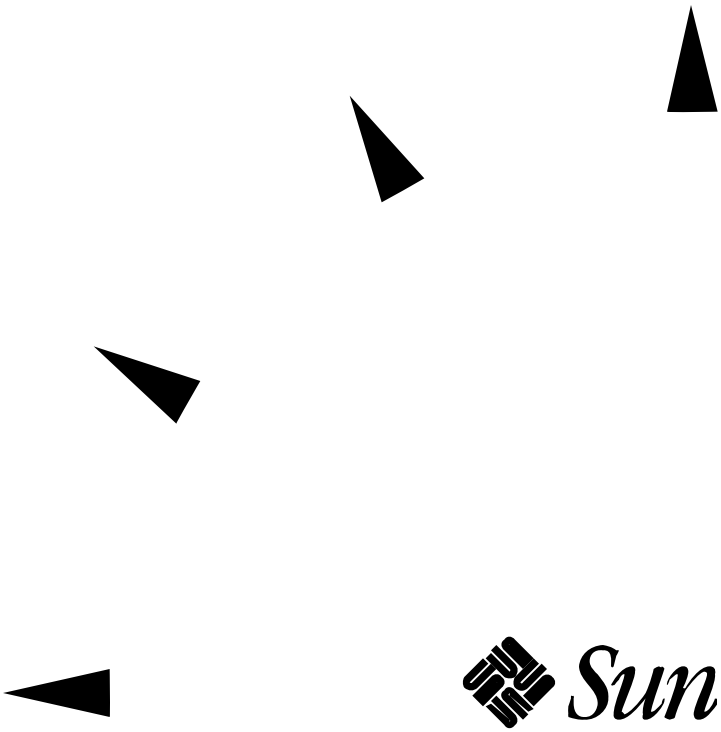
SMCC NFS™ Server Performance and Tuning Guide



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Preface

The *SMCC NFS Server Performance and Tuning Guide* is about the NFS™ distributed computing file system. It describes:

- NFS and network performance analysis and tuning
- NFS and network monitoring tools

This book is written with these assumptions about your server:

- It runs the Solaris™ 2.x system software.
- It is set up in a networked configuration.
- It is a SPARCserver™ system, UltraServer™ system, SPARCcenter™ 2000(E), Netra™ *nfs*150 Server, or an Ultra™ Enterprise™ 3000, 4000, 5000, and 6000 systems.

This book is for system administrators and network specialists who configure, analyze the performance, or tune servers that provide the NFS service to network clients.

Related Documents

You can find more detailed coverage of some of the topics discussed in this book in the following documents:

- *Sun Performance and Tuning (SunSoft Press/Prentice Hall)*
- *Solaris 2.5.1 Handbook for SMCC Peripherals*
- *Security, Performance, and Accounting Administration (SunSoft)*
- *NFS Administration Guide (SunSoft)*

- *Prestoserve User's Guide*
- *File System Administration*
- *FDDI/Sx.0 User's Guide*

Typographic Conventions

The following table describes the type changes and symbols used in this book.

Table P-1 Typographic Conventions

Typeface or Symbol	Meaning	Example
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `system% You have mail.`
`AaBbCc123`	What you type, contrasted with on-screen computer output	`system% su` `Password:`
AaBbCc123	variable: replace with a real name or value	To delete a file, type `rm` *filename*.
AaBbCc123	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in *User's Guide*. These are called *class* options. You *must* be `root` to do this.
Code samples are included in boxes and may display the following:		
%	UNIX C shell prompt	`system%`
$	UNIX Bourne and Korn shell prompt	`system$`
#	Superuser prompt, all shells	`system#`

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Germany	01-30-81-61-91	01-30-81-61-92
The Netherlands	06-022-34-45	06-022-34-46
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NFS Overview 1

This chapter briefly discusses NFS characteristics, the tuning cycle, and third party tools used to monitor NFS activity.

NFS Characteristics

The NFS environment provides transparent file access to remote files over a network. File systems of remote devices appear to be local. Clients access remote file systems by using either the `mount` command or the automounter.

The NFS protocol enables multiple client retries and easy crash recovery. The client provides all the information for the server to perform the requested operation. The client retries the request until it is acknowledged by the server, or until it times out. The server acknowledges writes when the data is flushed to nonvolatile storage.

The multithreaded kernel does not require the maintenance of multiple `nfsd` or asynchronous-block I/O daemon (`biod`) processes; they are both implemented as operating system kernel threads. There are no `biod`s on the client and one `nfsd` process exists on the server.

NFS traffic is characterized by its random patterns. NFS requests, which are usually of many types, are generated in bursts. The capacity of an NFS server must address the bursty nature of NFS file service demands. Demand varies widely but is relatively predictable during normal activity.

Most requests from applications (which may be local or remote), follow this pattern:

1. The user reads in the sections of the application binary then executes the code pages leading to a user dialog, which specifies a data set on which to operate.
2. The application reads the data set from the (remote) disk.
3. The user can then interact with the application, manipulating the in-memory representation of the data (this phase continues for most of the runtime of the application).
4. The modified data set is saved to disk.

Note – More sections of the application binary may be paged in as the application continues to run.

NFS Version 2 and Version 3

The Solaris 2.5 software environment is shipped with both NFS Version 2 and NFS Version 3. NFS Version 3 is a new addition to the Solaris 2.5 and later software environment.s You tune NFS Version 2 and NFS Version 3 in a similar manner.

NFS Version 3 Features

NFS Version 3 contains several features to improve performance, reduce server load, and reduce network traffic. Since NFS Version 3 is faster for I/O writes, and uses fewer operations over the network, you will have more efficient use of the network. Note that higher throughput may make the network busier.

NFS Version 3 maintains the stateless server design and simple crash recovery of Version 2 along with its approach to build a distributed file service from cooperating protocols.

A discussion of the main features of NFS Version 3 follows:

64-Bit File Size

NFS Version 3 allows 64-bit file sizes, which gives you access to files over 4 Gbytes. However, although NFS Version 3 allows access to file larger than 4 Gbytes, that only works if both the client and the server the operating systems have sufficient hooks. Currently, the software environment (up through the Solaris 2.5.1 software environment), does not have these hooks.

Asynchronous Writes

NFS Version 3 can use asynchronous writes, which is optional. The NFS Version 3 client sends asynchronous writes requests to the server who acknowledges receiving the data. However, the server is not required to write the data to stable storage before replying. The server may schedule the write, or wait to gather multiple write requests together.

The client maintains a copy of the data in case the server is unable to complete the writes. When the client wishes to free its copy, it notifies the server with a `COMMIT` operation. The server responds positively only after it ensures the data has been written to stable storage. Otherwise, it responds with an error and the client resends the data synchronously.

The advantages of asynchronous writes is that by allowing the server to determine the best policy to sync the data and the high likelihood that it has been synchronized by the time the `COMMIT` arrives. Compared with NFS Version 2, this scheme allows for better buffering and more parallelism.

With NFS Version 2, the server does not respond to a write request until the data is placed in stable storage. However, it may use techniques such as write gathering to issue multiple concurrent requests before responding to any of the requests.

Read Directory with Attributes

NFS Version 3 contains an operation called `READDIRPLUS`. Most `READDIR`s are now issued as `READDIRPLUS` calls. For example, a `ls` or an `ls -l` triggers them. When the `ls -l` commands runs over Version 3, the file handles and attributes are returned with the list of names in the directory. With Version 2, the names are returned first, then additional calls to the server are needed to get the file handles and attributes.

The advantage with the `READDIRPLUS` operation in Version 3 is than an `ls` and an `ls -l` now are comparable in speed due to the saving in not having to send separate `GETATTR` requests for each file.

Weak Cache Consistency

Many NFS Version 2 clients cache file and directory data to improve performance. At times, the Version 2 method fails when multiple clients are sharing and caching the same data.

Weak cache consistency allows the client to detect if another client has changed the data between its last access and the current request. This is accomplished by having the server send back the previous attributes with the response. The client can then compare the previous attributes with what it thought the previous attributes were and detect changes.

Tuning Cycle

The tuning cycle includes these tasks:

1. Measuring current performance and analyzing the data (see Chapter 3, “Analyzing NFS Performance”)
2. Tuning for NFSops/second; see Chapter 4, “Configuring the Server and the Client to Maximize NFS Performance”
3. Repeating tasks 1 and 2 until no further improvements are required
4. Reconfiguring new hardware on the server, if needed
5. Repeating tasks 1 through 3

Third-Party Tools

Some of the third party tools you can use for NFS and networks include:

- NetMetrix™ (Hewlett-Packard)
- SharpShooter™ (AIM Technology)

SharpShooter (Version 3) understands the NFS Version 3 protocol.

