noarch.rpm
3. gpfs.msg.en_US-3.1*.noarch.rpm
4. gpfs.docs-3.1*.noarch.rpm

The License agreements will remain available in the extraction target directory under the **license** subdirectory for future access. The license files are written using operating system-specific code pages. Accordingly, you may view the license in English and the local language configured on your machine. The other languages are not guaranteed to be viewable.

Installing the GPFS man pages

In order to use the GPFS man pages the **gpfs.docs** RPM must be installed. Once you have installed the **gpfs.docs** RPM, the GPFS manual pages will be located at **/usr/share/man/**.

Note: The **gpfs.docs** RPM need not be installed on all nodes if man pages are not desired or local file space on the node is minimal.

Installing GPFS over a network

Install GPFS according to these directions, where *localNode* is the name of the node on which you are running:

1. If you are installing on a shared file system network, ensure the directory where the GPFS images can be found is NFS exported to all of the nodes planned for your GPFS cluster (**/tmp/gpfs.allnodes**).
2. Ensure an acceptable directory or mountpoint is available on each target node, such as **/tmp/gpfslpp**. If there is not, create one:

   ```
   cat /tmp/gpfs.allnodes | xargs -i rsh {} mkdir /tmp/gpfslpp
   ```
3. If you are installing on a shared file system network, to place the GPFS images on each node in your network, issue:

   ```
   cat /tmp/gpfs.allnodes | xargs -i rsh {} mount localNode:/tmp/gpfslpp /tmp/gpfslpp
   ```

   Otherwise, issue:

   ```
   cat /tmp/gpfs.allnodes | xargs -i rcp /tmp/gpfslpp/gpfs*.rpm {}:/tmp/gpfslpp
   ```
4. Install GPFS on each node:

   ```
   cat /tmp/gpfs.allnodes | xargs -i rsh {} rpm -Uvh /tmp/gpfslpp/gpfs*.rpm
   ```

Verifying the GPFS installation

Verify the installation of GPFS file sets on each system node to check that the software has been successfully installed:

```
rpm -qa | grep gpfs
```

The system should return output similar to:

```
gpfs.docs-3.1.0-0
gpfs.base-3.1.0-0
gpfs.msg.en_US-3.1.0-0
gpfs.gpl-3.1.0-0
```

Building your GPFS portability layer

Prior to starting GPFS, you must build the GPFS portability layer, which is a set of binaries that need to be built locally from source code to match your Linux kernel and configuration:

1. Before building the portability layer check for:
   - Updates to the portability layer at techsupport.services.ibm.com/server/cluster/fixes/gpfsfixhome.html.
   - The latest kernel level support in the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/ gpfsclustersfaq.html
   - Any applicable GPFS Linux Kernel Patches available at www.ibm.com/developerworks/oss/linux/patches/ under the project *General Parallel File System (GPFS) for Linux Kernel Patches*.
2. Build your GPFS portability layer in one of two ways:
   - Using the directions in **/usr/lpp/mmfs/src/README**
   - Using the Autoconfig tool described in "Using the automatic configuration tool to build GPFS portability layer."

Using the automatic configuration tool to build GPFS portability layer

To help you build the portability layer, GPFS provides an automatic configuration tool. This tool, named **configure** is a Perl script residing in **/usr/lpp/mmfs/src/config/configure** on installed GPFS systems. When you run the **configure** tool, it automatically examines the system and generates a working configuration file. GPFS will then use the configuration file as it creates the portability layer.

Note: You must manually invoke the **configure** tool.

While it is running, the **configure** tool gathers system-specific parameters and combines them with a template file to produce a configuration file for the build. The **makefile** invocation for the **configure** tool is **make Autoconfig** which must be issued from the top level **$SHARKCLONEROOT** directory. The configuration file is then invoked by issuing **make World** in the usual manner. The invoker has the option to specify input parameters as well as pairs of attributes and values to change the configuration attributes. Use **configure -help** to see a list of options and attributes.

Notes:

1. The environment variable **SHARKCLONEROOT** is the root of the GPFS source
2. If **SHARKCLONEROOT** is not set, **configure** uses **/usr/lpp/mmfs/src**

This example shows the commands to create the configuration file and then invoke it to make the portability layer:

```
cd /usr/lpp/mmfs/src
export SHARKCLONEROOT=/usr/lpp/mmfs/src
make Autoconfig
#Can check /usr/lpp/mmfs/src/config/site.mcr
make World
make InstallImages
echo $?
```

Chapter 5. Installing GPFS on AIX 5L nodes

It is suggested you read Chapter 2, “Planning for GPFS,” on page 15 and the GPFS FAQs at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Do not attempt to install GPFS if you do not have the prerequisites listed in “Hardware requirements” on page 15 and “Software requirements” on page 15.

Ensure that the **PATH** environment variable on each node includes **/usr/lpp/mmfs/bin**.

The installation process includes:

1. “Files to ease the installation process”
2. “Verifying the level of prerequisite software”
3. “Installation procedures”

Files to ease the installation process

Creation of a file that contains all of the nodes in your GPFS cluster prior to the installation of GPFS, will be useful during the installation process. Using either host names or IP addresses when constructing the file will allow you to use this information when creating your cluster through the **mmcrcluster** command.

For example, create the file **/tmp/gpfs.allnodes**, listing the nodes one per line:

```
k145n01.dpd.ibm.com
k145n02.dpd.ibm.com
k145n03.dpd.ibm.com
k145n04.dpd.ibm.com
k145n05.dpd.ibm.com
k145n06.dpd.ibm.com
k145n07.dpd.ibm.com
k145n08.dpd.ibm.com
```

Verifying the level of prerequisite software

Before you can install GPFS, you must verify that your system has the correct software levels installed. If your system *does not* have the prerequisite AIX level, refer to the appropriate installation manual before proceeding with your GPFS installation. For GPFS Version 3.1, your system must have AIX 5L Version 5 Release 3 with the latest service packs installed. To verify the software version, run the command:

```
WCOLL=/tmp/gpfs.allnodes dsh "oslevel"
```

The system should display output similar to:

```
5.3.0.10
```

Note: If you are utilizing NFS V4, at a minimum your output should include:

```
5.3.0.10
```

Installation procedures

The installation procedures are generalized for all levels of GPFS. Ensure you substitute the correct numeric value for the modification (*m*) and fix (*f*) levels, where applicable. The modification and fix level are dependent upon the current level of program support.

Follow these steps to install the GPFS software using the **installp** command:

1. “Electronic license agreement” on page 50
2. “Creating the GPFS directory” on page 50

3. “Creating the GPFS installation table of contents file”
4. “Installing the GPFS man pages”
5. “Installing GPFS over a network”
6. “Existing GPFS files” on page 51
7. “Verifying the GPFS installation” on page 51

Electronic license agreement

The GPFS software license agreements is shipped and viewable electronically. The electronic license agreement must be accepted before software installation can continue.

For additional software package installations, the installation cannot occur unless the appropriate license agreements are accepted. When using the **installp** command, use the **-Y** flag to accept licenses and the **-E** flag to view license agreement files on the media.

Creating the GPFS directory

To create the GPFS directory:

1. On any node create a temporary subdirectory where GPFS installation images will be extracted. For example:

   ```
   mkdir  /tmp/gpfslpp
   ```

2. Copy the installation images from the CD-ROM to the new directory, by issuing:

   ```
   bffcreate -qvX -t /tmp/gpfslpp -d /dev/cd0 all
   ```

   This command places these GPFS installation files in the images directory:

   a. gpfs.base
   b. gpfs.docs.data
   c. gpfs.msg.en_US

Creating the GPFS installation table of contents file

To create the GPFS installation table of contents file:

1. Make the new image directory the current directory:

   ```
   cd /tmp/gpfslpp
   ```

2. Use the **inutoc** command to create a **.toc** file. The **.toc** file is used by the **installp** command.

   ```
   inutoc .
   ```

Installing the GPFS man pages

In order to use the GPFS man pages you must install the **gpfs.docs.data** image. The GPFS manual pages will be located at **/usr/share/man/**.

Installation consideration: The **gpfs.docs.data** image need not be installed on all nodes if man pages are not desired or local file system space on the node is minimal.

Installing GPFS over a network

Install GPFS according to these directions, where *localNode* is the name of the node on which you are running:

1. If you are installing on a shared file system network, ensure the directory where the GPFS images can be found is NFS exported to all of the nodes planned for your GPFS cluster (**/tmp/gpfs.allnodes**).
2. Ensure an acceptable directory or mountpoint is available on each target node, such as **/tmp/gpfslpp**. If there is not, create one:

   ```
   WCOLL=/tmp/gpfs.allnodes dsh "mkdir /tmp/gpfslpp"
   ```

3. If you are installing on a shared file system network, to place the GPFS images on each node in your network, issue:

   ```
   WCOLL=/tmp/gpfs.allnodes dsh "mount localNode:/tmp/gpfslpp /tmp/gpfslpp"
   ```

   Otherwise, issue:

   ```
   WCOLL=/tmp/gpfs.allnodes dsh "rcp localNode:/tmp/gpfslpp/gpfs* /tmp/gpfslpp"
   WCOLL=/tmp/gpfs.allnodes dsh "rcp localNode:/tmp/gpfslpp/.toc /tmp/gpfslpp"
   ```

4. Install GPFS on each node:

   ```
   WCOLL=/tmp/gpfs.allnodes dsh "installp -agXYd /tmp/gpfslpp gpfs"
   ```

Existing GPFS files

If you have previously installed GPFS on your system, during the install process you may see messages similar to:

```
Some configuration files could not be automatically merged into the
system during the installation.  The previous versions of these files
have been saved in a configuration directory as listed below.  Compare
the saved files and the newly installed files to determine if you need
to recover configuration data.  Consult product documentation to
determine how to merge the data.

Configuration files which were saved in /lpp/save.config:
  /var/mmfs/etc/gpfsready
  /var/mmfs/etc/gpfsrecover.src
  /var/mmfs/etc/mmfsdown.scr
  /var/mmfs/etc/mmfsup.scr
```

If you have made changes to any of these files, you will have to reconcile the differences with the new versions of the files in directory **/var/mmfs/etc**. This does not apply to file **/var/mmfs/etc/mmfs.cfg** which is automatically maintained by GPFS.

Verifying the GPFS installation

Verify that the installation procedure placed the required GPFS files on each node by running the **lslpp** command on *each* node:

```
lslpp -l gpfs\*
```

The system should return output similar to:

```
  Fileset                      Level  State      Description
  ----------------------------------------------------------------------------
Path: /usr/lib/objrepos
  gpfs.base                  3.1.0.0  COMMITTED  GPFS File Manager
  gpfs.msg.en_US             3.1.0.0  COMMITTED  GPFS Server Messages - U.S.
                                                 English

Path: /etc/objrepos
  gpfs.base                  3.1.0.0  COMMITTED  GPFS File Manager

Path: /usr/share/lib/objrepos
  gpfs.docs.data             3.1.0.0  COMMITTED  GPFS Server Manpages and
                                                 Documentation
```

Note: The path returned by `lslpp -l` shows the location of the package control data used by **installp**. The listed path does not show GPFS file locations. To view GPFS file locations, use the `-f` flag.

Installing Tivoli SANergy and configuring SANergy file systems

If you plan to use Tivoli SANergy clients to access GPFS files, there are a number of steps you must perform:

1. Before working with SANergy, refer to SANergy export considerations in *General Parallel File System: Advanced Administration Guide* for GPFS restrictions on the use of SANergy.
2. Choose the correct level of SANergy software to install. You must use version 3.2.2.0 or higher.
3. Install the SANergy software. Refer to *A Practical Guide to Tivoli SANergy* and search on *installation*.

   Note: If you currently have SANergy software installed, and need to check the version, it is located in file: **/usr/SANergy/version.txt**.
4. Perform these steps to link the libraries and prepare file systems:
   a. Recycle the SANergy daemons on the GPFS metadata controller node with these commands: **/etc/rc.sanergy stop** and **/etc/rc.sanergy start**.
   b. Modify **/var/mmfs/etc/gpfsready** to restart the SANergy daemon (**sanergyd**) on the GPFS metadata controller when GPFS restarts on that node. The GPFS daemon must be up when **sanergyd** starts.

      A sample of needed modification can be found in **/usr/lpp/mmfs/samples/gpfsready.sample**, which is copied below:

      ```
      #
       # Uncomment the following to start sanergyd after the daemon is up.
       #

       ## ############## sanergy init START
       ##
       ## sanergyd_cmd=/usr/SANergy/sanergyd32
       ##
       ## if [ -x $sanergyd_cmd ]
       ## then
       ##   print "$(date) $0 $sanergyd_cmd started"
       ##   $sanergyd_cmd &
       ## else
       ##   print "$(date) $0 can't execute $sanergyd_cmd"
       ## fi
       ##
       ## ############## sanergy init END
      ```
   c. Make a GPFS file system NFS exportable and mount the file system on the SANergy client by issuing this command: **mount -o noac** *node_name*:*file_system_name /nfs_mnt_point*.
   d. On the client, issue the SANergy **fuse** command for the file system: **/usr/SANergy/SANergyconfig fuse** */nfs_mnt_point*.

Chapter 6. Migration, coexistence and compatibility

GPFS migration consists of these topics:

For the latest information on migration, coexistence, and compatibility, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html

Migrating to GPFS 3.1 from GPFS 2.3

To migrate a cluster to GPFS 3.1 from GPFS 2.3, perform these steps:

1. Stop all user activity in the file systems.
2. Cleanly unmount all mounted GPFS file systems. Do not use force unmount.
3. Follow any local administrative backup procedures to ensure protection of your file system data in the event of a failure.
4. Stop GPFS on all nodes in the cluster:

   ```
   mmshutdown -a
   ```
5. Copy the install images and install the new code on the nodes in the cluster as described in:
   - Chapter 4, "Installing GPFS on Linux nodes," on page 45.
   - Chapter 5, "Installing GPFS on AIX 5L nodes," on page 49.
6. Start GPFS on all nodes in the new cluster, issue:

   ```
   mmstartup -a
   ```
7. Mount the file systems if not done automatically upon GPFS daemon start.
8. Proceed to "Completing the migration to a new level of GPFS" on page 56.

Migrating to GPFS 3.1 from GPFS 2.2 or earlier releases of GPFS

In release 2.2 and earlier, GPFS could be configured in a number of cluster types: **sp**, **hacmp**, **rpd**, **lc**. The different cluster types supported different disk types - virtual shared disks, AIX logical volumes, NSDs. In addition, one could divide a GPFS cluster into a number of independent nodesets which determined the scope of the nodes on which a given file system could be mounted.

Starting with GPFS 2.3, many of these concepts have been eliminated and streamlined. For example:

- The only (implied) GPFS cluster type is **lc**.
- The concept of nodesets is eliminated.
- All nodes in the GPFS cluster are now automatically members of the one and only nodeset that you can have in a GPFS cluster.
- The dependence on RSCT has been removed.
- The only disk type that you can have is NSD.

  NSDs can be created out of any of the existing disk types, preserving file systems created prior to GPFS 2.3.

All of these changes, plus some of the new features that are introduced with GPFS 2.3, require you rebuild your existing cluster. For a complete list of new functions and changes, see "Summary of changes" on page xv. For an overview and description of GPFS cluster and NSD, please see Chapter 1, "Introducing General Parallel File System," on page 3.

If you currently utilize more than one nodeset, you have to decide whether you want to combine the nodesets into one GPFS cluster, or create more than one GPFS cluster to correspond to each of your nodesets. The migration procedure described in this book assumes that you are going to create a single GPFS cluster and move all of your file systems into it. You can always create new clusters later and move your file systems around using the **mmexportfs** and **mmimportfs** commands.

Notes:

1. Before you proceed, it is recommended that you read the notes specific for your existing cluster environment.
2. **GPFS cluster type sp:** The **mmcrcluster** command is not available on GPFS cluster type **sp**. If you have an **sp** type cluster, use the **mmlsnode -a** command to obtain the names of your nodesets and the nodes that belong to them.

To determine your cluster type, issue the **mmlscluster** command. That command displays output similar to:

```
GPFS cluster information
========================
  GPFS cluster type:         rpd
  GPFS cluster id:           gpfs0103263150103
  RSCT peer domain name:     rpd12
  Remote shell command:      /usr/bin/rsh
  Remote file copy command:  /usr/bin/rcp

GPFS cluster data repository servers:
-------------------------------------
  Primary server:    k145n43.kgn.ibm.com
  Secondary server:  k145n44.kgn.ibm.com

Nodes in nodeset set1:
----------------------
    1   k145n29     9.114.133.29  k145n29.kgn.ibm.com
    2   k145n30     9.114.133.30  k145n30.kgn.ibm.com
    3   k145n31     9.114.133.31  k145n31.kgn.ibm.com
    4   k145n32     9.114.133.32  k145n32.kgn.ibm.com

Nodes in nodeset set2:
----------------------

    5   k145n33     9.114.133.33   k145n33.kgn.ibm.com
    6   k145n34     9.114.133.34   k145n34.kgn.ibm.com
    7   k145n35     9.114.133.35   k145n35.kgn.ibm.com
    8   k145n36     9.114.133.36   k145n36.kgn.ibm.com
    9   k145n37     9.114.133.37   k145n37.kgn.ibm.com
   10   k145n38     9.114.133.38   k145n38.kgn.ibm.com
   11   k145n39     9.114.133.39   k145n39.kgn.ibm.com
   12   k145n40     9.114.133.40   k145n40.kgn.ibm.com
   13   k145n41     9.114.133.41   k145n41.kgn.ibm.com
   14   k145n42     9.114.133.42   k145n42.kgn.ibm.com
   15   k145n43     9.114.133.43   k145n43.kgn.ibm.com
   16   k145n44     9.114.133.44   k145n44.kgn.ibm.com
   17   k145n45     9.114.133.45   k145n45.kgn.ibm.com
   18   k145n46     9.114.133.46   k145n46.kgn.ibm.com

Cluster nodes that are not assigned to a nodeset:
-------------------------------------------------
   19  k145n47      9.114.133.47   k145n47.kgn.ibm.com
```

- If your current cluster type is **lc**:

  Since your disks are already defined as NSDs, there are no additional considerations. Some or all of your nodes are members of an RSCT peer domain. As GPFS no longer depends on RSCT, whether you continue to keep the nodes in the domain from now on should be dictated by other non-GPFS considerations you may have. GPFS will not be affected one way or another.