Hardware Overview 2

This chapter describes an overview of these NFS servers and expansion units:

- Ultra Enterprise™ 1 system
- Ultra Enterprise 2 system
- SPARCserver™ 5 system
- SPARCserver 10 system
- SPARCserver 20 system
- Ultra Enterprise 3000, 4000, 5000, and 6000 systems
- SPARCserver 1000 or SPARCserver 1000E system
- SPARCcenter™ 2000 or SPARCserver 2000E system
- Netra *nfs*150 Server system
- SPARCstorage™ Array subsystem
- SPARCstorage MultiPack enclosure
- Multi-Disk Pack enclosure
- SPARCstorage UniPack enclosure
- Desktop Disk Pack enclosure

NFS File Servers

This section provides a hardware overview of Sun NFS servers. Table 2-1 illustrates the conditions under which a particular NFS file server will meet your needs.

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Table 2-1 NFS Server Comparison Table

Server	Maximum Specifications	Positioning	Key Advantages
SPARCcenter 2000 or 2000E	500 NFS clients 36 subnets 731 Gbytes of disk storage Ethernet, FDDI, SunATM, and Token Ring	Highest capacity Multipurpose enterprise server (the total solution for an entire company)	Centralized administration Maximum headroom for growth Multiprocessor, I/O, and network performance scalability
SPARCserver 1000 or 1000E	300 NFS clients 12 subnets 395 Gbytes of disk storage Ethernet, FDDI, SunATM, and Token Ring	High capacity Multipurpose workgroup server	Excellent capacity performance Multipurpose server (NFS, compute, database), affordable, scalable, integrated packaging
Ultra Enterprise 1	200-220 NFS clients 147 Gbytes of disk storage 4 subnets Ethernet, optional FDDI and SunATM	High capacity Medium to large workgroup server (50 to 100 users)	Excellent performing uniprocessor workgroup server that simplifies administration and lowers costs
Ultra Enterprise 2	At least 350-400 NFS clients 67 Gbytes of disk storage (4 Gbytes in the system and 63 Gbytes in the SPARCstorage Array) 4 subnets Ethernet, optional FDDI and SunATM	High performance multiprocessing server for mid to large size workgroups	High throughput for multiprocessing applications. Very high application performance. Efficient design and process handling.
Ultra Enterprise 3000	At least 300 NFS clients 42 Gbytes of disk storage (system enclosure only) More than 20 subnets per system Ethernet, optional FDDI, SunATM, and Token Ring	Affordable departmental server	Applications support up to hundreds of users in office environments. Able to handle arbitrary NFS client loads

Table 2-1 NFS Server Comparison Table *(Continued)*

Server	Maximum Specifications	Positioning	Key Advantages
Ultra Enterprise 4000	At least 400 NFS clients 168 Gbytes of disk storage (system enclosure only) More than 20 subnets per system Ethernet, optional FDDI, SunATM, and Token Ring	Compact yet highly expandable system	Delivers high performance scalability for department applications in a distributed network computing environment. Able to handle arbitrary NFS client loads
Ultra Enterprise 5000	At least 400 NFS clients 233 Gbytes of disk storage (system enclosure only) More than 20 subnets per system Ethernet, optional FDDI, SunATM, and Token Ring	Data center server system	Delivers high performance and high availability for enterprise wide applications supporting thousands of users. Able to handle arbitrary NFS client loads.
Ultra Enterprise 6000	At least 600 NFS clients 189 Gbytes of disk storage (system enclosure only) More than 20 subnets per system Ethernet, optional FDDI, SunATM, and Token Ring	Most scalable and expandable Sun server	Can handle a minimum of 14,000 ops/second, which is equivalent to 140,000 PC clients. Able to handle arbitrary NFS client loads

Table 2-1 NFS Server Comparison Table *(Continued)*

Server	Maximum Specifications	Positioning	Key Advantages
Netra *nfs*150 Server	100 NFS clients 24 Gbytes of internal disk storage (48 Gbytes with 4 Gbyte disk drives) 2 subnets with Fast Ethernet (100 BaseT), Token Ring, FDDI 9 subnets with 10BaseT Ethernet	Dedicated NFS server supporting both workgroup and department needs	Industry leading NFS price/performance with RAID 5. Very fast response times. Easy to administer with HTML user interface. Highly reliable with internal UPS and RAID 5. Includes PC-NFS server software. Exclusively supports NFS applications. RAID 5 and single file system preconfigured.
SPARCserver 20	125 NFS clients 138 Gbytes of disk storage 4 subnets Ethernet, FDDI, SunATM, and Token Ring	Low cost Multipurpose workgroup server PC LAN server	Low cost, yet powerful, flexible, and easily redeployed
SPARCserver 5	60 clients 40 Gbytes of disk storage 4 subnets Ethernet	Low cost Multipurpose workgroup server PC LAN server	Low cost High NFS performance at a low cost

SPARCserver 5 System

The SPARCserver 5 system is based on the microSPARC™ II CPU. It provides fast application performance and networking extensibility. It is ideal for a dedicated workgroup NFS server.

SPARCserver 5 System Features

The SPARCserver 5 system features are:

- 70 MHz or 85 MHz microSPARC II CPU
- 16 to 256 Mbytes of RAM (8 or 32 Mbyte SIMMs)
- 64-bit memory bus
- Two internal hard drives,
- 644 Mbyte CD-ROM drive (optional)
- 1.44 Mbyte diskette drive (optional)
- Twisted pair Ethernet (can be expanded between 5 and 9 Ethernet networks)
  - Optional AUI support
- Three SBus expansion slots
- Two serial ports, one parallel port
- Greater than 20 Gbytes mass storage capacity with external disk drives
- SBus Prestoserve™ NFS accelerator (optional)

A SPARCserver 5 system can be upgraded to a SPARCserver 20 system by substituting the system board with a SPARCserver 20 system board. Figure 2-1 shows a front view of the SPARCserver 5 system.

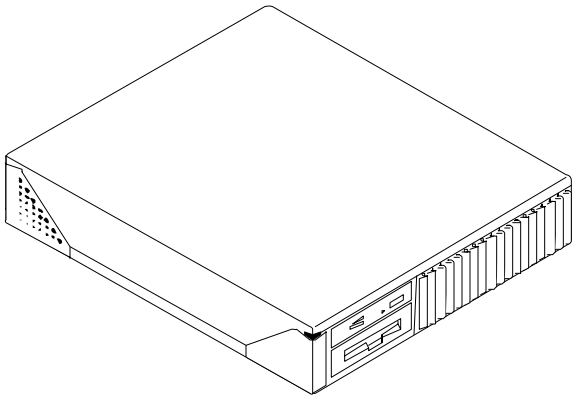

Figure 2-1 SPARCserver 5 System Front View

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SPARCserver 10 System

The SPARCserver 10 system is a high-performance workstation designed to be a workgroup NFS file server or a database server in an office environment. The system was shipped in both uniprocessor and multiprocessor configurations. Some of the uniprocessor configurations available are:

- Model 30LC—single 36MHz SuperSPARC™ processor, no external cache
- Model 40—single 40MHz SuperSPARC processor, no external cache
- Model 41—single 40MHz SuperSPARC processor, 1 Mbyte of external cache
- Model 51—single 50MHz SuperSPARC processor, 1 Mbyte of external cache

Some of the multiprocessor configurations available are:

- Model 402—two 40 MHz SuperSPARC processors, no external cache
- Model 512—two 50 MHz SuperSPARC processors, each with 1 Mbyte of external cache
- Model 514—four 50 MHz SuperSPARC processors, each with 1 Mbyte of external cache

Figure 2-2 shows a front view of the system.

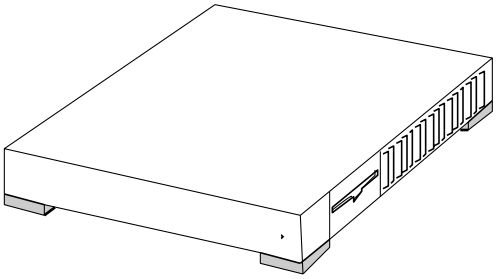

Figure 2-2 SPARCserver 10 System Front View

SPARCserver 10 System Features

The SPARCstation 10 system features are:

- High performance throughput based on balanced coherent bus, graphic, and networking components
- SuperSPARC processors set in a multiprocessor architecture
- Memory (RAM) ranging from 32 Mbytes to 512 Mbytes

- With four SPARCstorage Array subsystems (Model 101), the disk storage capacity of the disk arrays is 126 Gbytes.
- Twisted pair Ethernet (standard) and thick Ethernet (AUI) with an optional adapter cable
- 4 SBus expansion slots
- 2 serial ports, 1 parallel port
- 16-bit audio
- NVRAM-NVSIMM and SBus Prestoserve NFS accelerators (optional)

SPARCserver 20 System

The SPARCserver 20 system, introduced in 1994, is designed to be a workgroup NFS file server or a database server in an office environment. It is based on the same MBus and SBus technologies as the SPARCserver 10 system. Performance is increased over the SPARCserver 10 by using faster MBus and SBus technology, and faster SPARC modules. The SPARCserver 20 system has increased compute and network performance.

The SPARCserver 20 system is available in three uniprocessor configurations and three multiprocessor configurations.

The three uniprocessor configurations are:

- Model 50—50 MHz SuperSPARC processor
- Model 51—50 MHz SuperSPARC processor and 1 Mbyte SuperCache™
- Model 61—60 MHz SuperSPARC processor and 1 Mbyte SuperCache
- Model 71—75 MHz SuperSPARC processor and 1 Mbyte SuperCache
- Model 151—Single 150 MHz HyperSPARC processor and 0.5 Mbyte external cache

The three multiprocessor configurations are:

- Model 502MP—two 50 MHz SuperSPARC processors
- Model 514MP—four 50 MHz SuperSPARC processors and 1 Mbyte SuperCache
- Model 612MP—two 60 MHz SuperSPARC processors and 1 Mbyte SuperCache
- Model 712—two 75 MHz SuperSPARC processors and 1 Mbyte SuperCache
- Model 152MP—two 150 MHz HyperSPARC processors and 0.5 Mbyte of external cache

Figure 2-3 shows the front view of the SPARCserver 20 system. This system and the SPARCserver 5 system look alike from the front.

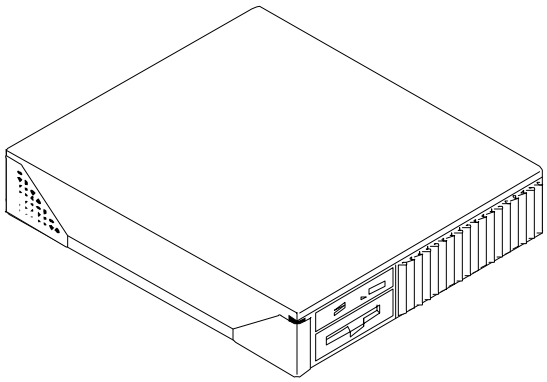

Figure 2-3 SPARCserver 20 System Front View

SPARCserver 20 System Features

The SPARCserver 20 system features include:

- More than 2 Gbytes of internal hard disk storage (two 1.05 Gbyte internal disk drives)
- Provides up to 126 Gbytes of disk storage in the SPARCstorage Array (Model 101) subsystems when directly connected to four SPARCstorage Array subsystems
- 1.44 Mbyte diskette drive (optional)
- 644 Mbyte CD-ROM drive (optional)
- Two serial ports, one parallel port
- Twisted-pair Ethernet
- Up to 512 Mbytes of memory (60 ns SIMMs)
- AUI Ethernet (optional) (can have up to 9 Ethernet networks)
- SBus or NVRAM-NVSIMM Prestoserve NFS accelerator (optional)

Sun Ultra Enterprise 1 and 2 Systems

The Ultra Enterprise 1 system is the first member of a new class of workstations based on the UltraSPARC-I processor and is designed to deliver balanced system performance.

The Ultra Enterprise 1 system can be used as a high capacity NFS server for medium to large workgroups (50 to 100 users). It is designed for reliability, availability, and serviceability. It allows easy access to replace disk drives, SIMMs, and graphics cards.

The Ultra Enterprise 2 system is a multiprocessor system based on the UltraSPARC-I processor. It comes standard with Fast/Wide SCSI and Fast Ethernet to allow the data throughput capability of this system to include the disk I/O and the network traffic. The system also has a 64-bit SBus running at 25 MHz giving maximum SBus throughput.

The Ultra Enterprise 2 system can be used as an NFS server for mid to large sized workgroups.

The Ultra SPARC CPU is matched by a very high performance crossbar-switched interconnect that can move data at peak rates of 1.3 Gbytes/second. This interconnect, the Ultra Port Architecture (UPA), is the key in providing the greatly enhanced memory bandwidth. Both the Ultra Enterprise 1 and 2 systems have a 64-bit SBus running at 25 MHz giving maximum SBus throughput.

The Ultra architecture was designed to be fully compatible with the previous generation of workstations so that all Solaris operating environment applications can run unchanged.

Figure 2-4 shows a front view of the Ultra Enterprise 1 system.

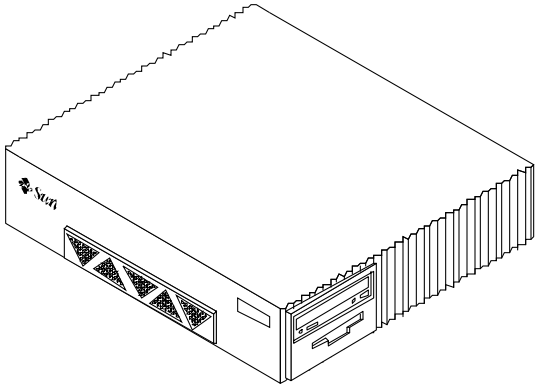

Figure 2-4 Ultra Enterprise 1 Front View

SPARCserver 1000 and SPARCserver 1000E Systems

The SPARCserver 1000 and SPARCserver 1000E multiprocessor systems, introduced in 1993, are designed to be departmental NFS file servers with flexibility for dedicated or multifunctional application environments. They support more than 200 NFS clients and provide file, database, timeshare, or computing services to a network and attached devices.

The modular design makes expansion of system boards, memory, and peripherals easy to perform. You can upgrade or expand processors by adding or replacing SuperSPARC modules. Figure 2-5 shows the front view of the SPARCserver 1000 or the SPARCserver 1000E system.

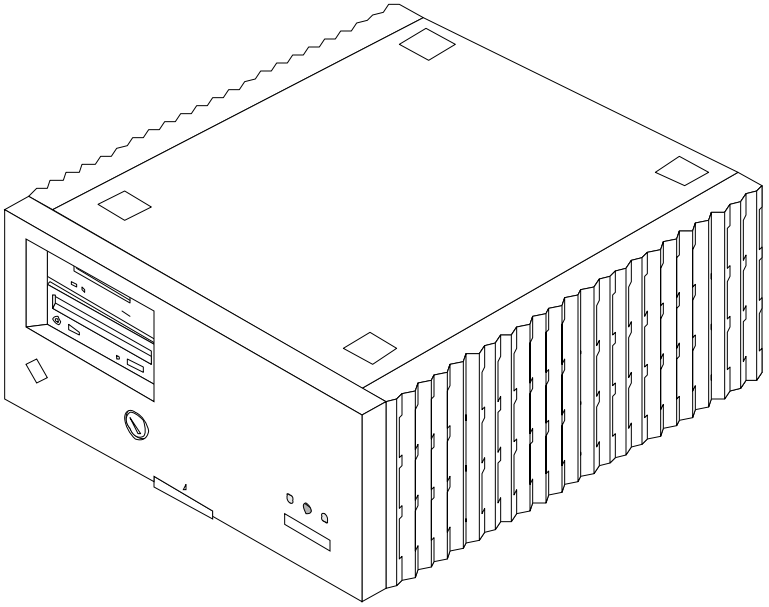

Figure 2-5 SPARCserver 1000 / SPARCserver 1000E System Front View

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The SPARCserver 1000 and the SPARCserver 1000E systems are built around the XDBus, the system bus that provides very high data transfer bandwidth.

The CPU building blocks consist of:

- 60 or 85 MHz SuperSPARC modules (50 MHz SuperSPARC on the SPARCserver 1000 system)
- SuperCache controller
- 1 Mbyte of cache

The system has three SBus slots per system board, which are accessed by the XDBus. The multiple memory banks process information from multiple CPUs and I/O devices in parallel.

SPARCserver 1000 and the SPARCserver 1000E System Features

The SPARCserver 1000 and the SPARCserver 1000E systems have the following features:

- Up to four system boards can be installed
- Up to eight SuperSPARC processors (two per system board) can be installed
- Up to 2 Gbytes of main memory (using 32 Mbyte SIMMs) can be installed
- Up to 16.8 Gbytes of internal storage
- 50 MHz system clock speed in the SPARCserver 1000E system (40 MHz in the SPARCserver 1000 system)
- 25 MHz SBus speed in the SPARCserver 1000E system (20 MHz in the SPARCserver 1000 system)
- When connected to 12 SPARCstorage Array subsystems, the SPARCserver 1000 or 1000E systems provide up to 756 Gbytes of external storage
- Up to 12 SBus slots
- Onboard SCSI-2 port and twisted pair Ethernet on each system board
- Internal 5 Gbyte 4mm tape drive (or 10 Gbyte 8mm tape drive)
- Internal CD-ROM drive
- NVRAM-NVSIMM Prestoserve NFS accelerator (optional)

SPARCcenter 2000 or SPARCcenter 2000E Systems

The SPARCcenter 2000 or the SPARCcenter 2000E systems, introduced in 1992, provide the computing solution for a company. As such, the SPARCcenter 2000 system and the SPARCcenter 2000E system are multifunctional network NFS file servers. They support less than 500 NFS clients and have the flexibility required for dedicated or multifunctional application environments.