- If your current cluster type is **rpd** or **hacmp**:

  Your current GPFS disks are either virtual shared disks or AIX logical volumes. They will continue to be the same but GPFS automatically converts them into NSDs as part of the **mmimportfs** command processing (see step 13). During the import process, even though your disks are converted to NSDs, the names of your disks are preserved. For example, you may have NSDs with the names **gpfs5vsd** or **gpfs7lv**. This is only an cosmetic artifact and does not affect the performance of your file system in any way.

  Although GPFS does not depend on RSCT any more, if your current disks are virtual shared disks you will have to maintain the node membership in the RSCT peer domain because of the requirements of the IBM Virtual Shared Disk subsystem.
- If your current cluster type is **sp**:

  Your current GPFS disks are virtual shared disks. They will continue to be the same but GPFS will automatically convert them into NSDs as part of the **mmimportfs** command processing (see step 13). During the import process, even though your disks are converted to NSDs, the names of your disks are preserved. For example, you may have an NSD with the name **gpfs5vsd**. This is only an cosmetic artifact and does not affect the performance of your file system in any way.

To migrate your GPFS cluster to GPFS 3.1, follow these steps:

1. Ensure all disks, in all GPFS file systems to be migrated, are in working order by issuing the **mmlsdisk** command. Verify that the disk status is **ready** and availability is **up**. If not, correct any problems and reissue the **mmlsdisk** command before continuing.
2. Stop all user activity in the file systems.
3. Follow any local administrative backup procedures to ensure protection of your file system data in the event of a failure.
4. Cleanly unmount all mounted GPFS file systems. Do not use force unmount.
5. Shutdown the GPFS daemon on all nodes in the cluster, issue:

   ```
   mmshutdown -a
   ```
6. Export the GPFS file systems by issuing the **mmexportfs** command. This command creates the configuration output file *exportDataFile*, which contains all exported configuration data. Retain this file because it is required when issuing the **mmimportfs** command to import your file systems into the new cluster or in the event that you decide to go back to the previous release.

   ```
   mmexportfs all -o exportDataFile
   ```
7. Delete all existing nodes. For each nodeset in the cluster, where *nodesetId* is the name of the nodeset, issue:

   ```
   mmdelnode -a -C nodesetId
   ```
8. Delete the existing cluster by issuing:

   ```
   mmdelcluster -a
   ```

   Note: This step does not apply to GPFS cluster type **sp**.
9. Ensure that all disks from the old GPFS cluster are properly connected, and are online and available to the appropriate nodes of the new GPFS cluster.
10. Install the new level of GPFS on the affected nodes:
    - For your Linux nodes, see Chapter 4, “Installing GPFS on Linux nodes,” on page 45
    - For your AIX nodes, see Chapter 5, “Installing GPFS on AIX 5L nodes,” on page 49
11. Decide which nodes in your system will be quorum nodes (see “Quorum” on page 16).
12. Create a new GPFS cluster across all desired nodes by issuing the **mmcrcluster** command.
13. To complete the movement of your file systems to the new cluster, using the configuration file created in step 6, issue:

    ```
    mmimportfs all -i ImportfsFile
    ```
14. Start GPFS on all nodes in the new cluster, issue:

```
mmstartup -a
```

15. Mount the file systems if not done automatically upon GPFS daemon start.
16. Proceed to "Completing the migration to a new level of GPFS."

Completing the migration to a new level of GPFS

Operate GPFS with the new level of code until you are sure that you want to permanently migrate. If you decide to go back to the previous level of GPFS, see "Reverting to the previous level of GPFS." Once the new level of GPFS is satisfactory for your environment, you must complete migration of both the cluster configuration data and all file systems:

1. Migrate the cluster configuration data and enable new cluster-wide functionality:

   ```
   mmchconfig release=LATEST
   ```

2. Migrate all file systems to the latest metadata format changes.

   For each file system in your cluster, where *filesystem* is the name of the file system, issue:

   ```
   mmchfs filesystem -V
   ```

   Notes:

   a. Once the **mmchfs -V** command has been issued against a file system, any attempt to mount a migrated file system on a back-level GPFS system will be rejected with an error.

   b. Refer to "Migrate file system format to latest level" on page 38 for additional information.

3. If you were using single-node quorum in versions prior to GPFS 2.3, you must transition to the new node quorum with tiebreaker disks. See "Quorum" on page 16.

Reverting to the previous level of GPFS

If you should decide not to continue the migration to the latest level of GPFS, and you have not yet issued the **mmchfs -V** command, you may reinstall the earlier level of GPFS. Note that the procedure differs depending on which GPFS release you are reverting to.

Reverting to GPFS 2.3

The procedure for reverting to GPFS 2.3 differs depending on whether you have issued the **mmchconfig release=LATEST** command or not.

- If you have **not** issued the **mmchconfig release=LATEST** command, see "Reverting to GPFS 2.3 when you have *not* issued mmchconfig release=LATEST."
- If you **have** issued the **mmchconfig release=LATEST** command, see "Reverting to GPFS 2.3 when you *have* issued mmchconfig release=LATEST" on page 57.

Reverting to GPFS 2.3 when you have** not **issued mmchconfig release=LATEST: If you have **not** issued the **mmchconfig release=LATEST** command, perform these steps:

1. Stop all user activity in the file systems.
2. Cleanly unmount all mounted GPFS file systems. Do not use force unmount.
3. Stop GPFS on all nodes in the cluster:

   ```
   mmshutdown -a
   ```

4. Run the appropriate de-install program to remove GPFS from each node in the cluster. For example:
   - For your Linux nodes:

     ```
     rpm -e gpfs.gpl gpfs.base gpfs.docs
     ```

   - For your AIX nodes:

     ```
     installp -u gpfs
     ```

   Documentation: For the remaining steps, please see the GPFS 2.3 *Concepts, Planning, and Installation Guide* at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/ gpfsbooks.html.

5. Copy the install images of the GPFS 2.3 code on all affected nodes.

6. Install the original install images and all required PTFs.
7. For Linux nodes running GPFS, you must rebuild the GPFS portability layer.
8. Reboot all nodes.

Reverting to GPFS 2.3 when you** have **issued mmchconfig release=LATEST: If you **have** issued the **mmchconfig release=LATEST** command, you will have to rebuild the cluster. Perform these steps:

1. Stop all user activity in the file systems.
2. Cleanly unmount all mounted GPFS file systems. Do not use force unmount.
3. Stop GPFS on all nodes in the cluster:

   ```
   mmshutdown -a
   ```
4. Export the GPFS file systems by issuing the **mmexportfs** command:

   ```
   mmexportfs all -o exportDataFile
   ```
5. Delete the cluster:

   ```
   mmdelnode -a
   ```
6. Run the appropriate de-install program to remove GPFS from each node in the cluster. For example:
   - For your Linux nodes:

     ```
     rpm -e gpfs.gpl gpfs.base gpfs.docs
     ```
   - For your AIX nodes:

     ```
     installp -u gpfs
     ```

   Documentation: For the remaining steps, please see the GPFS 2.3 *Concepts, Planning, and Installation Guide* at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/ gpfsbooks.html.
7. Copy the install images of the GPFS 2.3 code on all affected nodes.
8. Install the original install images and all required PTFs.
9. For Linux nodes running GPFS, you must rebuild the GPFS portability layer.
10. Reboot all nodes.
11. Recreate your original cluster using the **mmcrcluster** command.
12. Import the file system information using the **mmimportfs** command. Specify the file created by the **mmexportfs** command from Step 4 above:

    ```
    mmimportfs all -i exportDataFile
    ```
13. Start GPFS on all nodes in the cluster, issue:

    ```
    mmstartup -a
    ```
14. Mount the file systems if not done automatically upon GPFS daemon start.

Reverting to GPFS 2.2 or earlier releases

If you are moving back to GPFS 2.2 and you still have the result from the **mmexportfs** command from step 6 on page 55, follow these steps to recreate your original environment:

Attention: If you are moving back to release other than GPFS 2.2, or if you do not have the original output from the **mmexportfs** command, contact IBM Service for assistance.

1. Ensure all disks, in all GPFS file systems, are in working order. Verify that the disk status is **ready** and availability is **up**. If not, correct any problems and reissue the **mmlsdisk** command to verify the status before continuing. For each file system, where *Device* is the name of the file system, issue:

   ```
   mmlsdisk Device
   ```
2. Stop all user activity in the file systems.
3. Cleanly unmount all mounted GPFS file systems. Do not use force unmount.
4. Shutdown the GPFS daemon on all nodes in the cluster, issue:

   ```
   mmshutdown -a
   ```

5. Export the GPFS file systems by issuing the **mmexportfs** command. This command creates the configuration output file which contains all exported configuration data. Retain this file in case you need to recover from a failure.

   Attention: Do not specify the same name and accidently destroy the file created by the **mmexportfs** command from step 6 on page 55.

   ```
   mmexportfs all -o exportDataFile2
   ```

6. Delete the cluster, issue:

   ```
   mmdelnode -a
   ```

7. Run the de-install program on each node:
   - For your Linux nodes, run the de-install to remove GPFS for the correct version of the RPM for your hardware platform and Linux distribution. For example:

     ```
     rpm -e gpfs.gpl gpfs.base gpfs.docs
     ```

   - For your AIX nodes:

     ```
     installp -u gpfs
     ```

   Documentation: For the remaining steps, please see the GPFS 2.2 *Concepts, Planning, and Installation Guide* for your cluster type at publib.boulder.ibm.com/infocenter/clresctr/topic/ com.ibm.cluster.gpfs.doc/ gpfsbooks.html.

8. Copy the install images of the GPFS 2.2 code on all affected nodes.
9. Install the original install images and all required PTFs.
10. For Linux nodes running GPFS, you must rebuild the GPFS portability layer.
11. Reboot all nodes.
12. Recreate your original cluster and nodesets using the **mmcrcluster** and **mmconfig** commands.

    GPFS cluster type sp: Use of the **mmcrcluster** command is not needed if your GPFS cluster type is **sp**.

13. Import the file system information using the **mmimportfs** command:

    Attention: Specify file created by the **mmexportfs** command from step 6 on page 55

    ```
    mmimportfs all -i ImportfsFile
    ```

14. Start GPFS on all nodes in the cluster, issue:

    ```
    mmstartup -a
    ```

15. Mount the file systems if not done automatically upon GPFS daemon start.

Coexistence

Each GPFS cluster may have multiple GPFS file systems that coexist on the cluster but function independently of each other. In addition, each file system may have different data management programs. However, if your configuration uses multiple file systems and multiple data management programs, there are several file system functions that cannot be used on the same file system. With coexistence, the functions that cannot be used on the same file system include:

- If you are using SANergy to export GPFS file systems, you cannot use the GPFS Data Management API or GPFS file system snapshots.
- If you are using the GPFS Data Management API, you cannot use SANergy to export GPFS file systems or have GPFS file system snapshots.
- If you are using GPFS file system snapshots, you cannot use SANergy to export GPFS file systems or use the GPFS Data Management API.

Compatibility

All applications which executed on the previous release of GPFS will execute on the new level of GPFS. File systems created under the previous release of GPFS may continue to be used under the new level of GPFS. However, once a file system has been migrated explicitly by issuing the **mmchfs -V** command, the disk images can no longer be read by a prior version of GPFS. You will be required to recreate the file system from the backup media and restore the content if you choose to go back after this command has been issued. The same rules apply for file systems newly created with GPFS 3.1. See “Migrating to GPFS 3.1 from GPFS 2.2 or earlier releases of GPFS” on page 53.

Applying maintenance to your GPFS system

Maintenance reminders:

1. Interoperability between maintenance levels will be specified on a per-maintenance-level basis. See the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for the latest on service information for GPFS.
2. Maintenance images for GPFS Linux retrieved from the web are named differently from the installation images of the GPFS Linux product. Maintenance images contain the word **update** in their name. For example, **gpfs.base-2.3-1-1.i386.update.rpm**.
3. For the latest service information, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html

To download fixes for GPFS go to techsupport.services.ibm.com/server/cluster/fixes/gpfsfixhome.html and obtain the fixes for your hardware and operating system.

To install the latest fixes:

- For AIX nodes, see Chapter 5, “Installing GPFS on AIX 5L nodes,” on page 49.
- For Linux nodes, see Chapter 4, “Installing GPFS on Linux nodes,” on page 45.

Chapter 7. Configuring and tuning your system for GPFS

In addition to configuring your GPFS cluster (see “GPFS cluster creation considerations” on page 21), you need to configure and tune your system. Values suggested here reflect evaluations made at the time this document was written. For the latest system configuration settings, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Additional GPFS and system configuration and tuning considerations include:

1. “General system configuration and tuning considerations”
2. “Linux configuration and tuning considerations” on page 65
3. “AIX configuration and tuning considerations” on page 67

See the *GPFS: Advanced Administration Guide* for information on:

- The **mmpmon** command for analyzing I/O performance on a per-node basis in *Monitoring GPFS I/O performance with the* **mmpmon** *command*
- See *Large system considerations* for information on using multiple token servers.

General system configuration and tuning considerations

Configuration and tuning considerations for all systems include:

1. “Clock synchronization”
2. “GPFS administration security”
3. “Cache usage” on page 62
4. “Private IP addresses” on page 63
5. “GPFS I/O” on page 64
6. “Access patterns” on page 64
7. “Aggregate network interfaces” on page 64
8. “Swap space” on page 65
9. “SANergy-controlled file systems” on page 65

For the latest system configuration settings, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html

Clock synchronization

The clocks of all nodes in the GPFS cluster must be synchronized. If this is not done, NFS access to the data, as well as other GPFS file system operations may be disrupted.

GPFS administration security

Before administering your GPFS file system, make certain that your system has been properly configured for security. This includes:

- Assigning root authority to perform all GPFS administration tasks except:
  - Tasks with functions limited to listing GPFS operating characteristics.
  - Tasks related to modifying individual user file attributes.
- Establishing the authentication method between nodes in the GPFS cluster.
  - Until you set the authentication method, you cannot issue any GPFS commands.
- Designating a remote communication program for remote shell and remote file copy commands.

  The default remote communication commands are **rcp** and **rsh**. If you have designated the use of a different remote communication program, you must make certain that:
  - You have granted proper authorization to all nodes in the GPFS cluster.

– The nodes in the GPFS cluster can communicate without the use of a password and without any extraneous messages.

Note: If you are using **rcp** and **rsh** commands for remote communication, the root user must have a properly configured **.rhosts** file in the home directory on each node in the GPFS cluster.

Cache usage

GPFS creates a number of cache segments on each node in the cluster. The amount of cache is controlled by three attributes. These attributes have default values at cluster creation time and may be changed through the **mmchconfig** command:

pagepool

The GPFS pagepool is used to cache user data and file system metadata. The pagepool mechanism allows GPFS to implement read as well as write requests asynchronously. Increasing the size of pagepool increases the amount of data or metadata that GPFS may cache without requiring synchronous I/O. The default value for pagepool is 64 MB. The maximum GPFS pagepool size is 8 GB. The minimum allowed value is 4 MB. On Linux systems, the maximum pagepool size is one half the physical memory in the machine. The amount of memory available for GPFS pagepool on a particular node may be restricted by the operating system and other software running on the node.

The optimal size of the pagepool depends on the needs of the application and effective caching of its re-accessed data. For systems where applications access large files, reuse data, benefit from GPFS prefetching of data, or have a random I/O pattern, increasing the value for **pagepool** may prove beneficial. However, if the value is set too large, GPFS will not start. See the *GPFS: Problem Determination Guide* and search on *The GPFS daemon will not come up*.

To change the pagepool to 100 MB:

```
mmchconfig pagepool=100M
```

maxFilesToCache

The total number of different files that can be cached at one time. Every entry in the file cache requires some pageable memory to hold the content of the file's inode plus control data structures. This is in addition to any of the file's data and indirect blocks that might be cached in the page pool.

The total amount of memory required for inodes and control data structures can be calculated as:

maxFilesToCache × **2.5 KB**

where 2.5 KB = 2 KB + 512 bytes for an inode

Valid values of **maxFilesToCache** range from 1 to 100,000. For systems where applications use a large number of files, of any size, increasing the value for **maxFilesToCache** may prove beneficial. This is particularly true for systems where a large number of small files are accessed. The value should be large enough to handle the number of concurrently open files plus allow caching of recently used files. The default value is 1000.

maxStatCache

This parameter sets aside additional pageable memory to cache attributes of files that are not currently in the regular file cache. This is useful to improve the performance of both the system and GPFS **stat( )** calls for applications with a working set that does not fit in the regular file cache.

The memory occupied by the stat cache can be calculated as:

maxStatCache × 176 bytes

Valid values of **maxStatCache** range from 0 to 10,000,000. For systems where applications test the existence of files, or the properties of files, without actually opening them (as backup applications do), increasing the value for **maxStatCache** may prove beneficial. The default value is:

4 × maxFilesToCache

The total amount of memory GPFS uses to cache file data and metadata is arrived at by adding **pagepool** to the amount of memory required to hold inodes and control data structures (**maxFilesToCache** × 2.5 KB), and the memory for the stat cache (**maxStatCache** × 176 bytes) together. The combined amount of memory to hold inodes, control data structures, and the stat cache is limited to 50% of the physical memory on a node running GPFS.

During configuration, you can specify the **maxFilesToCache**, **maxStatCache**, and **pagepool** parameters that control how much cache is dedicated to GPFS. These values can be changed later, so experiment with larger values to find the optimum cache size that improves GPFS performance without negatively affecting other applications.

The **mmchconfig** command can be used to change the values of **maxFilesToCache**, **maxStatCache**, and **pagepool**. The **pagepool** parameter is the only one of these parameters that may be changed while the GPFS daemon is running. A **pagepool** change occurs immediately when using the **-i** option on the **mmchconfig** command. Changes to the other values are effective only after the daemon is restarted.

For further information on these cache settings for GPFS, please see *GPFS and memory*.

The GPFS token system's affect on cache settings

Lock tokens play a role in maintaining cache consistency between nodes. A token allows a node to cache data it has read from disk, because the data cannot be modified elsewhere without revoking the token first. Each token manager can handle approximately 300,000 different file tokens (this number depends on how many distinct byte-range tokens are used when multiple nodes access the same file). If you divide the 300,000 by the number of nodes in the GPFS cluster you get a value that should approximately equal **maxFilesToCache** (the total number of different files that can be cached at one time) + *maxStatCache* (additional pageable memory to cache file attributes that are not currently in the regular file cache).

The configuration parameter:

- **maxFilesToCache** should be large enough to handle the number of concurrently open files plus allow caching of recently used files.
- **maxStatCache** defaults to **4 x maxFilesToCache** but can be set independently to balance the speed of **ls -l** calls with the memory load on the token manager memory.
- **maxStatCache** can be set higher on user-interactive-nodes and smaller on dedicated compute-nodes, since **ls -l** performance is mostly a human response issue.
- **maxFilesToCache** and **maxStatCache** are indirectly affected by the **distributedTokenServer** configuration parameter because distributing the tokens across multiple token servers might allow keeping more tokens than if a file system has only one token server.

Private IP addresses

GPFS uses private IP addresses among cluster nodes that are connected with communications adapters. To define private IP addresses, use the **subnets** operand of the **mmchconfig** command. For more information and an example, see *Using remote access with public and private IP addresses* in *General Parallel File System: Advanced Administration*.

Note: Standard private IP addresses as those on are located on these subnets:

- 10.0.0.0
- 172.16.0.0
- 192.168.0.0

GPFS I/O

The **maxMBpS** option determines the maximum amount of I/O in MB that can be submitted by GPFS per second. If the default value is not adjusted accordingly it will affect GPFS performance. Note that setting this number too high can have an adverse effect on performance of the system since overrunning the capabilities of the I/O bus or network adapter tends to drastically degrade throughput. This number is normally set after empirical study to determine your nodes I/O bandwidth limits. The default value is 150 MB per second. To change maxMBpS to 500 MB per second:

```
mmchconfig maxMBpS=500
```

Access patterns

GPFS attempts to recognize the pattern of accesses (such as strided sequential access) that an application makes to an open file. If GPFS recognizes the access pattern, it will optimize its own behavior. For example, GPFS can recognize sequential reads and will retrieve file blocks before they are required by the application. However, in some cases GPFS does not recognize the access pattern of the application or cannot optimize its data transfers. In these situations, you may improve GPFS performance if the application explicitly discloses aspects of its access pattern to GPFS through the **gpfs_fcntl()** library call.

Aggregate network interfaces

It is possible to aggregate multiple physical Ethernet interfaces into a single virtual interface. This is known as *Channel Bonding* on Linux and *EtherChannel/IEEE 802.3ad Link Aggregation* on AIX. GPFS supports using such aggregate interfaces. The main benefit is increased bandwidth. The aggregated interface has the network bandwidth close to the total bandwidth of all its physical adapters. Another benefit is improved fault tolerance. If a physical adapter fails, the packets are automatically sent on the next available adapter without service disruption.

EtherChannel and IEEE802.3ad each requires support within the Ethernet switch. Refer to the product documentation for your switch to determine if EtherChannel is supported.

For details on how to configure EtherChannel and IEEE 802.3ad Link Aggregation:

1. Go to
   `publib16.boulder.ibm.com/pseries/en_US/aixbman/commadmn/tcp_etherchannel.htm#yu528frokferg`
2. Search on *Configuring EtherChannel*

Hint: Make certain that the switch ports are configured for **LACP** (the default is **PAGP**).

For details on how to verify whether the adapter and the switch are operating with the correct protocols For IEEE 802.3ad:

1. Go to
   `publib16.boulder.ibm.com/pseries/en_US/aixbman/commadmn/tcp_etherchannel.htm#yu528frokferg`
2. Search on *Troubleshooting IEEE 802.3ad*.

For additional service updates regarding the use of EtherChannel:

1. Go to www.ibm.com/support
2. In the **Search technical support** box, enter the search term *EtherChannel*
3. Click **Search**

Hint: A useful command for troubleshooting, where device is the Link Aggregation device, is:

```
entstat -d device
```

Swap space

It is highly suggested that a sufficiently large amount of swap space is configured. While the actual configuration decisions should be made taking into account the memory requirements of other applications, it is suggested to configure at least as much swap space as there is physical memory on a given node.

SANergy-controlled file systems

Tuning the hyper-extension values of SANergy may improve performance for those file systems accessed by GPFS and SANergy. See the *IBM Tivoli SANergy Administrator's Guide* and search for the **hyper** command.

For more information about GPFS and SANergy, see *SANergy export considerations* in *General Parallel File System: Advanced Administration*.

Linux configuration and tuning considerations

Configuration and tuning considerations for the Linux nodes in your system include:

1. "updatedb considerations"
2. "SUSE LINUX considerations"
3. "GPFS helper threads" on page 66
4. "Communications I/O" on page 66
5. "Disk I/O" on page 66

For the latest system configuration settings, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html

updatedb considerations

On some Linux distributions, for example, Red Hat EL 3.0, the system is configured by default to run the file system indexing utility **updatedb** through the **cron** daemon on a periodic basis (usually daily). This utility traverses the file hierarchy and generates a rather extensive amount of I/O load. For this reason, it is configured by default to skip certain file system types and nonessential file systems. However, the default configuration does not prevent **updatedb** from traversing GPFS file systems. In a cluster this results in multiple instances of **updatedb** traversing the same GPFS file system simultaneously. This causes general file system activity and lock contention in proportion to the number of nodes in the cluster. On smaller clusters, this may result in a relatively short-lived spike of activity, while on larger clusters, depending on the overall system throughput capability, the period of heavy load may last longer. Usually the file system manager node will be the busiest, and GPFS would appear sluggish on all nodes. Re-configuring the system to either make **updatedb** skip all GPFS file systems or only index GPFS files on one node in the cluster is necessary to avoid this problem.

SUSE LINUX considerations

On the SUSE LINUX ES 9 distribution, it is recommended you adjust the **vm.min_free_kbytes** kernel tunable. This tunable controls the amount of free memory that Linux kernel keeps available (i.e. not used in any kernel caches). When **vm.min_free_kbytes** is set to its default value, on some configurations it is possible to encounter memory exhaustion symptoms when free memory should in fact be available. Setting **vm.min_free_kbytes** to a higher value (Linux **sysctl** utility could be used for this purpose), on the order of magnitude of 5-6% of the total amount of physical memory, should help to avoid such a situation.

Also, please see the GPFS Redpapers:

- *GPFS Sequential Input/Output Performance on IBM pSeries 690* at www.redbooks.ibm.com/redpapers/pdfs/redp3945.pdf
- *Native GPFS Benchmarks in an Integrated p690/AIX and x335/Linux Environment* at www.redbooks.ibm.com/redpapers/pdfs/redp3962.pdf

GPFS helper threads

Since systems vary, it is suggested you simulate an expected workload in GPFS and examine available performance indicators on your system. For instance some SCSI drivers publish statistics in the **/proc/scsi** directory. If your disk driver statistics indicate that there are many *queued requests* it may mean you should throttle back the helper threads in GPFS. Suggested starting points are:

```
mmchconfig prefetchThreads=18
mmchconfig worker1Threads=24
```

Communications I/O

To optimize the performance of GPFS and your network, it is suggested you:

- Enable Jumbo Frames if your switch supports it:

  If GPFS is configured to operate over Gigabit Ethernet, set the MTU size for the communication adapter to 9000.

  If GPFS is configured to operate over Myrinet, to enable the Jumbo Frames for Myrinet IP driver build the GM driver with the **--enable-new-features**.
- Verify **/proc/sys/net/ipv4/tcp_window_scaling** is enabled. It should be by default.
- Tune the TCP window settings by adding these lines to the **/etc/sysctl.conf** file:

  ```
  # increase Linux TCP buffer limits
  net.core.rmem_max = 8388608
  net.core.wmem_max = 8388608
  # increase default and maximum Linux TCP buffer sizes
  net.ipv4.tcp_rmem = 4096 262144 8388608
  net.ipv4.tcp_wmem = 4096 262144 8388608
  # increase max backlog to avoid dropped packets
  net.core.netdev_max_backlog=2500
  ```

  After these changes are made to the **/etc/sysctl.conf** file, apply the changes to your system:

  1. Issue the **sysctl -p /etc/sysctl.conf** command to set the kernel settings.
  2. Issue the **mmstartup -a** command to restart GPFS

Disk I/O

To optimize disk I/O performance, you should consider theses options for NSD servers or other GPFS nodes that are directly attached to a SAN over a Fibre Channel network:

1. The storage server cache settings can impact GPFS performance if not set correctly. Suggested settings for the IBM TotalStorage® DS4500 include:
   - read cache = enabled
   - read ahead multiplier = 0
   - write cache = disabled
   - write cache mirroring = disabled
   - cache block size = 16K

   Note: Other storage server brands may have similar settings.
2. When the storage server disks are configured for RAID5, some configuration settings can affect GPFS performance. These settings include:
   - GPFS block size
   - Maximum I/O size of host Fibre Channel (FC) host bus adapter (HBA) device driver
   - Storage server RAID5 stripe size

   Note: For optimal performance, GPFS block size should be a multiple of the maximum I/O size of the FC HBA device driver. In addition, the maximum I/O size of the FC HBA device driver should be a multiple of the RAID5 stripe size.

3. These suggestions may avoid the performance penalty of read-modify-write at the storage server for GPFS writes. Examples of the suggested settings are:
   - 8+P RAID5
     - GPFS block size = 512K
     - Storage Server RAID5 segment size = 64K (RAID5 stripe size=512K)
     - Maximum IO size of FC HBA device driver = 512K
   - 4+P RAID5
     - GPFS block size = 256K
     - Storage Server RAID5 segment size = 64K (RAID5 stripe size = 256K)
     - Maximum IO size of FC HBA device driver = 256K

   For the example settings using 8+P and 4+P RAID5, the RAID5 parity can be calculated from the data written and will avoid reading from disk to calculate the RAID5 parity. The maximum IO size of the FC HBA device driver can be verified using **iostat** or the Storage Server performance monitor. In some cases, the device driver may need to be patched to increase the default maximum IO size.
4. The GPFS parameter **maxMBpS** can limit the maximum throughput of an NSD server or a single GPFS node that is directly attached to the SAN with a FC HBA. Increase the **maxMBpS** from the default value of 150 to 200 (200 MB/s). The **maxMBpS** parameter is changed by issuing the **mmchconfig** command. After this change is made, restart GPFS on the nodes and test both read and write performance of both a single node in addition to a large number of nodes.

AIX configuration and tuning considerations

Configuration and tuning considerations for the AIX nodes in your system include:

1. "Communications I/O"
2. "Disk I/O"
3. "Switch pool" on page 68
4. "@server High Performance Switch" on page 68
5. "IBM Virtual Shared Disk" on page 68
6. "GPFS use with Oracle" on page 69

For the latest system configuration settings, see the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html.

Communications I/O

There are two considerations for communications within your cluster:

1. For a cluster utilizing the HPS:
   - Configure GPFS to communicate and pass administrative traffic over the LAN, not the switch.
   - Attach and configure AIX nodes designated as virtual shared disk servers, to use the switch.
2. The **ipqmaxlen** network option should be considered when configuring for GPFS. The **ipqmaxlen** parameter controls the number of incoming packets that can exist on the IP interrupt queue. Since both GPFS and IBM Virtual Shared Disk use IP, the default of 100 is often insufficient. The suggested setting is 512. To set the value to 512 after the next reboot, issue the command:

   ```
   no -r -o ipqmaxlen=512
   ```

   This value will persist throughout subsequent reboots. For detailed information on the **ipqmaxlen** parameter, see the *AIX 5L Performance Management Guide* for AIX V5.3: publib.boulder.ibm.com/infocenter/pseries/index.jsp.

Disk I/O

The disk I/O option to consider when configuring GPFS and using SSA RAID:

max_coalesce

The **max_coalesce** parameter of the SSA RAID device driver allows the device driver to coalesce requests which have been broken up to satisfy LVM requirements. This parameter can be critical when using RAID and is required for effective performance of RAID **write**s. The suggested setting is 0x40000 for RAID-5**4+P** configurations.

- To view:

  ```
  lsattr -E -l hdiskX -a max_coalesce
  ```

- To set:

  ```
  chdev -l hdiskX -a max_coalesce=0x40000
  ```

For further information on the **max_coalesce** parameter see the *AIX 5L Technical Reference: Kernel and Subsystems, Volume 2* for AIX V5.3: publib.boulder.ibm.com/infocenter/pseries/index.jsp

Switch pool

If your hardware configuration consists of the @server HPS, there are two communication subsystem parameters which must be considered when tuning for GPFS. They are **rpoolsize** and **spoolsize**. For optimal system performance, you must allocate sufficient memory for use by these switch pools.

- Switch receive pool, **rpoolsize**, is the pool of memory which is allocated for buffers being received from the switch. Shortages of these buffers will result in dropped packets and retries at higher protocol levels.
- Switch send pool, **spoolsize**, is the pool of memory which is used for all switch output. Shortages of these buffers will result in a delay of I/O operations. On virtual shared disk servers, shortages of these buffers may result in idle disks because buddy buffers can not be freed.

For the HPS, the default value for **rpoolsize** and **spoolsize** is 67108864. The maximum allowed value for both parameters is 134217728. When setting the **rpoolsize** and **spoolsize** parameters for a individual node, the value should scale with the number of HPS links.

- For each link on a node you need to allocate 16 Megabytes of **rpoolsize** and **spoolsize**.
- For a 2 link system, the **rpoolsize** and **spoolsize** values should be 33554432.
- For an 8 link node the values should be set to 134217728.
- For other configurations the value should be proportional.

The suggested setting on virtual shared disk servers is the default value. Under some loads, lesser values may be sufficient on application nodes without disks attached to them.

- To verify the value of spoolsize and rpoolsize:

  ```
  lsattr -E -l sni0
  ```

- To change the value:

  ```
  chgsni sn0 -a rpoolsize=33554432 -a spoolsize 33554432
  ```

For a complete listing of the required AIX file sets and for information on network tuning and Technical Large Page Support configuration, refer to the *Switch Network Interface for @server High Performance Switch Guide and Reference*, (SC23-4869):

- For AIX V5.3, go to publib.boulder.ibm.com/infocenter/pseries/index.jsp

@server High Performance Switch

If your system consists of the @server High Performance Switch, it is suggested that you configure GPFS over the **ml0** IP network interface.

IBM Virtual Shared Disk

There are three IBM Virtual Shared Disk configuration settings for the efficient operation of GPFS:

1. The buddy buffer is pinned kernel memory. The virtual shared disk server node uses the buddy buffer to temporarily store data for I/O operations originating at a client node. The data in a buddy buffer is purged immediately after the I/O operation completes. The values associated with the buddy buffer are:
   - Minimum buddy buffer size allocated to a single request
   - Maximum buddy buffer size allocated to a single request
   - Total number of maximum-size buddy buffers that the system will attempt to dynamically allocate

   Suggested values (unless your system is memory-constrained and you want to restrict the amount of buddy buffer space) are:
   - Minimum buddy buffer size: 4096 (4 KB)
   - Maximum buddy buffer size: 262144 (256 KB)

     If your application uses the **fastpath** option of asynchronous I/O, the maximum buddy buffer size must be greater than or equal to 128 KB. Otherwise, you will receive **EMSGSIZE Message too long** errors.
   - Total number of maximum-size buffers:
     - 2000 for a virtual shared disk server node
     - One for a virtual shared disk client-only node

   You can either set these values using the **vsdnode** command, or update the values using the **updatevsdnode** command.

   When the device driver is configured, the total buddy buffer space is not pinned; instead, approximately one-quarter of the total space requested is pinned when the device driver is configured. This initial amount of spaced pinned is limited to a maximum of 64 MB for a 32-bit kernel, or 128 MB for a 64-bit kernel. After configuration, the device driver attempts to dynamically expand and contract additional buddy buffer space up to the maximum specified, or until AIX can no longer satisfy the memory request. If a buddy buffer cannot be obtained, then the request is queued at the virtual shared disk server until a buddy buffer is available.
2. The **IP_max_msg_size** parameter controls the size of the packets that the IBM Virtual Shared Disk will send between the client and the server. Larger message sizes will result in fewer packets to transfer the same amount of data. The suggested setting is 61440 on all nodes.

Note: For virtual shared disks in a system utilizing the HPS, see the *Reliable Scalable Cluster Technology: Managing Shared Disks* manual for information on buddy buffers.

GPFS use with Oracle

When utilizing GPFS with Oracle, configuration and tuning considerations include:

- When setting up your LUNS it is important to:
  1. Create the logical volumes such that they map one to one with a volume group and a volume group be one to one with a LUN which is a single RAID device.
  2. Not stripe logical volumes across multiple RAIDs for I/O parallelism when using raw logical volumes because:
     - GPFS puts each block of a file on different LUNs spread across all LUNs
     - Logical volume striping makes removing a bad RAID more difficult
- For file systems holding large Oracle databases, set the GPFS file system block size through the **mmcrfs** command using the **-B** option, to a large value:
  - 512 KB is generally suggested.
  - 256 KB is suggested if there is activity other than Oracle using the file system and many small files exist which are not in the database.
  - 1 MB is suggested for file systems 100 TB or larger.