The SPARCcenter 2000 system and the SPARCcenter 2000E system provide scalability and extensive expansion in these areas:

- CPU processor power
- Memory capability
- I/O connectivity

They meet the following requirements:

- High capacity I/O requirements of corporate data centers
- Computationally intensive demands of other organizations

The heart of the SPARCcenter 2000 system or the SPARCcenter 2000E system is a high-speed packet-switched bus complex that provides very high data transfer bandwidth. The backplane supports two distinct XDBuses operating in parallel.

The SPARCcenter 2000 system or the SPARCcenter 2000E system use up to twenty SuperSPARC modules in a shared-memory symmetric multiprocessing configuration, meeting most performance needs. You can expand or upgrade the processing capability by adding SuperSPARC modules.

Main memory is configured in multiple logical units that are installed in the bus complex.

The I/O is expandable. For example, you can configure up to 40 SBus slots on 10 independent busses. The large I/O capacity and configurability makes the SPARCcenter 2000 system or the SPARCcenter 2000E system suitable for very large applications.

SPARCcenter 2000 and the SPARCcenter 2000E System Features

The SPARCcenter 2000 system and the SPARCcenter 2000E system features are:

- 20, 40, 50, 60, or 85 MHz SuperSPARC modules (each with up to 2 Mbytes of built in cache)
- Dual XDbus system bus
- Greater than 5 Gbyte main memory capacity (8 Mbyte or 32 Mbyte SIMMs)
- Up to 10 SBus channels (for a total of 40 SBus slots)
- Two RS232 serial ports on each system board (up to 20 total)
- Twisted pair Ethernet connections via SBus cards
- 10 Mbytes/second SCSI-2 channels via SBus cards
- Up to 52.2 Gbytes of internal SCSI disk storage
- 50 MHz system clock speed in the SPARCserver 2000E system (40 MHz in the SPARCserver 2000 system)
- 25 MHz SBus speed in the SPARCserver 2000E system (20 MHz in the SPARCserver 2000 system)
- When connected to 20 SPARCstorage Array subsystems, Model 101, the total disk capacity for the expansion subsystems is 630 Gbytes
- NVRAM-NVSIMM Prestoserve NFS accelerator (optional)

Figure 2-6 shows the front view of the SPARCcenter 2000 or the SPARCserver 2000E system.

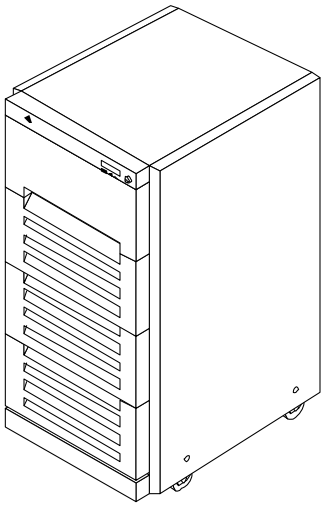

Figure 2-6 SPARCcenter 2000 or the SPARCcenter 2000E System Front View

Ultra Enterprise 4000, 5000, and 6000 Systems

The Ultra Enterprise 6000 server system, the Ultra Enterprise 5000 server system and the Ultra Enterprise 4000 server system are available in two enclosures (see Figure 2-7):

- Enterprise 6000 or 5000 is a 56-inch cabinet containing either a 16-slot or 8-slot card cage
- Enterprise 4000 is a standalone enclosure containing an 8-slot card cage

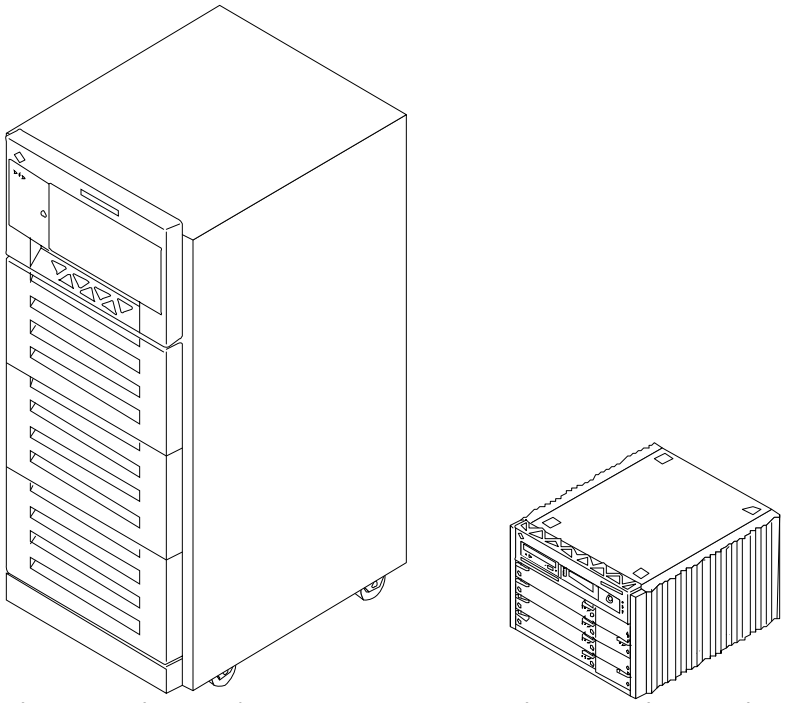

Figure 2-7 Ultra Enterprise 6000 and 5000 Server Cabinet System and Ultra Enterprise 4000 Standalone System

The same CPU/memory board, I/O boards, disk board, processor modules, memory SIMMs, power modules, and cooling modules are used in all enclosures.

The minimum configuration for the Ultra Enterprise 4000, 5000, and 6000 is:

- 16-slot or 8-slot chassis/card cage
- Modular power supply
- Fan tray (cabinet servers) or fan box (standalone server)
- Clock board
- CPU/memory board
- I/O board
- Peripheral power supply
- AC distribution unit
- SCSI receptacle for removable media, including CD-ROM

Ultra Enterprise systems have extensive error detection mechanisms, and an Automatic System Reconfiguration (ASR) feature that allows the system to be rebooted with failed components (such as CPUs, memory, or I/O) disabled. When an error is detected, the system is reconfigured so that the board containing the failed components is placed in low power mode and is no longer accessible.

The hot-plugable feature is the ability to insert a new board into a powered up system, despite being “live,” or being supplied with electrical power. Once a working board is added to a powered on system with the hot-plugable feature, the Solaris 2.5.1 software environment will not use the new board until the system is rebooted. The systems also support hot plugable disk drives and redundant, hot plugable power and cooling units.

High speed networking is supported by integrated 10 or 100 Mbit Ethernet and optional ATM interface.

The systems support remote control administration, which allows remote rebooting and power cycling.

The system monitor for these servers is Solstice™ SyMON™, a system performance tool that you can use to:

- Monitor the performance of a large server with multiple processors, I/O, and disks.
- Optimize the configuration and throughput of the server.
- Identify hardware and software failures quickly. Failures range from major failures (CPU crash), to minor failures (slow cooling fan). Solstice SyMON identifies the component or software and its location.

- Monitor hardware performance to detect incipient hardware failure (soft read errors on a disk).

Netra nfs150 Server System

The Netra *nfs*150 Server system provides an easily managed, highly reliable, highly tuned dedicated NFS server. It is built exclusively to support NFS applications and running the Solaris software environment applications on it are not supported. This Netra NFS server provides superior NFS operations performance over general purpose servers.

The key benefits of this Netra NFS server include:

- Easy to install (comes with a pre-configured, turnkey system)
- Easy to use HTML management interface with the LCD system status and input panel
- Factory pre-configured RAID 5 disks
- Dedicated, simplified operation set
- Tuned for NFS performance
- System reliability (UPS for graceful shutdown on power failure)
- Uninterruptible power supply

This server meets the demands of high speed network environments. Because this server delivers high performance for NFS operations, it is most often installed in departments and workgroups where data access requirements are high and other servers are available for running applications and system management software (see Figure 2-8 on page 22).