The large block size makes the allocation of space for the databases manageable and has no affect on performance when Oracle is using the Asynchronous I/O (AIO) and Direct I/O (DIO) features of AIX.

- Set the GPFS worker threads through the **mmchconfig - prefetchThreads** command to allow the maximum parallelism of the Oracle AIO threads:
  - On a 64-bit AIX kernel, the setting can be as large as 548.

    The GPFS prefetch threads must be adjusted accordingly through the **mmchconfig - prefetchThreads** command as the sum of those two classes of threads must be 550 or less.
  - On a 32-bit kernel, the setting can be as large as 162.

    The GPFS prefetch threads must be adjusted accordingly through the **mmchconfig - prefetchThreads** command as the sum of those two classes of threads must be 164 or less.
  - When requiring GPFS sequential I/O, set the prefetch threads between 50 and 100 (the default is 64), and set the worker threads to have the remainder.

  Note: These changes through the **mmchconfig** command take effect upon restart of the GPFS daemon.
- The number of AIX AIO *kprocs* to create should be approximately the same as the GPFS *worker1Threads* setting.
- The AIX AIO *maxservers* setting is the number of *kprocs* PER CPU. It is suggested to set is slightly larger than *worker1Threads* divided by the number of CPUs. For example if *worker1Threads* is set to 500 on a 32-way SMP, set *maxservers* to 20.
- Set the Oracle database block size equal to the LUN segment size or a multiple of the LUN pdisk segment size.
- Set the Oracle read-ahead value to prefetch one or two full GPFS blocks. For example, if your GPFS block size is 512 KB, set the Oracle blocks to either 32 or 64 16 KB blocks.
- Do not use the **dio** option on the **mount** command as this forces DIO when accessing *all* files. Oracle automatically uses DIO to open database files on GPFS.
- When running Oracle RAC 10g, it is suggested you increase the value for **OPROCD_DEFAULT_MARGIN** to at least 500 to avoid possible random reboots of nodes.

  In the control script for the Oracle CSS daemon, located in **/etc/init.cssd** the value for **OPROCD_DEFAULT_MARGIN** is set to 500 (milliseconds) on all UNIX derivatives except for AIX. For AIX this value is set to 100. From a GPFS perspective, even 500 milliseconds maybe too low in situations where node failover may take up to a minute or two to resolve. However, if during node failure the surviving node is already doing direct IO to the **oprocd** control file, it should have the necessary tokens and indirect block cached and should therefore not have to wait during failover.

Chapter 8. Steps to permanently uninstall GPFS

GPFS maintains a number of files that contain configuration and file system related data. Since these files are critical for the proper functioning of GPFS and must be preserved across releases, they are not automatically removed when you uninstall GPFS.

Follow these steps if you do not intend to use GPFS any more on any of the nodes in your cluster and you want to remove all traces of GPFS:

Attention: After following these steps and manually removing the configuration and file system related information, you will permanently lose access to all of your current GPFS data.

1. **unmount** all GPFS file systems on all nodes.
2. Issue the **mmdelfs** command for each file system in the cluster to remove GPFS file systems.
3. Issue the **mmdelnsd** command for each NSD in the cluster to remove the NSD volume ID written on sector 2.

   If the NSD volume ID is not removed and the disk is again used with GPFS at a later time, you will receive an error message when issuing the **mmcrnsd** command. See *NSD creation fails with a message referring to an existing NSD* in the *GPFS: Problem Determination Guide*.
4. Issue the **mmshutdown -a** command to shutdown GPFS on all nodes.
5. Uninstall GPFS from each node:
   - For your Linux nodes, run the de-install to remove GPFS for the correct version of the RPM for your hardware platform and Linux distribution. For example:

     ```
     cat /tmp/gpfs.allnodes | xargs -i rsh {} rpm -e gpfs.gpl
     cat /tmp/gpfs.allnodes | xargs -i rsh {} rpm -e gpfs.msg.en_us
     cat /tmp/gpfs.allnodes | xargs -i rsh {} rpm -e gpfs.base
     cat /tmp/gpfs.allnodes | xargs -i rsh {} rpm -e gpfs.docs
     ```
   - For your AIX nodes:

     ```
     installp -u gpfs
     ```
6. Remove the **/var/mmfs** and **/usr/lpp/mmfs** directories.
7. Remove all files that start with **mm** from the **/var/adm/ras** directory.
8. Remove **/tmp/mmfs** directory and its content, if present.

Appendix A. GPFS architecture

Interaction between nodes at the file system level is limited to the locks and control flows required to maintain data and metadata integrity in the parallel environment.

A discussion of GPFS architecture includes:

Special management functions

In general, GPFS performs the same functions on all nodes. It handles application requests on the node where the application exists. This provides maximum affinity of the data to the application. There are three cases where one node provides a more global function affecting the operation of multiple nodes. These are nodes acting as:

1. "The GPFS configuration manager"
2. "The file system manager"
3. "The metanode" on page 75

The GPFS configuration manager

There is one GPFS configuration manager per cluster. The configuration manager is chosen through an election held between the set of quorum nodes designated for the cluster (see "Quorum" on page 16). The roles of the configuration manager are to:

- Drive recovery from node failure within the cluster.

  The configuration manager determines whether or not a quorum of nodes exist to allow the GPFS daemon to start and for file system usage to continue.
- Select the *file system manager* node.

  The configuration manger prevents multiple nodes from assuming the role of file system manager thereby avoiding data corruption as the token management function resides on the file system manager node and possibly other nodes. See *Large system considerations* in *General Parallel File System: Advanced Administration*.

The file system manager

There is one file system manager per file system, which handles all of the nodes using the file system. The services provided by the file system manager include:

1. File system configuration

   Processes changes to the state or description of the file system:
   - Adding disks
   - Changing disk availability
   - Repairing the file system

Mount and unmount processing is performed on both the file system manager and the node requesting the service.

2. Management of disk space allocation

   Controls which regions of disks are allocated to each node, allowing effective parallel allocation of space.

3. Token management

   The file system manager node may also perform the duties of the token manager server. If you have explicitly designated some of the nodes in your cluster as file system manager nodes, then the token server load will be distributed among all of the designated manager nodes. For additional information, refer to *Large system considerations* in *General Parallel File System: Advanced Administration*.

   The token management server coordinates access to files on shared disks by granting tokens that convey the right to read or write the data or metadata of a file. This service ensures the consistency of the file system data and metadata when different nodes access the same file. The status of each token is held in two places:

   a. On the token management server

   b. On the token management client holding the token

   The first time a node accesses a file it must send a request to the token management server to obtain a corresponding **read** or **write** token. After having been granted the token, a node may continue to read or write to the same file without requiring additional interaction with the token management server. This continues until an application on another node attempts to read or write to the same region in the file.

   The normal flow for a token is:

   - A message to the token management server.

     The token management server then either returns a granted token or a list of the nodes that are holding conflicting tokens.

   - The token management function at the requesting node then has the responsibility to communicate with all nodes holding a conflicting token and get them to relinquish the token.

     This relieves the token server of having to deal with all nodes holding conflicting tokens. In order for a node to relinquish a token, the daemon must give it up. First, the daemon must release any locks that are held using this token. This may involve waiting for I/O to complete.

4. Quota management

   In a quota-enabled file system, the file system manager node automatically assumes quota management responsibilities whenever the GPFS file system is mounted. Quota management involves:

   - Allocating disk blocks to nodes that are writing to the file system
   - Comparing the allocated space to the quota limits at regular intervals

   Note: To reduce the number of space requests from nodes writing to the file system, the quota manager allocates more disk blocks than requested (see “Automatic quota activation” on page 37). That allows nodes to write to the file system without having to go to the quota manager and check quota limits each time they write to the file system.

The file system manager is selected by the configuration manager. If a file system manager should fail for any reason, a new file system manager is selected by the configuration manager and all functions continue without disruption, except for the time required to accomplish the takeover.

Depending on the application workload, the memory and CPU requirements for the services provided by the file system manager may make it undesirable to run a resource intensive application on the same node as the file system manager. GPFS allows you to control the pool of nodes from which the file system manager is chosen through:

- the **mmcrcluster** command when creating your cluster
- the **mmaddnode** command when adding nodes to your cluster

- the **mmchconfig** command to change a node's designation at any time

These preferences are honored except in certain failure situations where multiple failures occur (see *Multiple file system manager failures* in the *GPFS: Problem Determination Guide*). You may list which node is currently assigned as the file system manager by issuing the **mmlsmgr** command or change which node has been assigned to this task through the **mmchmgr** command.

The metanode

There is one metanode per open file. The metanode is responsible for maintaining file metadata integrity (see "Metadata"). In almost all cases, the node that has had the file open for the longest continuous period of time is the metanode. All nodes accessing a file can read and write data directly, but updates to metadata are written only by the metanode. The metanode for each file is independent of that for any other file and can move to any node to meet application requirements.

Use of disk storage and file structure within a GPFS file system

A file system consists of a set of disks, a *stripe group*, which are used to store:

- "Metadata"
- "Quota files" on page 77
- "GPFS recovery logs" on page 77
- "User data" on page 78

This set of disks is listed in a *file system descriptor*, which is at a fixed position on each of the disks in the stripe group. In addition, the file system descriptor contains information about the state of the file system.

Metadata

Within each file system, files are written to disk as in traditional UNIX file systems, using inodes, indirect blocks, and data blocks. Inodes and indirect blocks are considered *metadata*, as distinguished from data, or actual file content. You can control which disks GPFS uses for storing metadata when you create disk descriptors at file system creation time when issuing **mmcrfs** or at a later time by issuing **mmchdisk**.

Each file has an inode containing information such as file size and time of last modification. The inodes of small files also contain the addresses of all disk blocks that comprise the file data. A large file can use too many data blocks for an inode to directly address. In such a case, the inode points instead to one or more levels of indirect blocks that are deep enough to hold all of the data block addresses. This is the indirection level of the file.

A file starts out with direct pointers to data blocks in the inodes (a zero level of indirection). As the file increases in size to the point where the inode cannot hold enough direct pointers, the indirection level is increased by adding an indirect block and moving the direct pointers there. Subsequent levels of indirect blocks are added as the file grows. This allows file sizes to grow up to the file system size.

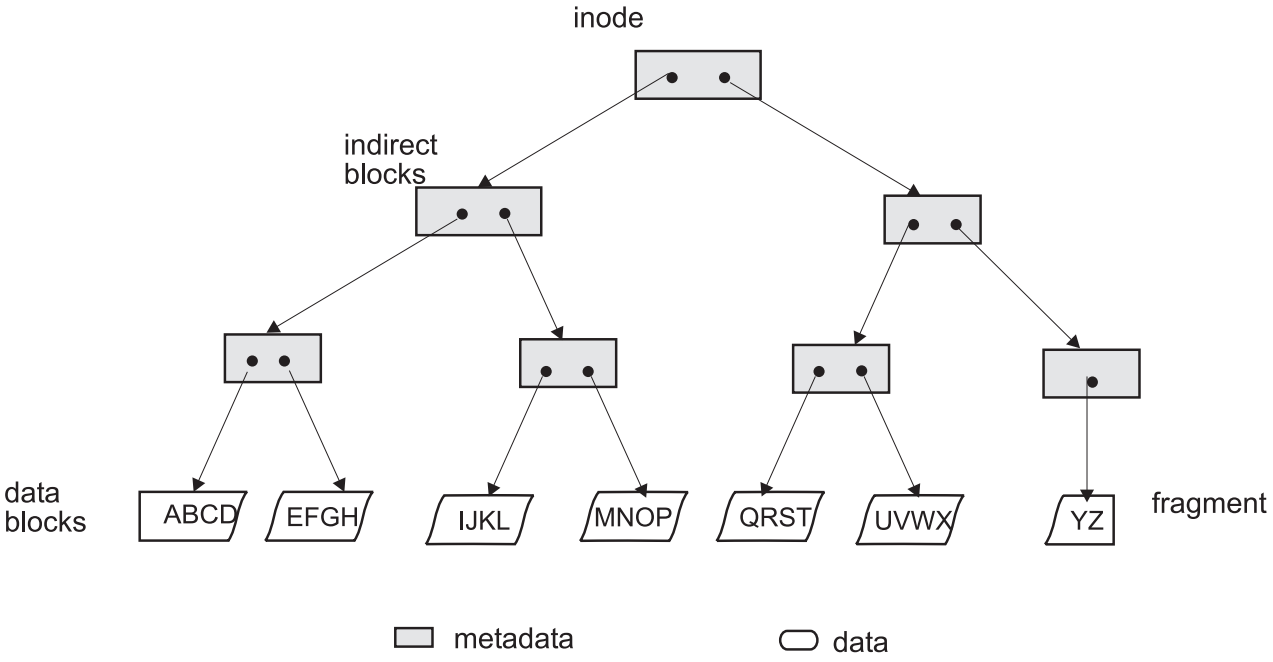


Figure 14. GPFS files have a typical UNIX structure

Notes:

1. The maximum number of mounted file systems within a GPFS cluster is 32.
2. See the GPFS FAQ at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.html for the latest supported file system size.
3. The maximum number of files within a file system cannot exceed the architectural limit of 2,147,484,647.

Using the file system descriptor to find all of the disks that make up the file system's stripe group, and their size and order, it is possible to address any block in the file system. In particular, it is possible to find the first inode, which describes the *inode file*, and a small number of inodes that are the core of the rest of the file system. The inode file is a collection of fixed length records that represent a single file, directory, or link. The unit of locking is the single inode because the inode size must be a multiple of the sector size (the inode size is internally controlled by GPFS). Specifically, there are fixed inodes within the inode file for the:

- Root directory of the file system
- Block allocation map
- Inode allocation map

The data contents of each of these files are taken from the data space on the disks. These files are considered metadata and are allocated only on disks where metadata is allowed.

Block allocation map

The block allocation map is a collection of bits that represent the availability of disk space within the disks of the file system. One unit in the allocation map represents a subblock or 1/32 of the block size of the file system. The allocation map is broken into regions that reside on disk sector boundaries. The number of regions is set at file system creation time by the parameter that specifies how many nodes will access this file system. The regions are separately locked and, as a result, different nodes can be allocating or de-allocating space represented by different regions independently and concurrently.

Inode allocation map

The inode allocation file represents the availability of inodes within the inode file. This file represents all the files, directories, and links that can be created. The **mmchfs** command can be used to change the maximum number of files that can be created in the file system.

Quota files

For file systems with quotas enabled, quota files are created at file system creation time. There are three quota files for a file system:

- **user.quota** for users
- **group.quota** for groups
- **fileset.quota** for filesets

For a file system with fileset quotas enabled, there is a single quota file named **fileset.quota**.

For every user who works within the file system, the **user.quota** file contains a record of limits and current usage within the file system for the individual user. If default quota limits for new users of a file system have been established, this file also contains a record for that value.

For every group whose users work within the file system, the **group.quota** file contains a record of common limits and the current usage within the file system of all the users in the group. If default quota limits for new groups of a file system have been established, this file also contains a record for that value.

For every fileset, the **fileset.quota** file contains a record of limits and current usage within the fileset. If default quota limits for filesets have been established, this file also contains a record for that value. The quota limit on blocks and inodes in a fileset are independent of the limits for specific users or groups of users. During allocation, the corresponding the limits for users, groups, and filesets are checked and the lowest threshold is applied.

Quota files are found through a pointer in the file system descriptor. Only the file system manager has access to the quota files. For backup purposes, quota files are also accessible as regular files in the root directory of the file system.

Quota security:

1. If you are a root user, you may view quota information for all users, groups, and filesets.
2. If you are a non-root user, you may view:
   - Your own quota information
   - Quota information for any groups to which you belong
   - Fileset quota information

GPFS recovery logs

GPFS recovery logs are created at file system creation. Additional recovery logs may be created if needed. Recovery logs are always replicated and are found through a pointer in the file system descriptor. The file system manager assigns a recovery log to each node accessing the file system.

Logging

GPFS maintains the atomicity of the on-disk structures of a file through a combination of rigid sequencing of operations and logging. The data structures maintained are the inode, the indirect block, the allocation map, and the data blocks. Data blocks are written to disk before any control structure that references the data is written to disk. This ensures that the previous contents of a data block can never be seen in a new file. Allocation blocks, inodes, and indirect blocks are written and logged in such a way that there will never be a pointer to a block marked unallocated that is not recoverable from a log.

There are certain failure cases where blocks are marked allocated but not part of a file, and this can be recovered by running **mmfsck** online or offline. GPFS always replicates its log. There are two copies of the log for each executing node. Log recovery is run:

1. As part of the recovery of a node failure affecting the objects that the failed node might have locked.
2. As part of a **mount** after the file system has been unmounted everywhere.

User data

The remaining space is allocated from the block allocation map as needed and is used for user data and directories.

GPFS and memory

GPFS uses three areas of memory:

- Memory allocated from the kernel heap
- Memory allocated within the daemon segment
- Shared segments accessed from both the daemon and the kernel

Memory allocated from the kernel heap

GPFS uses kernel memory for control structures such as vnodes and related structures that establish the necessary relationship with the operating system.

Memory allocated within the daemon segment

GPFS uses daemon segment memory for file system manager functions. Because of that, the file system manager node requires more daemon memory since token states for the entire file system are initially stored there. File system manager functions requiring daemon memory include:

- Structures that persist for the execution of a command
- Structures that persist for I/O operations
- States related to other nodes

Note: Other nodes may assume token management responsibilities. Refer to*Large system considerations* in *General Parallel File System: Advanced Administration*

Shared segments accessed from both the daemon and the kernel

Shared segments consist of both pinned and unpinned memory that are allocated at daemon startup. The initial values are the system defaults. However, you can change these values later using the **mmchconfig** command. See “Cluster configuration file” on page 25.