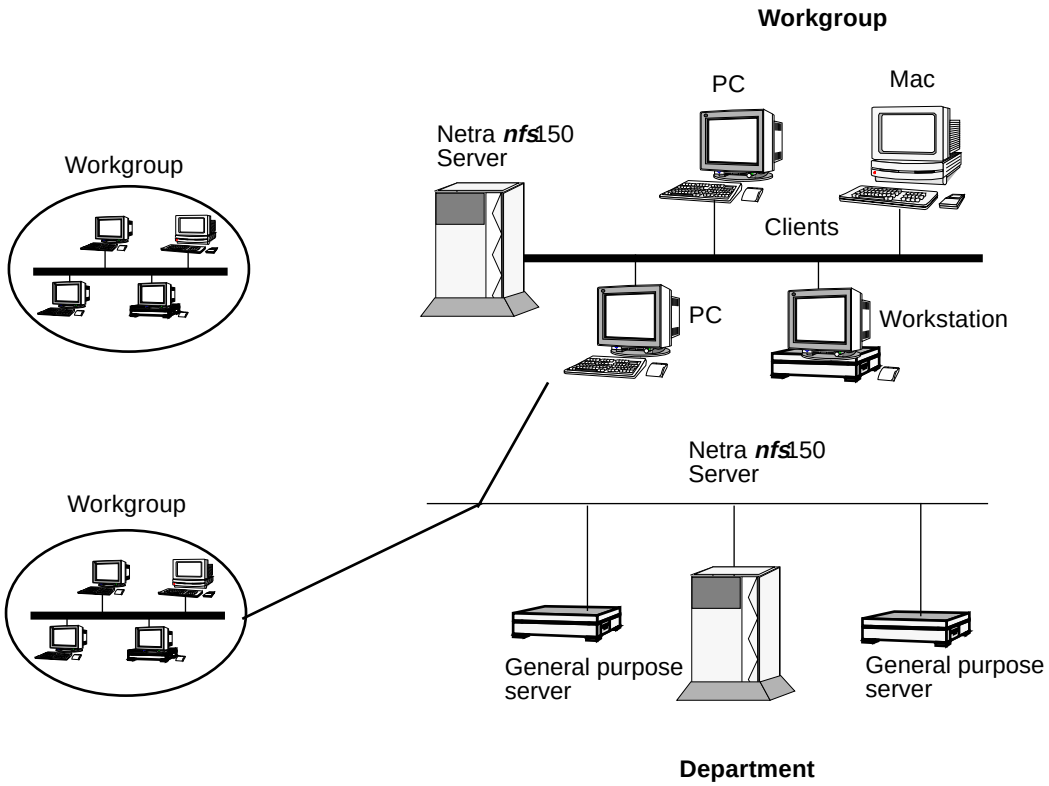

Figure 2-8 Environments Supported by the Netra *nfs*150 Server

As Figure 2-8 shows, the Netra *nfs*150 Server system supports both workgroup and department needs.

Netra nfs150 Server Software Support

The easy to use customized Netra NFS SmartServe™ software, which is focused exclusively on NFS applications, is tuned for NFS performance and is easy to administer. The software has the following features:

- Modified Solaris operating environment (dedicated and optimized for NFS)
- SNMP agent
- Single file system and RAID 5 preconfigured
- Backup software for online backups
- Support for NFS Version 2 and NFS Version 3
- Disk management support (RAID level 5 for storage management)
- Failure management and recovery
- System performance tuning (stable memory and NFS Smart Cache)
- PCNFSD (to use with NFS on PCs)

Netra NFS 150 Server Hardware Overview

This server is based on the Ultra 1 processor board, which is designed to deliver balanced system performance. With twelve slots of data disks, the data disk capacity of this server is 24 Gbytes (48 Gbytes with 4 Gbyte disk drives). The disk drives are hot plugable. A 10BaseT Ethernet controller is build in on-board.

One of the three SBus slots are used for ISP controllers. The second SBus slot contains a 100BaseT network card. The third SBus slot is available for additional network interfaces.

This system comes in two options: tower and rack ready. Four rack-ready systems can be installed in standard Sun racks. The system also has as a standard 3.5-inch diskette drive and a 644 Mbyte capacity CD-ROM drive. The eight SIMM slots can store up to 512 Mbytes of RAM.

2

Disk Expansion Units

This section describes an overview of the following disk expansion units:

- SPARCstorage Array subsystem
- Desktop Storage Module
- Multi-Disk Pack
- Desktop Disk Pack
- SPARCstorage MultiPack
- SPARCstorage UniPack

SPARCstorage Array Subsystem

To expand your disk storage, consider the SPARCstorage Array subsystem. This disk array is a high-performance and high-capacity companion unit for the Ultra Enterprise 4000, 5000, or 6000 systems, SPARCcenter 2000 or 2000E, SPARCserver 1000 or 1000E, Ultra Enterprise 2 system, SPARCserver 10, and the SPARCserver 20 systems.

The Model 101 uses 1.05 Gbyte single connector 3.5-inch disk drives. Each disk array contains three drive trays. Each drive tray supports up to ten 3.5-inch single-connector SCSI disk drives. All disk drive SCSI addresses are hardwired. The position of the disk drive in the drive tray automatically sets the SCSI addresses. Each disk array uses six internal fast, wide SCSI buses. Each drive tray contains two SCSI buses that support five disk drives for each SCSI bus.

Figure 2-9 shows a front view of the SPARCstorage Array subsystem.

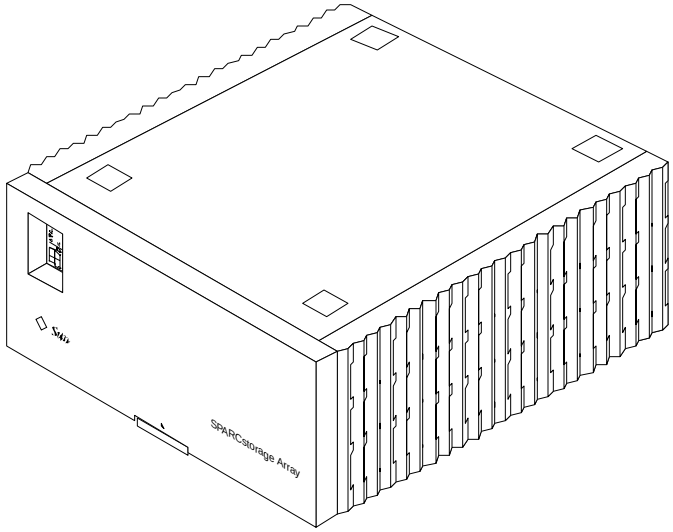

Figure 2-9 Front View of the SPARCstorage Array Subsystem

Figure 2-10 shows how you can connect the SPARCstorage Array subsystem to your NFS server.

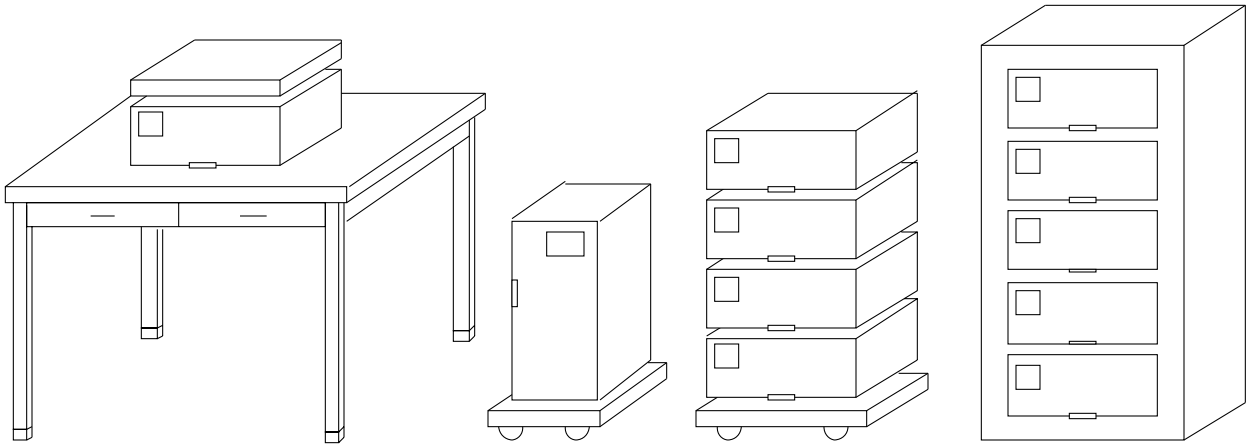

Figure 2-10 SPARCstorage Array Subsystem Installation Options

The SPARCstorage Array subsystem uses RAID (Redundant Array of Inexpensive Disks) technology. RAID 0 stripes data without parity, RAID 1does disk mirroring, RAID 0+1 does mirroring optimized stripes, and RAID 5 does striping data with parity.

Within the disk array, independent disks plus RAID levels 5, 1, 0, 0+1 are available at the same time so you can easily match data layouts to meet the specific requirements for capacity, performance, high availability, and cost.

If any disk in a RAID 5, 1, or 0+1 group fails, an optional hot spare (if configured) is automatically swapped in to replace the failed disk. Continuous, redundant data protection is provided, even if a disk fails.

Warm plug service lets you replace one or more disks without powering down the system and the disk array, or rebooting the system. You can obtain warm plug service if multiple disk arrays are configured.

Using the SPARCstorage Array subsystem can improve NFS performance because its processor manages and schedules disk I/O.