Pinned memory is labeled, *pagepool*. In a non-pinned area of the shared segment, GPFS keeps information about open and recently opened files. This information is held in two forms:

1. A full inode cache
2. A stat cache

Pinned and non-pinned memory

Pinned memory

GPFS uses pinned memory (also called **pagepool** memory) for storing file data and metadata in support of I/O operations. With some access patterns, increasing the amount of **pagepool** memory may increase I/O performance for file systems if they have these operating characteristics:

- Frequent writes that can be overlapped with application execution
- Reuse of files and sequential reads of a size such that prefetch will benefit the application

Non-pinned memory

The inode cache contains copies of inodes for open files and for some recently used files that are no longer open. The **maxFilesToCache** parameter controls the number of inodes cached by GPFS. However, the number of inodes for recently used files is constrained by how much the **maxFilesToCache** parameter exceeds the number of currently open files.

Note: The number of open files can exceed the value defined by the **maxFilesToCache** parameter.

The stat cache contains enough information to respond to inquiries about the file and open it, but not enough information to read from it or write to it. There is sufficient data from the inode to respond to a **stat( )** call (the system call under commands such as **ls -l**). A stat cache entry consumes significantly less memory than a full inode. The default value stat cache is four times the **maxFilesToCache** parameter. This value may be changed through the **maxStatCache** parameter on the **mmchconfig** command. Stat cache entries are kept for:

1. Recently accessed files
2. Directories recently accessed by a number of **stat( )** calls

Notes:

1. GPFS will prefetch data for stat cache entries if a pattern of use indicates this will be productive. Such a pattern might be a number of **ls -l** commands issued for a large directory.
2. Each entry in the inode cache and the stat cache requires appropriate tokens:
   a. To ensure the cached information remains correct
   b. For the storage of tokens on the file system manager node
3. Depending on the usage pattern, system performance may degrade when an information update requires revoking a token. This happens when two or more nodes share the same information and the most recent information is moved to a different location. When the current node needs to access the updated information, the token manager must revoke the token from the current node before that node can access the information in the new location.

GPFS and network communication

Within the GPFS cluster, you may specify different networks for GPFS daemon communication and for GPFS administration command usage. You make these selections using the **mmchcluster** command. In this command, the node descriptor allows you to specify separate node interfaces for those functions on each node. The correct operation of GPFS is directly dependent upon these selections:

- “GPFS daemon communications”
- “GPFS administration commands” on page 81

GPFS daemon communications

In a cluster environment, the GPFS daemon depends on the correct operation of TCP/IP. These dependencies exist because:

- The communication path between nodes must be built at the first attempt to communicate.
- Each node in the cluster is required to communicate with the configuration manager and the file system manager during startup and mount processing.
- Once a connection is established, it must remain active until the GPFS daemon is shut down on the nodes.

Note: Establishing other communication paths depends upon application usage among nodes.

The daemon also uses sockets to communicate with other instances of the file system on other nodes. Specifically, the daemon on each node communicates with the file system manager for allocation of logs, allocation segments, and quotas, as well as for various recovery and configuration flows. GPFS requires an active internode communications path between all nodes in a cluster for locking, metadata coordination,

administration commands, and other internal functions. The existence of this path is necessary for the correct operation of GPFS. The instance of the GPFS daemon on a node will go down if it senses that this communication is not available to it. If communication is not available to another node, one of the two nodes will exit GPFS.

Using public and private IP addresses for GPFS nodes

GPFS permits the system administrator to set up a cluster such that both public and private IP addresses are in use. For example, if a cluster has an internal network connecting some of its nodes, it is advantageous to use private IP addresses to communicate on this network, and public IP addresses to communicate to resources outside of this network. Public IP addresses are those that can be used to access the node from any other location for which a connection exists. Private IP addresses may be used only for communications between nodes directly connected to each other with a communications adapter. Private IP addresses are assigned to each node at hardware setup time, and must be in a specific address range (IP addresses on a 10.0.0.0, 172.16.0.0, or 192.168.0.0 subnet). For more information on private IP addresses see RFC 1597 - Address Allocation for Private Internets).

The **subnets** operand on the **mmchconfig** command specifies an ordered list of **subnets** available to GPFS for private TCP/IP communications. Each subnet listed may have a list of cluster names (allowing shell-style wild cards) that specifies other GPFS clusters that have direct access to the same subnet.

When the GPFS daemon starts on a node, it obtains a list of its own IP addresses and associated subnet masks from its local IP configuration. For each IP address, GPFS checks whether that address is on one of the subnets specified on the **subnets** configuration parameter. It records the list of its matching IP addresses and subnet masks, and then listens for connections on any of these addresses. If any IP address for the node (specified when the cluster was created or when the node was added to the cluster), is not specified with the **subnets** configuration parameter, GPFS automatically adds it to the end of the node's IP address list.

Therefore, when using public IP addresses for a node, there is no need to explicitly list the public IP subnet with the **subnets** configuration parameter. For example, the normal way to configure a system would be to use host names that resolve to the external Ethernet IP address in the **mmcrcluster** command, and then, if the system administrator wants GPFS to use the High Performance Switch within the cluster, add one **subnets** configuration parameter for the HPS subnet. It is acceptable to add two **subnets** configuration parameters, one for the HPS and one for the external Ethernet, making sure that they are in that order. In this case it does not matter which of each node's two addresses was specified when the cluster was created or when the node was added to the cluster. For example, to add remote access to an existing cluster that was using only switch addresses, it is sufficient to add two **subnets** configuration parameters.

When a node joins a cluster (its own cluster on startup, or another cluster when mounting a file system owned by another cluster), the node sends its list of IP addresses (ordered according to the order of **subnets** configuration parameters) to the configuration manager node, which forwards the list to all other nodes as part of the join protocol. No other additional information needs to be propagated.

When a node attempts to establish a connection to another node, GPFS determines the destination IP address to use according to this procedure:

1. For each of its own IP addresses, it searches the other node's list of IP addresses for an address that is on the same subnet.
   - For normal public IP addresses this is done by comparing IP address values ANDed with the node's subnet mask for its IP address.
   - For private IP addresses GPFS assumes that two IP addresses are on the same subnet only if the two nodes are within the same cluster, or if the other node is in one of the clusters explicitly listed in the **subnets** configuration parameter.
2. If the two nodes have more than one IP address pair on a common subnet, GPFS uses the first one found according to the order of **subnets** specified in the initiating node's configuration parameters.

3. If there are no two IP addresses on the same subnet, GPFS uses the last IP address in each node's IP address list. In other words, the last subnet specified in the **subnets** configuration parameter is assumed to be on a network that is accessible from the outside.

For more information and an example, see *Using remote access with public and private IP addresses* in *General Parallel File System: Advanced Administration*.

GPFS administration commands

Socket communications are used to process GPFS administration commands. Depending on the nature of the command, GPFS may process commands either on the node issuing the command or on the file system manager. The actual command processor merely assembles the input parameters and sends them along to the daemon on the local node using a socket.

Some GPFS commands permit you to specify a separate administrative network name. You make this specification using the **AdminNodeName** field of the node descriptor. For additional information, refer to the *GPFS: Administration and Programming Reference* for descriptions of these commands:

- **mmaddnode**
- **mmchcluster**
- **mmcrcluster**

If the command changes the state of a file system or its configuration, the command is processed at the file system manager. The results of the change are sent to all nodes and the status of the command processing is returned to the node, and eventually, to the process issuing the command. For example, a command to add a disk to a file system originates on a user process and:

1. Is sent to the daemon and validated.
2. If acceptable, it is forwarded to the file system manager, which updates the file system descriptors.
3. All nodes that have this file system are notified of the need to refresh their cached copies of the file system descriptor.
4. The return code is forwarded to the originating daemon and then to the originating user process.

Be aware that this chain of communication may allow faults related to the processing of a command to occur on nodes other than the node on which the command was issued.

Application and user interaction with GPFS

There are four ways to interact with a GPFS file system:

1. "Operating system commands"
2. "Operating system calls" on page 82
3. "GPFS command processing" on page 85
4. Programming calls (see the *GPFS: Administration and Programming Reference* and the *GPFS: Data Managemen API Guide*).

Operating system commands

Operating system commands operate on GPFS data during:

- The initialization of the GPFS daemon
- The mounting of a file system

Initialization

GPFS initialization can be done automatically as part of the node startup sequence, or manually using the **mmstartup** command to start the daemon. The daemon startup process loads the necessary kernel extensions, if they have not been previously loaded by an earlier instance of the daemon subsequent to the current boot of this node. The initialization sequence then waits for the configuration manager to

declare that a quorum exists. When quorum is achieved, the configuration manager changes the state of the group from *initializing* to *active*. This transition is evident in a message to the GPFS console file (**/var/adm/ras/mmfs.log.latest**). When this state changes from *initializing* to *active*, the daemon is ready to accept mount requests. The message `mmfsd ready` will appear in the GPFS console file.

mount

GPFS file systems are mounted using the operating system's **mount** command, or the GPFS **mmmount** command. GPFS mount processing builds the structures that serve as the path to the data, and is performed on both the node requesting the mount and the file system manager node. If there is no file system manager, a call is made to the configuration manager, which appoints one. The file system manager will ensure that the file system is ready to be mounted. This includes checking that there are no conflicting utilities being run by the **mmfsck** or **mmcheckquota** commands, for example, and running any necessary log processing to ensure that metadata on the file system is consistent.

On the local node the control structures required for a mounted file system are initialized and the token management function domains are created. In addition, paths to each of the disks that make up the file system are opened. Part of mount processing involves unfencing the disks, which may be necessary if this node had previously failed. This is done automatically without user intervention. If insufficient disks are up, the mount will fail. That is, in a replicated system if two disks are down in different failure groups, the mount will fail. In a non-replicated system, one disk down will cause the mount to fail.

Operating system calls

The most common interface is through normal file system calls to the operating system, which are relayed to GPFS if data in a GPFS file system is involved. This uses GPFS code in a kernel extension, which attempts to satisfy the application request using data already in memory. If this can be accomplished, control is returned to the application through the operating system interface. If the request requires resources that are not available at the time, the request is transferred for execution by a daemon thread. The daemon threads wait for work in a system call in the kernel, and are scheduled as necessary. Services available at the daemon level are the acquisition of tokens and disk I/O.

Operating system calls operate on GPFS data during:

- The opening of a file
- The reading of data
- The writing of data

open

The **open** of a GPFS file involves the application making a call to the operating system specifying the name of the file. Processing of an **open** involves two stages:

1. The directory processing required to identify the file specified by the application.
2. The building of the required data structures based on the inode.

The kernel extension code will process the directory search for those directories that reside in GPFS (part of the path to the file may be directories in other physical file systems). If the required information is not in memory, the daemon will be called to acquire the necessary tokens for the directory or part of the directory needed to resolve the lookup. It will also read the directory entry into memory.

The lookup process occurs one directory at a time in response to calls from the operating system. In the final stage of **open**, the inode for the file is read from disk and connected to the operating system vnode structure. This requires acquiring locks on the inode, as well as a lock that indicates the presence to the metanode:

- If no other node has this file open, this node becomes the metanode.
- If another node has a previous open, then that node is the metanode and this node will interface with the metanode for certain parallel write situations.

- If the **open** involves creation of a new file, the appropriate locks are obtained on the parent directory and the inode allocation file block. The directory entry is created, an inode is selected and initialized and then **open** processing is completed.

read

The GPFS **read** function is invoked in response to a **read** system call and a call through the operating system vnode interface to GPFS. **read** processing falls into three levels of complexity based on system activity and status:

1. Buffer available in memory
2. Tokens available locally but data must be read
3. Data and tokens must be acquired

Buffer and locks available in memory: The simplest **read** operation occurs when the data is already available in memory, either because it has been pre-fetched or because it has been read recently by another **read** call. In either case, the buffer is locally locked and the data is copied to the application data area. The lock is released when the copy is complete. Note that no token communication is required because possession of the buffer implies that we at least have a read token that includes the buffer. After the copying, prefetch is initiated if appropriate.

Tokens available locally but data must be read: The second, more complex, type of **read** operation is necessary when the data is not in memory. This occurs under three conditions:

1. The token has been acquired on a previous **read** that found no contention.
2. The buffer has been stolen for other uses.
3. On some random **read** operations.

   In the first of a series of random reads the token will not be available locally, but in the second read it might be available.

In such situations, the buffer is not found and must be read. No token activity has occurred because the node has a sufficiently strong token to lock the required region of the file locally. A message is sent to the daemon, which is handled on one of the waiting daemon threads. The daemon allocates a buffer, locks the file range that is required so the token cannot be stolen for the duration of the I/O, and initiates the I/O to the device holding the data. The originating thread waits for this to complete and is posted by the daemon upon completion.

Data and tokens must be acquired: The third, and most complex **read** operation requires that tokens as well as data be acquired on the application node. The kernel code determines that the data is not available locally and sends the message to the daemon waiting after posting the message. The daemon thread determines that it does not have the required tokens to perform the operation. In that case, a token acquire request is sent to the token management server. The requested token specifies a required length of that range of the file, which is needed for this buffer. If the file is being accessed sequentially, a desired range of data, starting at this point of this read and extending to the end of the file, is specified. In the event that no conflicts exist, the desired range will be granted, eliminating the need for token calls on subsequent reads. After the minimum token needed is acquired, the flow proceeds as in step 3 on page 74 (token management).

At the completion of a **read**, a determination of the need for prefetch is made. GPFS computes a desired read-ahead for each open file based on the performance of the disks and the rate at which the application is reading data. If additional prefetch is needed, a message is sent to the daemon that will process it asynchronously with the completion of the current read.

write

write processing is initiated by a system call to the operating system, which calls GPFS when the **write** involves data in a GPFS file system.

GPFS moves data from a user buffer into a file system buffer synchronously with the application **write** call, but defers the actual write to disk. This technique allows better scheduling of the disk and improved performance. The file system buffers come from the memory allocated based on the **pagepool** parameter in the **mmchconfig** command. Increasing this value may allow more writes to be deferred, which improves performance in certain workloads.

A block of data is scheduled to be written to a disk when:

- The application has specified synchronous **write**.
- The system needs the storage.
- A token has been revoked.
- The last byte of a block of a file being written sequentially is written.
- A **sync** is done.

Until one of these occurs, the data remains in GPFS memory.

write processing falls into three levels of complexity based on system activity and status:

1. Buffer available in memory
2. Tokens available locally but data must be read
3. Data and tokens must be acquired

Metadata changes are flushed under a subset of the same conditions. They can be written either directly, if this node is the metanode, or through the metanode, which merges changes from multiple nodes. This last case occurs most frequently if processes on multiple nodes are creating new data blocks in the same region of the file.

Buffer available in memory: The simplest path involves a case where a buffer already exists for this block of the file but may not have a strong enough token. This occurs if a previous **write** call accessed the block and it is still resident in memory. The write token already exists from the prior call. In this case, the data is copied from the application buffer to the GPFS buffer. If this is a sequential **write** and the last byte has been written, an asynchronous message is sent to the daemon to schedule the buffer for writing to disk. This operation occurs on the daemon thread overlapped with the execution of the application.

Token available locally but data must be read: There are two situations in which the token may exist but the buffer does not:

1. The buffer has been recently stolen to satisfy other needs for buffer space.
2. A previous **write** obtained a desired range token for more than it needed.

In either case, the kernel extension determines that the buffer is not available, suspends the application thread, and sends a message to a daemon service thread requesting the buffer. If the **write** call is for a full file system block, an empty buffer is allocated since the entire block will be replaced. If the **write** call is for less than a full block and the rest of the block exists, the existing version of the block must be read and overlaid. If the **write** call creates a new block in the file, the daemon searches the allocation map for a block that is free and assigns it to the file. With both a buffer assigned and a block on the disk associated with the buffer, the **write** proceeds as it would in “Buffer available in memory.”

Data and tokens must be acquired: The third, and most complex path through **write** occurs when neither the buffer nor the token exists at the local node. Prior to the allocation of a buffer, a token is acquired for the area of the file that is needed. As was true for **read**, if sequential operations are occurring, a token covering a larger range than is needed will be obtained if no conflicts exist. If necessary, the token management function will revoke the needed token from another node holding the token. Having acquired and locked the necessary token, the **write** will continue as in “Token available locally but data must be read.”

stat

The **stat()** system call returns data on the size and parameters associated with a file. The call is issued by the **ls -l** command and other similar functions. The data required to satisfy the **stat()** system call is contained in the inode. GPFS processing of the **stat()** system call differs from other file systems in that it supports handling of **stat()** calls on all nodes without funneling the calls through a server.

This requires that GPFS obtain tokens that protect the accuracy of the metadata. In order to maximize parallelism, GPFS locks inodes individually and fetches individual inodes. In cases where a pattern can be detected, such as an attempt to **stat()** all of the files in a larger directory, inodes will be fetched in parallel in anticipation of their use.

Inodes are cached within GPFS in two forms:

1. Full inode
2. Limited stat cache form

The full inode is required to perform data I/O against the file.

The stat cache form is smaller than the full inode, but is sufficient to open the file and satisfy a **stat()** call. It is intended to aid functions such as **ls -l**, **du**, and certain backup programs that scan entire directories looking for modification times and file sizes.

These caches and the requirement for individual tokens on inodes are the reason why a second invocation of directory scanning applications may run faster than the first.

GPFS command processing

GPFS commands fall into two categories: those that are processed locally and those that are processed at the file system manager for the file system involved in the command. The file system manager is used to process any command that alters the state of the file system. When commands are issued but the file system is not mounted, a file system manager is appointed for the task. The **mmchdisk** command and the **mmfsck** command represent two typical types of commands that are processed at the file system manager.