The SPARCstorage Manager software is provided with the disk array and provides similar functionality to Online: Disk Suite software. Since there are often many more disks to manage in the SPARCstorage Array subsystem, the SPARCstorage Manager software has an intuitive GUI interface.

SPARCstorage MultiPack

The SPARCstorage MultiPack™ enclosure, which is fast wide SCSI, can adapt to 50-pin or narrow hosts. The SPARCstorage MultiPack is self-terminating but it can be chained with units that require external termination.

The SPARCstorage MultiPack uses single connector disks and it is hot plugable. The enclosure can either contain from two to six 1.5-inch disk drives or from two to twelve 1-inch disk drives. To accommodate from two to twelve 1-inch disk drives you must use an SBus SCSI host adapter.

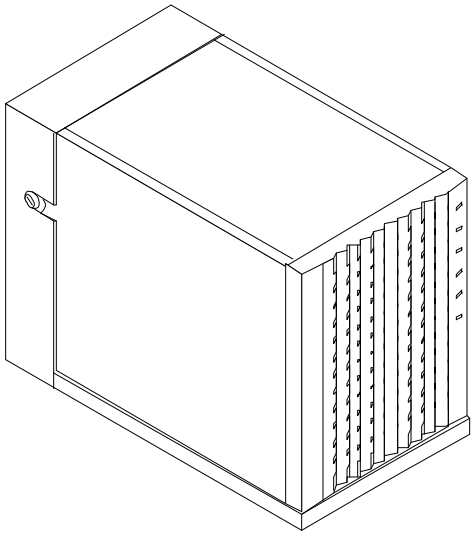

Figure 2-11 SPARCstorage MultiPack Front View

Desktop Storage Module

The Desktop Storage Module (disk unit) is an external hard disk drive unit for desktop servers and the SPARCserver series. It contains one full-height 1.3 Gbyte disk drive. Figure 2-12 shows a front view of the Desktop Storage Module.

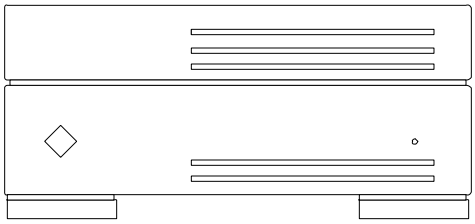

Figure 2-12 Front View of the Desktop Storage Module 1.3 Gbyte Disk Drive Unit

Multi-Disk Pack

The Multi-Disk Pack is a disk expansion unit for the SPARCserver 5, SPARCserver 10, and SPARCserver 20 systems and comes in two configurations:

- Four 1.05 Gbyte fast SCSI disk drives totaling 4.2 Gbytes of disk storage
- Two or four 2.1 Gbyte fast SCSI disk drives totaling 4.2 or 8.4 Gbytes of disk storage

The SCSI addresses are set by SCSI address jumpers on the disk drives. Figure 2-13 shows a front view of the Multi-Disk Pack.

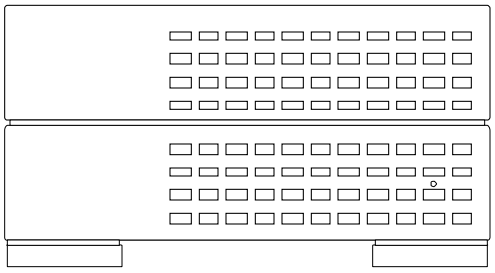

Figure 2-13 Front View of the Multi-Disk Pack

SPARCstorage UniPack

The disk model of the SPARCstorage UniPack™ enclosure contains a self terminating hard disk drive. Models containing a tape drive or a CD-ROM drive are also available. The unit is fast wide SCSI and can be adapted to a narrow 50-pin host.

This expansion unit can be used with the following desktop server systems:

- SPARCstation 5 system
- SPARCstation 10 system
- SPARCstation 20 system
- Sun Ultra Enterprise 1 system
- Sun Ultra Enterprise 2 system

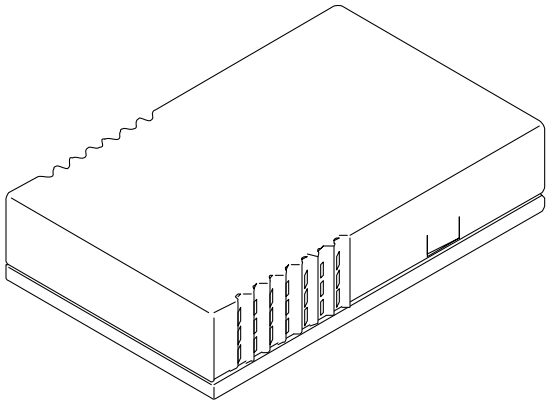

Figure 2-14 SPARCstorage UniPack Front View

Desktop Disk Pack

The Desktop Disk Pack is a disk expansion unit that contains one SCSI disk. Some of the disk capacities are:

- 207 Mbyte low profile disk drive
- 424 Mbyte disk drive
- 535 Mbyte low profile disk drive
- 1.05 Gbyte low profile disk drive

The SCSI address is set by a SCSI address switch at the rear of the unit. This expansion unit is useful for the following desktop server systems:

- SPARCstation 5 system
- SPARCstation 10 system
- SPARCstation 20 system

Figure 2-15 illustrates a front view of the Desktop Disk Pack.

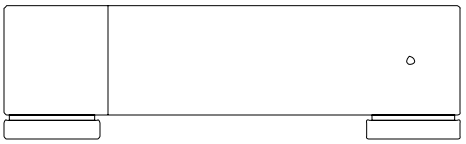

Figure 2-15 Front View of the Desktop Disk Pack

Analyzing NFS Performance 3

This chapter explains how to analyze NFS performance and describes the general steps for tuning your system. This chapter also describes how to verify the performance of the network, server, and each client.

Tuning the NFS Server

You may want to tune a server for optimal performance when you first set it up, and later, to improve performance in response to a specific problem.

Improving General Performance

Here are some general guidelines for improving the performance of your NFS server.

1. Measure the current level of performance for the network, server, and each client. See “Checking Network, Server, and Client Performance” on page 32.
2. Analyze the gathered data by graphing it. Look for exceptions, high disk and CPU utilization, and high disk service times. Apply thresholds or performance rules to the data.
3. Tune the server. See Chapter 4, “Configuring the Server and the Client to Maximize NFS Performance.
4. Repeat Steps 1 through 3 until you achieve the desired performance.

3

Resolving Performance Problems

Here are some general guidelines for resolving performance problems with your NFS server.

1. Use tools then observe the symptoms to pinpoint the source of the problem.
2. Measure the current level of performance for the network, server, and each client. See “Checking Network, Server, and Client Performance.
3. Analyze the data gathered by graphing the data. Look for exceptions, high disk and CPU utilization, and high disk service times. Apply thresholds or performance rules to the data.
4. Tune the server. See Chapter 4, “Configuring the Server and the Client to Maximize NFS Performance.”
5. Repeat Steps 1 through 4 until you achieve the desired performance.

Checking Network, Server, and Client Performance

Before you can tune the NFS server, you must check the performance of the network, the NFS server, and each client. The first step is to check the performance of the network.

Checking the Network

If disks are operating normally, check network usage because a slow server and a slow network look the same to an NFS client.

Figure 3-1 illustrates the steps you must follow in sequence to check the network.

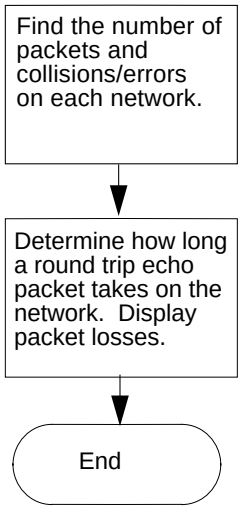

Figure 3-1 Flow Diagram for Checking the Network Performance

▼ To find the number of packets and collisions or errors on each network

1. Type `netstat -i 15`.

```
server% netstat -i 15
      input   le0       output    input       (Total)    output
packets errs  packets errs  colls  packets errs  packets errs  colls
10798731 533   4868520 0     1078   24818184 555   14049209 157   894937
51      0     43      0     0      238     0     139     0     0
85      0     69      0     0      218     0     131     0     2
44      0     29      0     0      168     0     94      0     0
```

Use `-I` (Capital I) *interface* to look at other interfaces.

`-i`	Shows the state of the interfaces that are used for TCP/IP traffic
`15`	Collects information every 15 seconds

In the `netstat -i 15` display, a machine with active network traffic should show both input packets and output packets continually increasing.

a. **Calculate the network collision rate by dividing the number of output collision counts (`Output Colls` - `le`) by the number of output packets (`le`).**
   A network-wide collision rate greater than 10 percent can indicate an overloaded network, a poorly configured network, or hardware problems.

b. **Calculate the input packet error rate by dividing the number of input errors (`le`) by the total number of input packets (`le`).**
   If the input error rate is high (over 25 percent), the host may be dropping packets.

   Other hardware on the network, as well as heavy traffic and low-level hardware problems, can introduce transmission problems. Bridges and routers can drop packets, forcing retransmissions and causing degraded performance.

   Bridges also cause delays when they examine packet headers for Ethernet addresses. During these examinations, bridge network interfaces may drop packet fragments.

To compensate for bandwidth-limited network hardware:

- Reduce the packet size specifications.
- Set the read buffer size, `rsize`, and the write buffer size, `wrsize`, when using `mount` or in the `/etc/vfstab` file. Reduce the appropriate variable(s) (depending on the direction of data passing through the bridge) to 2048.
  If data passes in both directions through the bridge or other device, reduce both variables:

```
server:/home  /home/server nfs rw,rsize=2048,wsize=2048 0 0
```

If a lot of read and write requests are dropped and the client is communicating with the server using the User Datagram Protocol (UDP), then the entire packet will be retransmitted, instead of the dropped packets.

▼ To determine how long a round trip echo packet takes on the network, and to display packet losses

♦ **Type** `ping -sRv` *servername* **from the client to show the route taken by the packets.**

If the round trip takes more than a few milliseconds (ms), there are slow routers on the network, or the network is very busy. Ignore the results from the first `ping` command.

```
client% ping -sRv servername
PING server: 56 data bytes
64 bytes from server (129.145.72.15): icmp_seq=0. time=5. ms
  IP options:  <record route> router (129.145.72.1), server
(129.145.72.15), client (129.145.70.114),  (End of record)
64 bytes from server (129.145.72.15): icmp_seq=1. time=2. ms
  IP options:  <record route> router (129.145.72.1), server
(129.145.72.15), client (129.145.70.114),  (End of record)
```

`s` Send option. Sends one datagram per second and prints one line of output for every echo response it receives. If there is no response, no output is produced.

`R` Record route option. Sets the Internet Protocol (IP) record option that stores the route of the packet inside the IP header.

`v` Verbose option. Lists any ICMP packets other than echo response that are received.

If you suspect a physical problem, use `ping -sRv` to find the response time of several hosts on the network. If the response time (ms) from one host is not what you would expect, investigate that host.

The `ping` command uses the ICMP protocol's echo request datagram to elicit an ICMP echo response from the specified host or network gateway. It can take a long time on a time-shared NFS server to obtain the ICMP echo. The distance from the client to the NFS server is a factor for how long it takes to obtain the ICMP echo from the server.

Figure 3-2 shows the possible responses or the lack of response to the `ping -sRv` command.

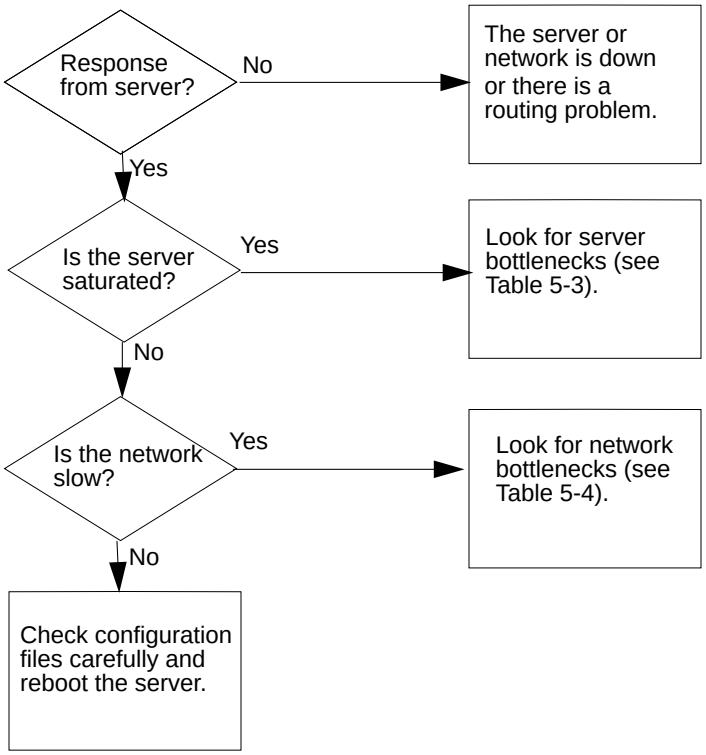

Figure 3-2 Flow Diagram of Possible Responses to the `ping -sRv` Command

Checking the NFS Server

Note – The server used in the following examples is a large SPARCserver 690 configuration.

Figure 3-3, which follows, illustrates the steps you must follow in sequence to check the NFS server.

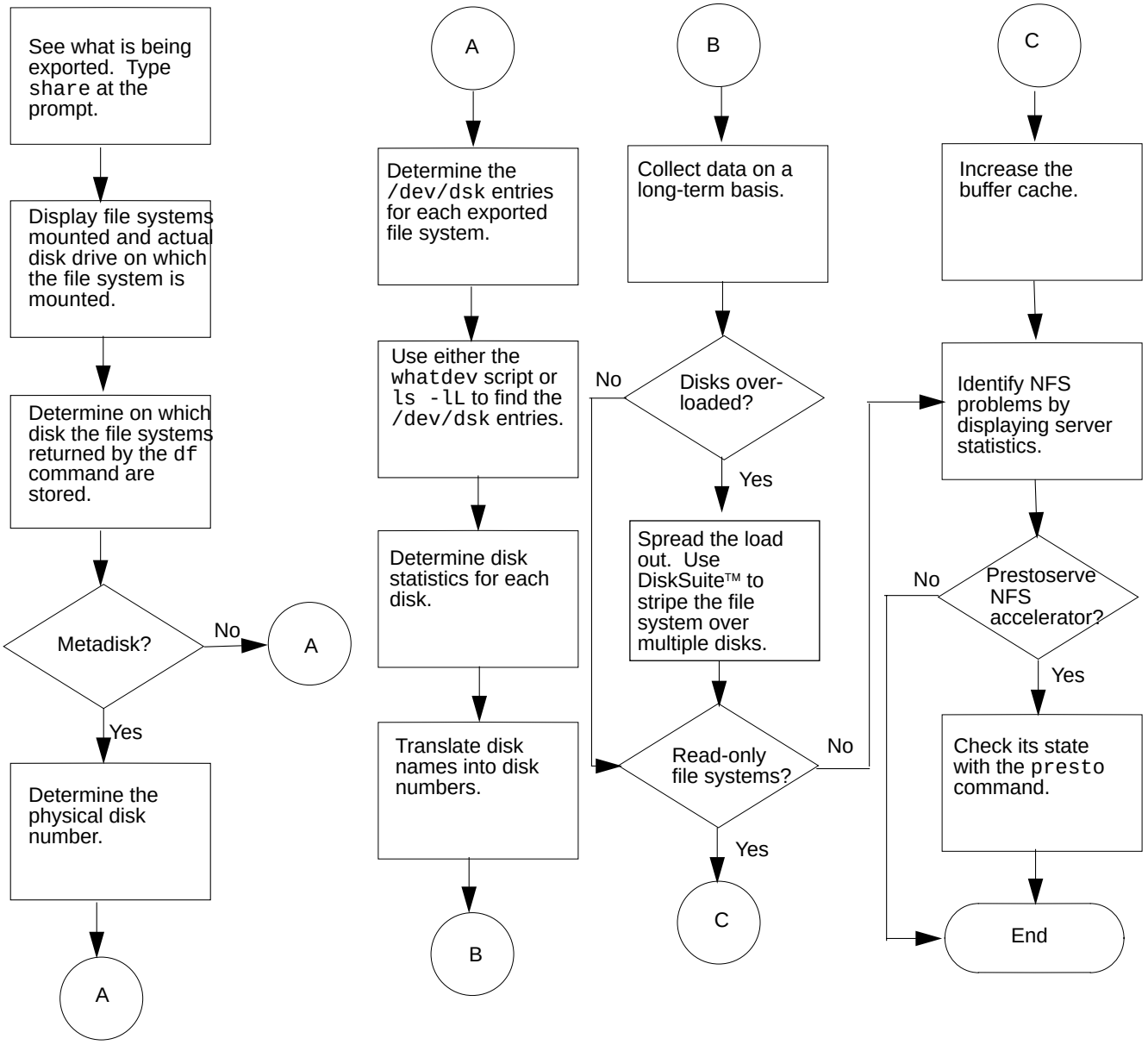

Figure 3-3 Flow Diagram to Check the NFS Server

▼ To see what is being exported

♦ **Type** `share`.

```
server% share
-               /export/home   rw=netgroup   ""
-               /var/mail   rw=netgroup   ""
-               /cdrom/solaris_2_3_ab   ro   ""
```

▼ To display the file systems mounted and the disk drive on which the file system is mounted

♦ **Type** `df -k`.
If an file system is over 100 percent full, it may cause NFS write errors on the clients.

```
server% df -k
Filesystem            kbytes    used   avail capacity  Mounted on
/dev/dsk/c1t0d0s0     73097     36739  29058     56%   /
/dev/dsk/c1t0d0s3     214638    159948 33230     83%   /usr
/proc                 0         0      0         0% /proc
fd                    0         0      0         0% /dev/fd
swap                  501684    32     501652    0%   /tmp
/dev/dsk/c1t0d0s4     582128    302556  267930   53%   /var/mail
/dev/md/dsk/d100      7299223   687386  279377   96%   /export/home
/vol/dev/dsk/c0t6/solaris_2_3_ab
                      113512    113514  0        100%   /cdrom/solaris_2_3_ab
```

Note – For this example, the `/var/mail` and `/export/home` file systems are used.