The mmchdisk command

The **mmchdisk** command is issued when a failure that caused the unavailability of one or more disks has been corrected. The need for the command can be determined by the output of the **mmlsdisk** command. **mmchdisk** performs four major functions:

- It changes the availability of the disk to **recovering**, and to **up** when all processing is complete. All GPFS utilities honor an availability of **down** and do not use the disk. **recovering** means that recovery has not been completed but the user has authorized use of the disk.
- It restores any replicas of data and metadata to their correct value. This involves scanning all metadata in the system and copying the latest to the recovering disk. Note that this involves scanning large amounts of data and potentially rewriting all data on the disk. This can take a long time for a large file system with a great deal of metadata to be scanned.
- It stops or suspends usage of a disk. This merely involves updating a disk state and should run quickly.
- Change disk attributes' metadata.

Subsequent invocations of **mmchdisk** will attempt to restore the replicated data on any disk left in with an availability of **recovering**

The mmfsck Command

The **mmfsck** command repairs file system structures. **mmfsck** operates in two modes:

1. online
2. offline

For performance reasons, GPFS logging allows the condition where disk blocks are marked **used** but not actually part of a file after a node failure. The online version of **mmfsck** cleans up that condition. Running **mmfsck -o -n** scans the file system to determine if correction might be useful. The online version of **mmfsck** runs on the file system manager and scans all inodes and indirect blocks looking for disk blocks that are allocated but not used. If authorized to repair the file system, it releases the blocks. If not authorized to repair the file system, it reports the condition to standard output on the invoking node.

The offline version of **mmfsck** is the last line of defense for a file system that cannot be used. It will most often be needed in the case where GPFS recovery logs are not available because of disk media failures. **mmfsck** runs on the file system manager and reports status to the invoking node. It is mutually incompatible with any other use of the file system and checks for any running commands or any nodes with the file system mounted. It exits if any are found. It also exits if any disks are **down** and require the use of **mmchdisk** to change them to **up** or **recovering**. **mmfsck** performs a full file system scan looking for metadata inconsistencies. This process can be lengthy on large file systems. It seeks permission from the user to repair any problems that are found, which may result in the removal of files or directories that are corrupt. The processing of this command is similar to those for other file systems.

NSD disk discovery

NSD disk access through disk discovery invokes:

- the GPFS shell script **/usr/lpp/mmfs/bin/mmdevdiscover**
- if it exists, the user modifiable shell script **/var/mmfs/etc/nsddevices**

These scripts provide a list of available disk devices that appear in the node's local **/dev** file system. This list is subsequently used by GPFS in determining if a **/dev** device interface on the local node maps to an NSD name recorded in the configuration database.

The process of mapping a **/dev** device interface to an NSD involves GPFS opening each device in turn and reading any NSD volume identifier potentially recorded at sector two of the disk.

If GPFS discovers that a NSD volume identifier read from a disk device matches the volume identifier recorded with the NSD name in the GPFS configuration database, I/O for the local node proceeds over the local **/dev** interface.

If no **/dev** mapping appears on the local node for a particular NSD, I/O proceeds over the IP network to the primary and, if specified, backup NSD server for that NSD.

Consult the **/usr/lpp/mmfs/samples/nsddevices.sample** file for configuration guidelines on how to provide additional disk discovery capabilities unique to your configuration.

Recovery

In general it is unnecessary to understand the internals of GPFS failure recovery processing. However some familiarity with the concepts may be useful when failures are observed. It should be noted that only one state change, such as the loss or initialization of a node, can be processed at a time and subsequent changes will be queued. This means that the entire failure processing must complete before the failed node can join the group again. All failures are processed first, which means that GPFS will handle all failures prior to completing any recovery.

GPFS recovers from node failure using join or leave processing messages explicitly sent by the configuration manager node. The configuration manager node observes that a node has failed when it no longer receives heartbeat messages from the node. The join or leave processing messages are broadcast to the entire group of nodes running GPFS, and each node updates its current status for the failing or joining node. Failure of the configuration manager node results in a new configuration manager being elected and processing a failure message for the old configuration manager.

When notified that a node has failed or that the GPFS daemon has failed on a node, GPFS invokes recovery for each of the file systems that were mounted on the failed node. If necessary, new file system managers are selected for any file systems that no longer have one.

The file system manager for each file system ensures the failed node no longer has access to the disks comprising the file system. If the file system manager is newly appointed as a result of this failure, it rebuilds token state by querying the other nodes of the group. After this is complete, the actual recovery of the log of the failed node proceeds. This recovery will rebuild the metadata that was being modified at the time of the failure to a consistent state with the possible exception that blocks may be allocated that are not part of any file and are effectively lost until **mmfsck** is run, online or offline. After log recovery is complete, the locks held by the failed nodes are released for this file system. Completion of this activity for all file systems completes the failure processing. The completion of the protocol allows a failed node to rejoin the cluster.

Cluster configuration data files

GPFS commands save configuration and file system information in one or more files collectively known as GPFS cluster configuration data files. These files are not intended to be modified manually. The GPFS administration commands are designed to keep these file synchronized between each other and with the GPFS system files on each node in the cluster. The GPFS commands constantly update the GPFS cluster configuration data files and any user modification made to this information may be lost without warning. On AIX nodes this includes the GPFS file system stanzas in **/etc/filesystems** and on Linux nodes the lists in **/etc/fstab**.

The GPFS cluster configuration data is stored in the **/var/mmfs/gen/mmsdrfs** file. This file is stored on the nodes designated as the primary GPFS cluster configuration server and, if specified, the secondary GPFS cluster configuration server. See “GPFS cluster configuration servers” on page 23. The first record in the **mmsdrfs** file contains a generation number. Whenever a GPFS command causes something to change in the cluster or any of the file systems, this change is reflected in the **mmsdrfs** file and the generation number is increased by one. The latest generation number is always recorded in the **mmsdrfs** file on the primary and secondary GPFS cluster configuration server nodes.

When running GPFS administration commands, it is necessary for the GPFS cluster configuration data to be accessible to the node running the command. Commands that update the **mmsdrfs** file require that both the primary and, if specified, the secondary GPFS cluster configuration server nodes are accessible. If one of the server nodes is inaccessible it can be changed through the **mmchcluster** command. Similarly, when the GPFS daemon starts up, at least one of the two server nodes must be accessible.

Based on the information in the GPFS cluster configuration data, the GPFS commands generate and maintain a number of system files on each of the nodes in the GPFS cluster. Some of these files are:

/etc/fstab
: On Linux nodes, contains lists for all GPFS file systems that exist in the cluster.

/etc/filesystems
: On AIX nodes, contains lists for all GPFS file systems that exist in the cluster.

/var/mmfs/gen/mmfsNodeData
: Contains GPFS cluster configuration data pertaining to the node.

/var/mmfs/gen/mmsdrfs
: Contains a local copy of the **mmsdrfs** file found on the primary and secondary GPFS cluster configuration server nodes.

/var/mmfs/etc/mmfs.cfg
: Contains GPFS daemon startup parameters.

GPFS backup data

The GPFS **mmbackup** command creates several files during command execution. Some of the files are temporary and deleted at the end of the backup operation. There are other files that remain in the root directory of the file system and should not be deleted:

.mmbuControl
Contains the control information and the results from the previous invocation of the **mmbackup** command. This includes the node designated as the backup server, nodes designated as backup clients, the number of processes per client node, the completion level (return code), and the total number of inodes processed. This information is used in resuming a partially successful backup.

.mmbuPendingChgs
Contains information regarding a partially successful invocation of the **mmbackup** command, where all changes did not complete. This file is used when the command is reissued with the resume (**-R**) option.

.mmbuPendingDels
Contains information regarding a partially successful invocation of the **mmbackup** command, where all deletions did not complete. This file is used when the command is reissued with the resume (**-R**) option.

.mmbuShadowCheck
Contains a list of all the files that were backed up. This file is used for subsequent incremental backups. The backup restore utility performs a full incremental backup where files deleted from the file system are deleted from the backup copy. In order to determine which files have since been deleted, this file must be available from the previous backup. The size of the shadow file is approximately (1100 * *N*) bytes, where *N* is the number of files in the file system.

The **mmbackup** command may create other files as well. Assume that files whose names begin with **.mmbu** are associated with the **mmbackup** command, and do not manually delete or change them.

Appendix B. IBM Virtual Shared Disk considerations

On AIX nodes in your cluster, disk subsystem support may be provided through:

- The IBM Virtual Shared Disk component providing disk driver level support for GPFS cluster wide disk accessibility.
- The IBM Recoverable Virtual Shared Disk component providing the capability to fence a node from accessing certain disks, which is a prerequisite for successful recovery of that node. It also provides for transparent failover of disk access in the event of the failure of a disk server.

Software simulation of a SAN is provided by the use of the IBM Virtual Shared Disk component of RSCT. Disks attached in this manner are formatted into virtual shared disks for use by GPFS through the **mmcrvsd** command provided by GPFS or by the **createvsd** command provided by the RSCT subsystem.

The IBM Virtual Shared Disk subsystem supports two methods of external disk access:

- A non-concurrent mode in which only one virtual shared disk server has access to a shared external disk at a given time. A primary and a backup server are defined.
- A concurrent mode in which multiple servers are defined to access the disk concurrently.

The IBM Recoverable Virtual Shared Disk component allows a secondary or backup server to be defined for a logical volume, providing the fencing capabilities required to preserve data integrity in the event of certain system failures. See “Node failure” on page 16. Therefore, the IBM Recoverable Virtual Shared Disk component is required even in the event there are no twin-tailed disks. The *Reliable Scalable Cluster Technology: Managing Shared Disks* manual contains installation, management, and usage information for both the IBM Virtual Shared Disk and the IBM Recoverable Virtual Shared Disk.

Virtual shared disk server considerations

Will your virtual shared disk servers be dedicated servers or will you also be using them to run applications? If you will have non-dedicated servers, consider running less time-critical applications on these nodes. If you run time-critical applications on a virtual shared disk server, servicing disk requests from other nodes might conflict with the demands of these applications.

The special functions of the GPFS file system manager consume extra processing time. If possible, avoid using a virtual shared disk server as the file system manager. The virtual shared disk server consumes both memory and processor cycles that could impact the operation of the file system manager. See “The file system manager” on page 73.

The actual processing capability required for virtual shared disk service is a function of the application I/O access patterns, the type of node, the type of disk, and the disk connection. You can later run **iostat** on the server to determine how much of a load your access pattern will place on a virtual shared disk server.

Assure that you have sufficient resources to run the IBM Virtual Shared Disk program efficiently. This includes enough buddy buffers of sufficient size to match your file system block size, as well as setting other parameters in the communications subsystem. See the *Managing Shared Disks* manual for your environment and search on *Performance and tuning considerations for virtual shared disks*:

- *Reliable Scalable Cluster Technology: Managing Shared Disks*

Disk distribution

Plan how to distribute your disks among the virtual shared disk servers. Two considerations should guide your decision. One involves providing sufficient disks and adapters on the system to yield the required I/O bandwidth. The other involves knowing approximately how much storage capacity you will need for your

data. Dedicated virtual shared disk servers should have sufficient disks and adapters to drive the I/O load you expect them to handle. See “Disk I/O” on page 67 for further information on configuring your disk I/O options.

Prepare a list of disks that each virtual shared disk server will be using. This list will be helpful when creating disk descriptors during file system creation. If you have multi-tailed disks, and want to configure for primary and backup virtual shared disk servers (to protect against virtual shared disk server node failure), record the disk device name on the primary server, and the node numbers of the primary and backup servers. For example, if your virtual shared disk servers are nodes 1, 3, 5, and 7:

```
Disk          on Primary node     Backup node
hdisk2               1                3
hdisk3               3                1
hdisk2               5               n/a
hdisk2               7               n/a
```

In this case, nodes 1 and 3 share disks using multi-tailing and will back up each other. However, nodes 5 and 7 will each bear the full responsibility of serving their disks. These are the disks that will be made into virtual shared disks from which your GPFS file system will be constructed.

Disk connectivity

If your disks are capable of twin-tailing and you wish to exploit this capability, you must select an alternate node as the backup virtual shared disk server. See the *Managing Shared Disks* manual for your environment for help in selecting these nodes:

- *Reliable Scalable Cluster Technology: Managing Shared Disks*

Virtual shared disk creation considerations

GPFS uses virtual shared disks to access raw logical volumes as if they were local at each of the nodes. Although the *Managing Shared Disks* book is the definitive source for instructions on how to create virtual shared disks, you can have GPFS create them through the **mmcrvsd** command.

For performance reasons, GPFS creates one virtual shared disk for each physical disk specified for the file system, and assigns an optimal partition size based on the disk's capacity. A virtual shared disk name is also automatically generated. If you want to take advantage of the flexibility available in creating virtual shared disks, follow the instructions in the *Managing Shared Disks* manual then pass the newly created virtual shared disk to the GPFS file system by specifying the virtual shared disk name (see “Disks for your file system” on page 33):

- *Reliable Scalable Cluster Technology: Managing Shared Disks*

The **mmcrvsd** command expects as input a file, *DescFile*, containing a disk descriptor, one per line, for each of the disks to be processed. Disk descriptors have the format:

```
DiskName:PrimaryServer:BackupServer:DiskUsage:FailureGroup:DesiredName:StoragePool
```

DiskName
: The physical device name of the disk you want to define as a virtual shared disk. This is the **/dev** name for the disk on the node on which the **mmcrvsd** command is issued and can be either an hdisk name or a vpath name for an SDD device. Each disk will be used to create a single virtual shared disk.

  Alternatively, the name of a virtual shared disk created using AIX and virtual shared disk commands. In this case, the virtual shared disk is registered in the GPFS configuration database for subsequent use by GPFS commands.

PrimaryServer
: The name of the primary virtual shared disk server node.

BackupServer
: The backup server name.

Disk Usage

What is to be stored on the disk.

dataAndMetadata
Indicates that the disk contains both data and metadata. This is the default.

dataOnly
Indicates that the disk contains data and does not contain metadata.

metadataOnly
Indicates that the disk contains metadata and does not contain data.

descOnly
Indicates that the disk contains no data or metadata and is used solely to keep a copy of the file system descriptor. Such a disk allows file system descriptor quorum to be maintained.

Disk usage considerations:

1. The *DiskUsage* parameter is not utilized by the **mmcrvsd** command but is copied intact to the output file that the command produces. The output file may then be used as input to the **mmcrnsd** command.
2. RAID devices are not well-suited for performing small block writes. Since GPFS metadata writes are often smaller than a full block, you may find using non-RAID devices for GPFS metadata better for performance.

FailureGroup

A number identifying the failure group to which this disk belongs. All disks that are either attached to the same adapter or virtual shared disk server have a common point of failure and should therefore be placed in the same failure group as shown in Figure 15.

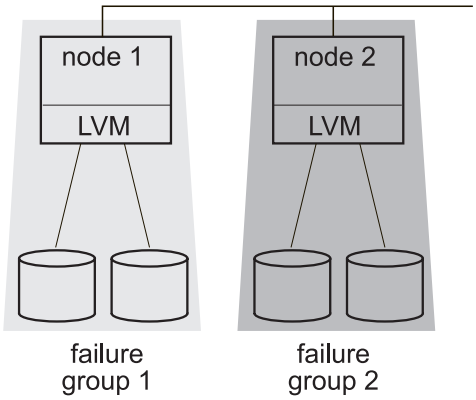


Figure 15. Basic failure groups with servers and disks

GPFS uses this information during data and metadata placement to assure that no two replicas of the same block will become unavailable due to a single failure. You can specify any value from -1 (where -1 indicates that the disk has no point of failure in common with any other disk) to 4000. If you specify no failure group, the value defaults to the primary virtual shared disk server node number plus 4000, thereby creating distinct failure groups.

If you plan to use both twin-tailed disks and replication, assign disks to the failure groups with their primary servers, as shown in Figure 16 on page 92. This arrangement would assure availability of replicated data if either server failed.

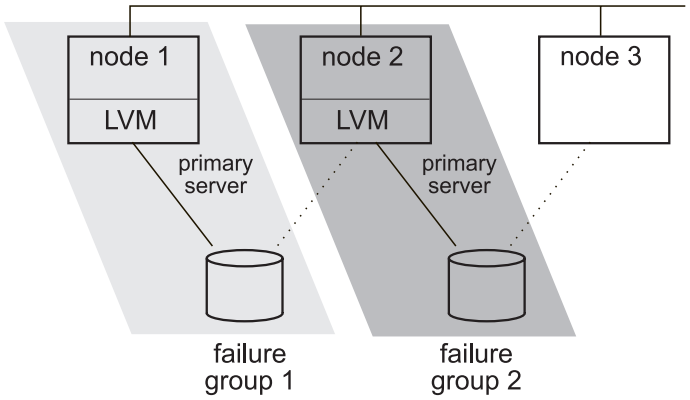


Figure 16. Failure groups with twin-tailed disks

Failure group considerations: The *FailureGroup* parameter is not utilized by the **mmcrvsd** command but is copied intact to the output file that the command produces. The output file may then be used as input to the **mmcrnsd** command.

DesiredName

Specify the name you desire for the virtual shared disk to be created. This name must not already be used by another GPFS disk name, and it must not begin with the reserved string ″gpfs″. If a desired name is not specified, the virtual shared disk is assigned a name according to the convention:

gpfs*NN***vsd**

Where *NN* is a unique non negative integer not used in any prior virtual shared disk. These global disk names must be subsequently used on all GPFS commands. GPFS commands, other than the **mmcrvsd** command, will not accept physical disk device names.

If a desired name is specified on the disk descriptor, **mmcrvsd** uses that name as the basis for the names of the global volume group, local logical volume, and local volume group name according to the convention:

*DesiredName***gvg**

The global volume group

*DesiredName***lv**

The local logical volume

*DesiredName***vg**

The local volume group

If a desired name is not specified on the disk descriptor, **mmcrvsd** assigns the names of the global volume group, local logical volume, and local volume group name according to the convention:

gpfs*NN***gvg**

Where *NN* is a unique non negative integer not used in any prior global volume group named with this convention.

gpfs*NN***lv**

Where *NN* is a unique non negative integer not used in any prior logical volume named with this convention.

gpfs*NN***vg**

Where *NN* is a unique non negative integer not used in any prior volume group named with this convention.

StoragePool

Specifies the name of the storage pool that the NSD is assigned to. This field is ignored by the **mmcrnsd** command, and is passed unchanged to the output descriptor file produced by the **mmcrnsd** command.

Upon successful completion of the **mmcrvsd** command the disk descriptors in the input file are rewritten:

- The physical device or vpath name is replaced with the created virtual shared disk name.
- The primary and backup servers are omitted.
- The *DiskUsage* and *FailureGroup* fields are not changed.

The rewritten disk descriptor file, *DescFile*, can then be used as input to the **mmcrnsd** command. The *DiskUsage* and *FailureGroup* specifications in the disk descriptor are only preserved in the *DescFile* file rewritten by the **mmcrvsd** command. If you do not use this file, you must accept the default values or specify these values when creating disk descriptors for subsequent **mmcrfs**, **mmadddisk**, or **mmrpldisk** commands.

If necessary, the *DiskUsage* and *FailureGroup* values for a disk can be changed with the **mmchdisk** command. The virtual shared disk name cannot be changed.

Virtual shared disk server and disk failure

One means of data protection is the use of a RAID controller, which masks disk failures with parity disks. An ideal configuration is shown in Figure 17, where a RAID device is twin-tailed to two nodes. This protects against server failure as well.

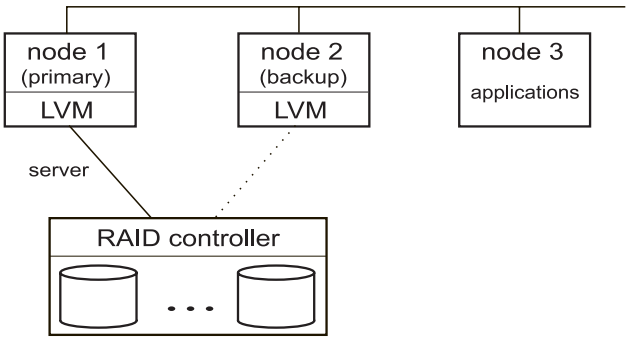


Figure 17. Primary node serving RAID device

If node 1, the primary server, fails, its responsibilities are assumed by node 2, the backup server, as shown in Figure 18.

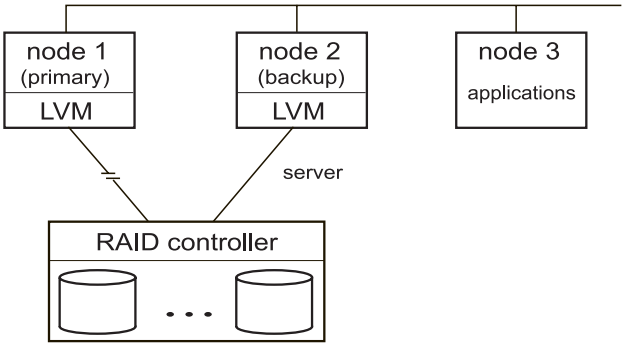


Figure 18. Backup node serving RAID device

If your disks are SAN-attached to the virtual shared disk servers, an ideal configuration is shown in Figure 19.

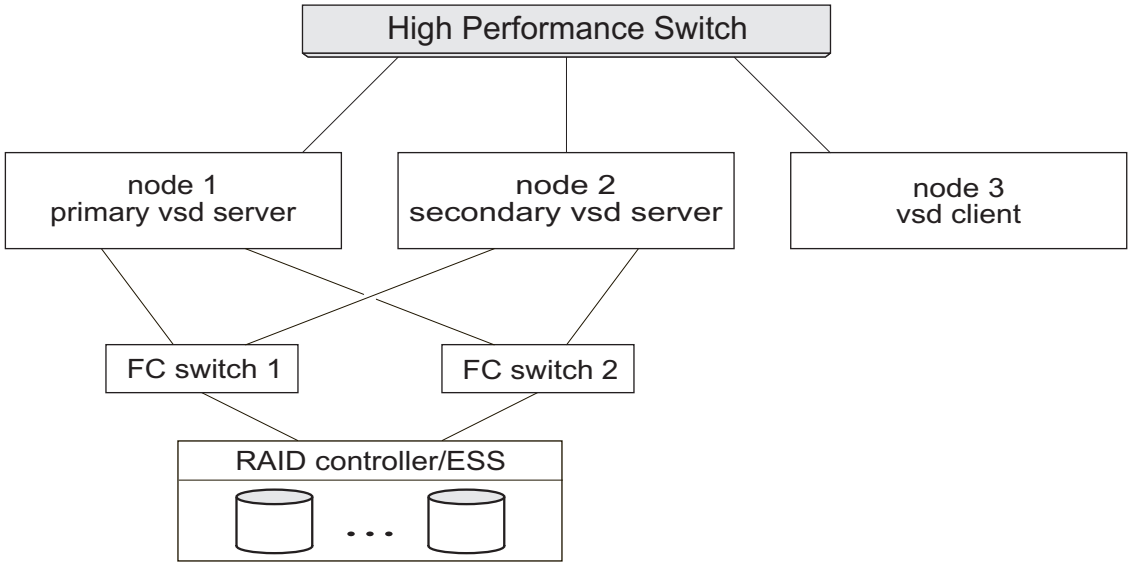


Figure 19. RAID/ESS Controller multi-tailed to the primary and secondary virtual shared disk servers

Another means of data protection is through the use of concurrent virtual shared disks, as shown in Figure 20. Concurrent disk access allows you to use multiple servers to satisfy disk requests by taking advantage of the concurrent disk access environment supplied by AIX. For further information regarding concurrent virtual shared disks, see the *Managing Shared Disks* manual for your environment:

- *Reliable Scalable Cluster Technology: Managing Shared Disks*

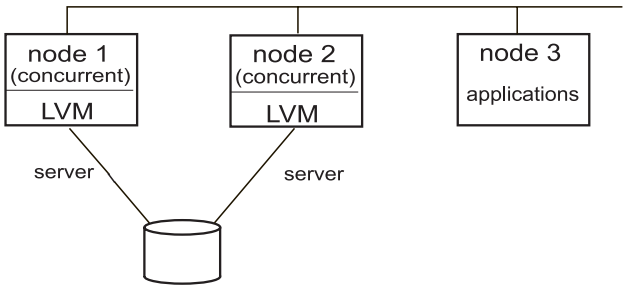


Figure 20. Concurrent node serving device

You can also protect your file system against disk failure by *mirroring data* at the logical volume manager (LVM) level, writing the data twice to two different disks. The addition of twin-tailed disks to such a configuration adds protection against server failure by allowing the IBM Recoverable Virtual Shared Disk program to route requests through a backup server.

Appendix C. Considerations for GPFS applications

Application design should take into consideration:

- "Exceptions to Open Group technical standards"
- "Determining if a file system is controlled by GPFS"
- "GPFS exceptions and limitations to NFS V4 ACLs" on page 96

Exceptions to Open Group technical standards

GPFS is designed so that most applications written to The Open Group technical standard for file system calls can access GPFS data with no modification, however, there are some exceptions.

Applications that depend on exact reporting of changes to the following fields returned by the **stat()** call may not work as expected:

1. **exact mtime**
2. **mtime**
3. **ctime**
4. **atime**

Providing exact support for these fields would require significant performance degradation to all applications executing on the system. These fields are guaranteed accurate when the file is closed.

These values will be accurate on a node right after it accesses or modifies a file, but may not be accurate for a short while when a file is accessed or modified on some other node.

If 'exact mtime' is specified for a file system (using the **mmcrfs** or **mmchfs** commands with the **-E yes** flag), the **mtime** and **ctime** values are always correct by the time the **stat()** call gives its answer. If 'exact mtime' is not specified, these values will be accurate after a couple of minutes, to allow the synchronization daemons to propagate the values to all nodes. Regardless of whether 'exact mtime' is specified, the **atime** value will be accurate after a couple of minutes, to allow for all the synchronization daemons to propagate changes.

Alternatively, you may use the GPFS calls, **gpfs_stat()** and **gpfs_fstat()** to return exact **mtime** and **atime** values.

The delayed update of the information returned by the **stat()** call also impacts system commands which display disk usage, such as **du** or **df**. The data reported by such commands may not reflect changes that have occurred since the last sync of the file system. For a parallel file system, a sync does not occur until all nodes have individually synchronized their data. On a system with no activity, the correct values will be displayed after the sync daemon has run on all nodes.

Determining if a file system is controlled by GPFS

A file system is controlled by GPFS if the **f_type** field in the **statfs** structure returned from a **statfs()** or **fstatfs()** call has the value 0x47504653, which is the ASCII characters 'GPFS'.

This constant is in the **gpfs.h** file, with the name **GPFS_SUPER_MAGIC**. If an application includes **gpfs.h**, it can compare **f_type** to **GPFS_SUPER_MAGIC** to determine if the file system is controlled by GPFS.

GPFS exceptions and limitations to NFS V4 ACLs

GPFS has the following exceptions and limitations to the NFS V4 ACLs:

1. Alarm type ACL entries are not supported.
2. Audit type ACL entries are not supported.
3. Inherit entries (**FileInherit** and **DirInherit**) are always propagated to all child subdirectories. The NFS V4 **ACE4_NO_PROPAGATE_INHERIT_ACE** flag is not supported.
4. Although the NFS V4 ACL specification provides separate controls for **WRITE** and **APPEND**, GPFS will not differentiate between the two. Either both must be specified, or neither can be.
5. Similar to **WRITE** and **APPEND**, NFS V4 allows for separate **ADD_FILE** and **ADD_SUBDIRECTORY** controls. In most cases, GPFS will allow these controls to be specified independently. In the special case where the file system object is a directory and one of its ACL entries specifies both **FileInherit** and **DirInherit** flags, GPFS cannot support setting **ADD_FILE** without **ADD_SUBDIRECTORY** (or the other way around). When this is intended, we suggest creating separate **FileInherit** and **DirInherit** entries.
6. Some types of access for which NFS V4 defines controls do not currently exist in GPFS. For these, ACL entries will be accepted and saved, but since there is no corresponding operation they will have no effect. These include **READ_NAMED**, **WRITE_NAMED**, and **SYNCHRONIZE**.
7. AIX requires that **READ_ACL** and **WRITE_ACL** always be granted to the object owner. Although this contradicts *NFS Version 4 Protocol*, it is viewed that this is an area where users would otherwise erroneously leave an ACL that only privileged users could change. Since ACLs are themselves file attributes, **READ_ATTR** and **WRITE_ATTR** are similarly granted to the owner. Since it would not make sense to then prevent the owner from accessing the ACL from a non-AIX node, GPFS has implemented this exception everywhere.
8. AIX does not support the use of special name values other than **owner@**, **group@**, and **everyone@**. Therefore, these are the only valid special name for use in GPFS NFS V4 ACLs as well.
9. NFS V4 allows ACL entries that grant users (or groups) permission to change the owner or owning group of the file (for example, with the **chown** command). For security reasons, GPFS now restricts this so that non-privileged users may only **chown** such a file to themselves (becoming the owner) or to a group that they are a member of.
10. GPFS does not support NFS V4 exporting GPFS file systems from Linux nodes. NFS V3 is acceptable.

For more information about GPFS ACLs and NFS export, see *Managing GPFS access control lists and NFS export* in *General Parallel File System: Administration and Programming Reference*.

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Glossary

This glossary defines technical terms and abbreviations used in GPFS documentation. If you do not find the term you are looking for, refer to the index of the appropriate book or view the IBM Glossary of Computing Terms, located on the Internet at: w3.ibm.com/standards/terminology.

B

backup NSD server. A node designated to perform NSD disk access functions in the event that the primary NSD server fails.

block utilization. The measurement of the percentage of used subblocks per allocated blocks.

C

cluster. A loosely-coupled collection of independent systems (nodes) organized into a network for the purpose of sharing resources and communicating with each other. (See also "GPFS cluster" on page 103).

cluster configuration data files. The configuration data that is stored on the cluster configuration servers.

configuration manager. The node that selects file system managers and determines whether quorum exists. The oldest continuously operating node in the file system group is automatically assigned as the configuration manager.

control data structures. Data structures needed to manage file data and metadata cached in memory. Control data structures include hash tables and link pointers for finding cached data; lock states and tokens to implement distributed locking; and various flags and sequence numbers to keep track of updates to the cached data.

D

Data Management Application Program Interface (DMAPI). The interface defined by the Open Group's XDSM standard as described in the publication *System Management: Data Storage Management (XDSM) API Common Application Environment (CAE) Specification C429*, The Open Group ISBN 1-85912-190-X.

deadman switch timer. A kernel timer that ensures that a node that has lost its disk lease and has outstanding I/O requests cannot complete those requests (and risk causing file system corruption). This is achieved by panicking the kernel.

disk descriptor. A disk descriptor defines how a disk is to be used within a file system. Each descriptor supplied to the **mmcrfs** command must be in the form (second, third and sixth fields reserved):

```
DiskName:::DiskUsage:FailureGroup::StoragePool
```

Each descriptor supplied to the **mmcrnsd** command must be in the form:

```
DiskName:PrimaryServer:BackupServer:DiskUsage:
FailureGroup:DesiredName:StoragePool
```

DiskName
: The block device name appearing in **/dev** for the disk you want to define as an NSD. Examples of disks accessible through a block device are SAN-attached disks or virtual shared disks. If a *PrimaryServer* node is specified, *DiskName* must be the **/dev** name for the disk device on the primary NSD server node. Use the GPFS FAQ link at http://publib.boulder.ibm.com/infocenter/clresctr/index.jsp?topic=/com.ibm.cluster.infocenter.doc/library.html for the latest supported disk types.

  Note that GPFS provides some helper commands to ease configuration of **/dev** disk devices. For instance the **mmcrvsd** command can configure a virtual shared disk and make it accessible to nodes connected over a high performance switch. The output disk descriptor file from an **mmcrvsd** command can be used as input to the **mmcrnsd** command since the virtual shared disk names enumerated in that file will appear as **/dev** block devices on switch attached nodes.

PrimaryServer
: The name of the primary NSD server node.

  If this field is omitted, the disk is assumed to be directly attached to all nodes in the cluster.

BackupServer
: The name of the backup NSD server node.

  If the *PrimaryServer* has been specified and this field is omitted, it is assumed you do not want failover in the event the *PrimaryServer* fails. If a *PrimaryServer* has not been specified, this field must also be omitted.

Disk Usage
: What is to be stored on the disk:

  dataAndMetadata
  : Indicates that the disk contains both data and metadata. This is the default.

  dataOnly
  : Indicates that the disk contains data and does not contain metadata.

metadataOnly
Indicates that the disk contains metadata and does not contain data.

descOnly
Indicates that the disk contains no data and no metadata. Such a disk is used solely to keep a copy of the file system descriptor, and can be used as a third failure group in certain disaster recovery configurations.

FailureGroup
A number identifying the failure group to which this disk belongs. All disks that are either attached to the same adapter or NSD server have a common point of failure and should therefore be placed in the same failure group.

GPFS uses this information during data and metadata placement to assure that no two replicas of the same block become unavailable due to a single failure. You can specify any value from -1 (where -1 indicates that the disk has no point of failure in common with any other disk) to 4000. If you specify no failure group, the value defaults to the primary NSD server node number plus 4000. For disk directly attached to all nodes in the cluster the value defaults to -1.

DesiredName
Specify the name you desire for the NSD to be created. This name must not already be used by another GPFS disk name, and it must not begin with the reserved string 'gpfs'. If a desired name is not specified, the NSD is assigned a name according to the convention:

gpfs*NN***nsd**
where *NN* is a unique non negative integer not used in any prior NSD. These global disk names must be subsequently used on all GPFS commands. GPFS commands, other than the **mmcrnsd** and **mmcrvsd** commands, do not accept physical disk device names.

StoragePool
Specifies the storage pool to which the disk is to be assigned. If this name is not provided, the default is **system**.

disposition. The session to which a data management event is delivered. An individual disposition is set for each type of event from each file system.

disk leasing. A method for controlling access to storage devices from multiple host systems. Any host that wants to access a storage device configured to use disk leasing registers for a lease; in the event of a perceived failure, a host system can deny access, preventing I/O operations with the storage device until the preempted system has reregistered.

domain. (1) A set of network resources (such as applications and printers, for example) for a group of users. A user logs in to the domain to gain access to the resources, which could be located on a number of different servers in the network. (2) A group of server and client machines that exist in the same security structure. (3) A group of computers and devices on a network that are administered as a unit with common rules and procedures. Within the Internet, a domain is defined by its Internet Protocol (IP) address. All devices that share a common part of the IP address are said to be in the same domain.

E

event. The encapsulated data that is sent as a result of an occurrence, or situation, in the system.

F

failback. Cluster recovery from failover following repair. See also *failover*.

failover. (1) The process of transferring all control of the ESS to a single cluster in the ESS when the other cluster in the ESS fails. See also *cluster*. (2) The routing of all transactions to a second controller when the first controller fails. See also *cluster*. (3) The assumption of file system duties by another node when a node fails.

failure group. A collection of disks that share common access paths or adapter connection, and could all become unavailable through a single hardware failure.

fileset. A hierarchical grouping of files managed as a unit for balancing workload across a cluster.

file-management policy. A set of policy rules used to manage file migration and deletion.

file-placement policy. A set of policy rules used to determine the initial placement of a newly created file.

file system descriptor. A data structure containing key information about a file system. This information includes the disks assigned to the file system (*stripe group*), the current state of the file system, and pointers to key files such as quota files and log files.

file system descriptor quorum. The number of disks needed in order to write the file system descriptor correctly.

file system manager. The provider of services for all the nodes using a single file system. A file system manager processes changes to the state or description of the file system, controls the regions of disks that are allocated to each node, and controls token management and quota management.

fragment. The space allocated for an amount of data too small to require a full block, consisting of one or more subblocks.

G

GPFS cluster. A cluster of nodes defined as being available for use by GPFS file systems.

GPFS portability layer . The interface module that each installation must build for its specific hardware platform and Linux distribution.

GPFS recovery log. A file that contains a record of metadata activity, and exists for each node of a cluster. In the event of a node failure, the recovery log for the failed node is replayed, restoring the file system to a consistent state and allowing other nodes to continue working.

I

ill-placed file. A file assigned to one storage pool, but having some or all of its data in a different storage pool.

ill-replicated file. A file with contents that are not correctly replicated according to the desired setting for that file. This situation occurs in the interval between a change in the file's replication settings or suspending one of its disks, and the restripe of the file.

indirect block. A block containing pointers to other blocks.

IBM Virtual Shared Disk. The subsystem that allows application programs running on different nodes access a raw logical volume as if it were local to each node. In actuality, the logical volume is local to only one of the nodes (the server node).

inode. The internal structure that describes the individual files in the file system. There is one inode for each file.

J

journaled file system (JFS). A technology designed for high-throughput server environments, key to running intranet and other high-performance e-business file servers.

junction.

A special directory entry that connects a name in a directory of one fileset to the root directory of another fileset.

L

logical volume. A collection of physical partitions organized into logical partitions all contained in a single volume group. Logical volumes are expandable and can span several physical volumes in a volume group.

Logical Volume Manager (LVM). A set of system commands, library routines, and other tools that allow the user to establish and control logical volume (LVOL) storage. The LVM maps data between the logical view of storage space and the physical disk drive module (DDM).

M

metadata. A data structures that contain access information about file data. These include: inodes, indirect blocks, and directories. These data structures are not accessible to user applications.

metanode. The one node per open file that is responsible for maintaining file metadata integrity. In most cases, the node that has had the file open for the longest period of continuous time is the metanode.

mirroring. The process of writing the same data to multiple disks at the same time. The mirroring of data protects it against data loss within the database or within the recovery log.

multi-tailed. A disk connected to multiple nodes.

N

namespace. Space reserved by a file system to contain the names of its objects.

Network File System (NFS). A protocol, developed by Sun Microsystems, Incorporated, that allows any host in a network to gain access to another host or netgroup and their file directories.

Network Shared Disk (NSD). A component for cluster-wide disk naming and access. All disks utilized by GPFS must first be given a cluster-wide NSD name.

NSD volume ID. A unique 16 digit hex number that is used to identify and access all NSDs.

node. An individual operating-system image within a cluster. Depending on the way in which the computer system is partitioned, it may contain one or more nodes.

node descriptor. A node descriptor defines how a node is to be used within GPFS.

Each node descriptor for a GPFS cluster must be in the form:

```
NodeName:NodeDesignations:AdminNodeName
```

NodeName
The hostname or IP address of the node.

designation
An optional, '-' separated list of node roles.

- **manager** | **client** – Indicates whether a node is part of the pool of nodes from which configuration and file system managers are selected. The special functions of the file system manager consume extra processing time. The default is to *not* have the node included in the pool.

  In general, small systems do not need multiple nodes dedicated for the file system manager. However, if you are running large parallel jobs, threads scheduled to a node performing these functions may run slower. As a guide, in a large system there should be one file system manager node for each file system.
- **quorum** | **nonquorum** – This designation specifies whether or not the node should be included in the pool of nodes from which quorum is derived.

AdminNodeName
: An optional field that consists of a node name to be used by the administration commands to communicate between nodes. If *AdminNodeName* is not specified, the *NodeName* value is used.

node number. The node number is generated and maintained by GPFS as the cluster is created and as nodes are added to or deleted from the cluster.

node quorum. The minimum number of nodes that must be running in order for the daemon to start.

node quorum with tiebreaker disks. Node quorum with tiebreaker disks allows you to run with as little as one quorum node available as long as you have access to a majority of the quorum disks. Switching to quorum with tiebreaker disks is accomplished by indicating a list of one or three disks to use on the **tiebreakerDisks** parameter on the **mmchconfig** command.

non-quorum node. A node in a cluster that is not counted for the purposes of quorum determination.

P

policy. A list of file-placement and service-class rules that define characteristics and placement of files. Several policies can be defined within the configuration, but only one policy set is active at one time.

policy rule. A programming statement within a policy that defines a specific action to be preformed.

pool. A group of resources with similar characteristics and attributes.

portability. The ability of a programming language to compile successfully on different operating systems without requiring changes to the source code.

primary GPFS cluster configuration server. In a GPFS cluster, the node chosen to maintain the GPFS cluster configuration data.

primary NSD server. A node designated to perform NSD disk access functions. Nodes not directly attached to a disk access it using the primary NSD server.

private IP address. A IP address used to communicate on a private network.

public IP address. A IP address used to communicate on a public network.

Q

quorum node. A node in the cluster that is counted to determine whether a quorum exists.

quota. The amount of disk space and number of inodes assigned as upper limits for a specified user, group of users, or fileset.

quota management. The allocation of disk blocks to the other nodes writing to the file system and comparison of the allocated space to quota limits at regular intervals.

R

Redundant Array of Independent Disks (RAID). A collection of two or more disk physical drives that present to the host an image of one or more logical disk drives. In the event of a single physical device failure, the data can be read or regenerated from the other disk drives in the array due to data redundancy.

recovery. The process of restoring access to file system data when a failure has occurred. Recovery can involve reconstructing data or providing alternative routing through a different server.

replication. The process of maintaining a defined set of data in more than one location. Replication involves copying designated changes for one location (a source) to another (a target), and synchronizing the data in both locations.

rule. A list of conditions and actions that are triggered when certain conditions are met. Conditions include attributes about an object (file name, type or extension, dates, owner, and groups), the requesting client, and the container name associated with the object.

S

SAN-attached. Disks that are physically attached to all nodes in the cluster using Serial Storage Architecture (SSA) connections or using fibre channel switches

SANergy. See Tivoli SANergy.

secondary GPFS cluster configuration server. In a GPFS cluster, the backup server node for the GPFS cluster configuration data (see “cluster configuration data” on page 101). The secondary GPFS cluster configuration server assumes responsibility for maintaining GPFS cluster configuration data, in the event that the primary GPFS cluster configuration server fails.

Secure Hash Algorithm digest (SHA digest). A character string used to identify a key registered with either the **mmauth** or **mmremotecluster** command.

Serial Storage Architecture (SSA). An American National Standards Institute (ANSI) standard, implemented by IBM, for a high-speed serial interface that provides point-to-point connection for peripherals, such as storage arrays.

session failure. The loss of all resources of a data management session due to the failure of the daemon on the session node.

session node. The node on which a data management session was created.

Small Computer Systems Interface (SCSI). An ANSI-standard electronic interface that allows personal computers to communicate with peripheral hardware, such as disk drives, tape drives, CD_ROM drives, printers, and scanners faster and more flexibly than previous interfaces.

snapshot. A copy of changed data in the active files and directories of a file system with the exception of the i-node number, which is changed to allow application programs to distinguish between the snapshot and the active files and directories.

source node. The node on which a data management event is generated.

SSA. See Serial Storage Architecture.

stand-alone client. The node in a one-node cluster.

storage area network (SAN). A dedicated storage network tailored to a specific environment, combining servers, storage products, networking products, software, and services.

storage pool. A grouping of storage space consisting of volumes, logical unit numbers (LUNs), or addresses that share a common set of administrative characteristics.

stripe group. The set of disks comprising the storage assigned to a file system.

striping. A storage process in which information is split into blocks (a fixed amount of data) and the blocks are written to (or read from) a series of disks in parallel.

subblock. The smallest unit of data accessible in an I/O operation, equal to one thirty-second of a data block.

system storage pool. A storage pool contains file system control structures, reserved files, directories, symbolic links, special devices, as well as the metadata associated with regular files, including indirect blocks, extended attributes, and so forth. The **system storage pool** can also contain user data.

T

Tivoli SANergy. A product of IBM Tivoli, that delivers shared data access at the speed of a storage area network (SAN), using fibre channel, Small computer system interface (SCSI), or iSCSI. Using standard networks and file systems, SANergy provides multiple computers with the power to dynamically share file and data access on SAN-based storage.

token management. A system for controlling file access in which each application performing a read or write operation is granted some form of access to a specific block of file data. Token management provides data consistency and controls conflicts.

Token management has two components: the token manager server, and the token management function.

token management function. Requests tokens from the token management server, and is located on each cluster node.

token management server. Controls tokens relating to the operation of the file system, and is located at the file system manager node.

twin-tailing. To connect a disk to multiple nodes

U

user storage pool. A storage pool containing the blocks of data that make up user files.

V

virtual file system (VFS). A remote file system that has been mounted so that it is accessible to the local user.

virtual shared disk. See “IBM Virtual Shared Disk” on page 103.

virtual node (vnode). The structure that contains information about a file system object in an virtual file system (VFS).

Bibliography

This bibliography contains references for:

- GPFS publications
- @server Cluster 1600 publications
- AIX publications
- Tivoli publications
- Storage references
- Disaster recovery
- IBM RedBooks
- White papers
- Useful Web sites
- Non-IBM publications that discuss parallel computing and other topics related to GPFS

All IBM publications are also available from the IBM Publications Center at www.ibmcom/shop/publications/order

GPFS publications

You may download, view, search, and print the supporting documentation for the GPFS program product in the following ways:

1. In PDF format:
   - On the World Wide Web at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfsbooks.html
   - From the IBM Publications Center at www.ibm.com/shop/publications/order
2. In HTML format at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.gpfs.doc/gpfsbooks.html
3. For the latest GPFS documentation updates refer to the GPFS Information Center athttp://publib.boulder.ibm.com/infocenter/clresctr/index.jsp?topic=/com.ibm.cluster.infocenter.doc/library.html

The GPFS library includes:

- *General Parallel File System: Concepts, Planning, and Installation Guide*, GA76-0413
- *General Parallel File System: Administration and Programming Reference*, SA23-2221
- *General Parallel File System: Advanced Administration Guide*, SC23-5182
- *General Parallel File System: Problem Determination Guide*, GA76-0415
- *General Parallel File System: Data Management API Guide*, GA76-0414

To view the GPFS PDF publications, you need access to either the Adobe Acrobat Reader or the **xpdf** package available with the Red Hat® Linux distribution. The Acrobat Reader is shipped with the AIX 5L Bonus Pack and is also freely available for downloading from the Adobe web site at www.adobe.com. Since the GPFS documentation contains cross-book links, if you choose to download the PDF files they should all be placed in the same directory and the files should not be renamed.

To view the GPFS HTML publications, you need access to an HTML document browser.

In order to use the GPFS man pages the **gpfsdocs** file set must first be installed. In the *General Parallel File System: Concepts, Planning, and Installation Guide*:

- For Linux nodes, see *Installing the GPFS man pages*

- For AIX nodes, see *Installing the GPFS man pages*

@server Cluster 1600 hardware publications

For a current list of @server Cluster 1600 hardware publications, see http://publib.boulder.ibm.com/infocenter/clresctr/index.jsp?topic=/com.ibm.cluster.infocenter.doc/library.html

AIX publications

For the latest information on:

- AIX 5L Version 5.3 and related products at publib.boulder.ibm.com/infocenter/pseries/index.jsp

Tivoli publications

- You can view or download the TSM for AIX documentation at: publib.boulder.ibm.com/tividd/td/IBMStorageManagerforAIX5.1.html
- You can view or download the TSM for Linux documentation at: publib.boulder.ibm.com/tividd/td/IBMTivoliStorageManagerforLinux5.1.html
- You can view or download the TSM UNIX documentation at: publib.boulder.ibm.com/tividd/td/IBMTivoliStorageManagerClient5.1.5.html
  - *Tivoli Storage Manager for UNIX Backup-Archive Clients Installation and User's Guide*
- You can view or download the TSM message documentation at: publib.boulder.ibm.com/tividd/td/IBMStorageManagerMessages5.1.html
- You can view or download the Tivoli SANergy documentation at: publib.boulder.ibm.com/tividd/td/SANergy2.2.4.html
- You can view or download IBM Tivoli Workload Scheduler LoadLeveler® for AIX (LoadLeveler) documentation at publib.boulder.ibm.com/infocenter/clresctr/topic/com.ibm.cluster.loadl.doc/llbooks.html

Storage references

Various references include:

- IBM System Storage™ and TotalStorage at http://www-03.ibm.com/servers/storage/
- IBM TotalStorage DS4000 series at ssdweb01.storage.ibm.com/disk/fastt/
- IBM Subsystem Device Driver support at www.ibm.com/server/storage/support/software/sdd.html
- IBM Enterprise Storage Server documentation at www.storage.ibm.com/hardsoft/products/ess/refinfo.htm

Disaster recovery references

- *IBM Enterprise Storage Server* at www.redbooks.ibm.com/redbooks/pdfs/sg245465.pdf
- *IBM TotalStorage Enterprise Storage Server User's Guide* at publibfp.boulder.ibm.com/epubs/pdf/f2bug05.pdf
- *IBM TotalStorage Enterprise Storage Server Implementing ESS Copy Services in Open Environments* at www.redbooks.ibm.com/redbooks/pdfs/sg245757.pdf
- *IBM TotalStorage Enterprise Storage Server Web Interface User's Guide*, SC26-7448, at publibfp.boulder.ibm.com/epubs/pdf/f2bui05.pdf
- *IBM Enterprise Storage Server Command-Line Interfaces User's Guide*, SC26-7994, at publibfp.boulder.ibm.com/epubs/pdf/f2bcli04.pdf
- *ESS Copy Services Tasks: A Possible Naming Convention* at publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/tips0289.html?Open
- *Valid Combinations of ESS Copy Services* at publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/tips0311.html?Open

- *Connectivity Guidelines for Synchronous PPRC* at publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/tips0211.html?Open
- *A Disaster Recovery Solution Selection Methodology* at www.redbooks.ibm.com/redpapers/pdfs/redp3847.pdf
- *IBM TotalStorage Solutions for Disaster Recovery*, SG24-6547, at www.redbooks.ibm.com/redbooks/pdfs/sg246547.pdf
- *Seven Tiers of Disaster Recovery* at publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/tips0340.html?Open

IBM Redbooks

IBM's International Technical Support Organization (ITSO) has published a number of Redbooks™. For a current list, see the ITSO Web site at www.ibm.com/redbooks

White papers

A primer for GPFS for AIX 5L at www.ibm.com/servers/eserver/pseries/software/whitepapers/gpfs_primer.html

A technical introduction to GPFS for AIX 5L at www.ibm.com/servers/eserver/pseries/software/whitepapers/gpfs_intro.html

IBM @server pSeries white papers at www.ibm.com/servers/eserver/pseries/library/wp_systems.html

Clustering technology white papers at www.ibm.com/servers/eserver/clusters/library/wp_aix_lit.html

AIX white papers at www.ibm.com/servers/eserver/clusters/library/wp_aix_lit.html

White paper and technical reports home page at www.ibm.com/servers/eserver/pseries/library/wp_systems.html

Useful Web sites

Linux at IBM at www.ibm.com/software/is/mp/linux/software

Clusters at IBM www.ibm.com/eserver/clusters

GPFS for Linux at www.ibm.com/servers/eserver/clusters/software/gpfs.html

GPFS for AIX at www.ibm.com/servers/eserver/pseries/software/sp/gpfs.html

xSeries Intel processor-based servers at www.pc.ibm.com/us/eserver/xseries/

UNIX servers: System p5, @server p5 and pSeries at www.ibm.com/servers/eserver/pseries/

Red Hat at www.redhat.com/

SuSE at www.suse.com/

Myrinet at www.myri.com/

Fibre Channel at www.fibrechannel.org/

The Linux documentation project at www.tldp.org/

RPM at www.rpm.org/

The Internet Engineering Task Force at www.ietf.org/

The Open Group at www.opengroup.org/

The Linux Kernel Archives at www.kernel.org/

OpenSSH at www.openssh.com

The OpenSSL Project at www.openssl.org

Non-IBM publications

Here are some non-IBM publications that you may find helpful:

- Almasi, G., Gottlieb, A., *Highly Parallel Computing*, Benjamin-Cummings Publishing Company, Inc., 2nd edition, 1994.
- Foster, I., *Designing and Building Parallel Programs*, Addison-Wesley, 1995.
- Gropp, W., Lusk, E., Skjellum, A., *Using MPI*, The MIT Press, 1994.
- Message Passing Interface Forum, *MPI: A Message-Passing Interface Standard, Version 1.1*, University of Tennessee, Knoxville, Tennessee, June 6, 1995.
- Message Passing Interface Forum, *MPI-2: Extensions to the Message-Passing Interface, Version 2.0*, University of Tennessee, Knoxville, Tennessee, July 18, 1997.
- Ousterhout, John K., *Tcl and the Tk Toolkit*, Addison-Wesley, Reading, MA, 1994, ISBN 0-201-63337-X.
- Pfister, Gregory, F., *In Search of Clusters*, Prentice Hall, 1998.
- *System Management: Data Storage Management (XDSM) API* Common Applications Environment (CAE) Specification C429, The Open Group, ISBN 1-85912-190-X. Available online in HTML from The Open Group's Web site at www.opengroup.org/.

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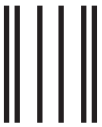

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