Determine on which disk the file systems returned by the `df -k` command are stored

In the previous example, you'll note that `/var/mail` is stored on `/dev/dsk/c1t0d0s4` and `/export/home` is stored on `/dev/md/dsk/d100`, an Online: DiskSuite™ metadisk.

▼ **If an Online: DiskSuite metadisk is returned by the `df -k` command, determine the number of the disk**

♦ **Type `/usr/opt/SUNWmd/sbin/metastat` *<disknumber>*.**
In the previous example, `/usr/opt/SUNWmd/sbin/metastat d100` determines what physical disk `/dev/md/dsk/d100` uses.

Note – The d100 disk is a mirrored disk. Each mirror is made up of three striped disks of one size concatenated with four striped disks of another size. There is also a hot spare disk. This system uses IPI disks, `id`*X*. SCSI disks, `sd`*X*, are treated identically.

```
server% /usr/opt/SUNWmd/sbin/metastat d100
d100: metamirror
    Submirror 0: d10
      State: Okay
    Submirror 1: d20
      State: Okay
    Regions which are dirty: 0%
    Pass = 1
    Read option = round-robin (default)
    Write option =  parallel (default)
    Size: 15536742 blocks
d10: Submirror of d100
    State: Okay
    Hot spare pool: hsp001
    Size: 15536742 blocks
    Stripe 0: (interlace : 96 blocks)
    Device              Start Block  Dbase State        Hot Spare
    /dev/dsk/c1t1d0s7          0     No    Okay
    /dev/dsk/c2t2d0s7          0     No    Okay
    /dev/dsk/c1t3d0s7          0     No    Okay
    Stripe 1: (interlace : 64 blocks)
    Device              Start Block  Dbase State        Hot Spare
    /dev/dsk/c3t1d0s7          0     No    Okay
    /dev/dsk/c4t2d0s7          0     No    Okay
    /dev/dsk/c3t3d0s7          0     No    Okay
    /dev/dsk/c4t4d0s7          0     No    Okay
d20: Submirror of d100
    State: Okay
    Hot spare pool: hsp001
Size: 15536742 blocks
    Stripe 0: (interlace : 96 blocks)
    Device              Start Block  Dbase State        Hot Spare
    /dev/dsk/c2t1d0s7          0     No    Okay
    /dev/dsk/c1t2d0s7          0     No    Okay
    /dev/dsk/c2t3d0s7          0     No    Okay
    Stripe 1: (interlace : 64 blocks)
    Device              Start Block  Dbase State        Hot Spare
    /dev/dsk/c4t1d0s7          0     No    Okay
    /dev/dsk/c3t2d0s7          0     No    Okay
    /dev/dsk/c4t3d0s7          0     No    Okay
    /dev/dsk/c3t4d0s7        0    No   Okay     /dev/dsk/c2t4d0s7
```

▼ To determine the /dev/dsk entries for each exported file system

Use the whatdev script to find the instance or nickname for the drive or type `ls -lL /dev/dsk/c1t0d0s4` and `more /etc/path_to_inst` to find the /dev/dsk entries.

Follow either procedure in sections "Using the whatdev Script" or "Using ls -lL to Identify /dev/dsk Entries."

Using the whatdev Script

a. Type the whatdev script using a text editor.

```
#!/bin/csh
# print out the drive name - st0 or sd0 - given the /dev entry
# first get something like "/iommu/.../.../sd@0,0"
set dev = `/bin/ls -l $1 | nawk '{ n = split($11, a, "/");
split(a[n],b,":"); for(i = 4; i < n; i++) printf("/%s",a[i]);
printf("/%s\n", b[1]) }'`
if ( $dev == "" ) exit
# then get the instance number and concatenate with the "sd"
nawk -v dev=$dev '$1 ~ dev { n = split(dev, a, "/"); split(a[n], \
b, "@"); printf("%s%s\n", b[1], $2) }' /etc/path_to_inst
```

b. Determine the /dev/dsk entry for the file system by typing df /<*filesystemname*>.
In this example you would type `df /var/mail`.

```
furious% df /var/mail
Filesystem            kbytes    used   avail capacity  Mounted on
/dev/dsk/c1t0d0s4     582128  302556  267930    53%    /var/mail
```

c. Determine the disk number by typing `whatdev` *diskname* **(the disk name returned by the** `df /`*<filesystemname>* **command).**

In this example you would type `whatdev /dev/dsk/c1t0d0s4`.

Disk number `id8` is returned. This is IPI disk 8.

```
server% whatdev /dev/dsk/c1t0d0s4
id8
```

d. Repeat steps b and c for each file system not stored on a metadisk (`dev/md/dsk`**).**

e. If the file system is stored on a meta disk, (`dev/md/dsk`**), look at the** `metastat` **output and run the** `whatdev` **script on** *all* **drives included in the metadisk.**

In this example type `whatdev /dev/dsk/c2t1d0s7`.

There are 14 disks in the `/export/home` file system. Running the `whatdev` script on the `/dev/dsk/c2t1d0s7` disk, one of the 14 disks comprising the `/export/home` file system, returns the following display.

```
server% whatdev /dev/dsk/c2t1d0s7
id17
```

Note that `/dev/dsk/c2t1d0s7` is disk `id17`. This is IPI disk 17.

f. Go to the procedure "To see the disk statistics for each disk" on page 44."

Using `ls -lL` to Identify `/dev/dsk` Entries

If you followed the procedure "Using the whatdev Script" skip this section. Go to the procedure "To see the disk statistics for each disk."

If you did not follow the procedure outlined in"Using the whatdev Script:"

a. List the drive and its major and minor device numbers by typing `ls -lL` <*disknumber*>**.**

For example, for the `/var/mail` file system, type:
`ls -lL /dev/dsk/c1t0d0s4`.

```
ls -lL /dev/dsk/c1t0d0s4
brw-r-----  1 root      66,  68 Dec 22 21:51 /dev/dsk/c1t0d0s4
```

b. Locate the minor device number in the `ls -lL` output.
In the previous screen example, the first number following the file ownership (`root`), `66`, is the major number. The second number, `68`, is the minor device number.

c. Determine the disk number.
Divide the minor device number, 68 in the previous example, by 8.

Disk number — 68/8 = 8.5

Truncate the fraction. The number, 8, is the disk number.

d. Determine the slice (partition) number.
Look at the number following the s (for slice) in the disk number. For example, in `/dev/dsk/c1t0d0s4`, the 4 following the s refers to slice 4.

Now you know that the disk number is 8 and the slice number is 4. This disk is either `sd8` (SCSI) or `ip8` (IPI).

e. Go to the procedure, "To see the disk statistics for each disk," which follows.

▼ To see the disk statistics for each disk

♦ **Type** `iostat -x 15`.

The `-x` option supplies extended disk statistics. The `15` means disk statistics are gathered every 15 seconds.

```
server% iostat -x 15
extended disk statistics
disk      r/s  w/s   Kr/s   Kw/s wait actv  svc_t  %w  %b
id10      0.1  0.2    0.4    1.0  0.0  0.0   24.1   0   1
id11      0.1  0.2    0.4    0.9  0.0  0.0   24.5   0   1
id17      0.1  0.2    0.4    1.0  0.0  0.0   31.1   0   1
id18      0.1  0.2    0.4    1.0  0.0  0.0   24.6   0   1
id19      0.1  0.2    0.4    0.9  0.0  0.0   24.8   0   1
id20      0.0  0.0    0.1    0.3  0.0  0.0   25.4   0   0
id25      0.0  0.0    0.1    0.2  0.0  0.0   31.0   0   0
id26      0.0  0.0    0.1    0.2  0.0  0.0   30.9   0   0
id27      0.0  0.0    0.1    0.3  0.0  0.0   31.6   0   0
id28      0.0  0.0    0.0    0.0  0.0  0.0    5.1   0   0
id33      0.0  0.0    0.1    0.2  0.0  0.0   36.1   0   0
id34      0.0  0.2    0.1    0.3  0.0  0.0   25.3   0   1
id35      0.0  0.2    0.1    0.4  0.0  0.0   26.5   0   1
id36      0.0  0.0    0.1    0.3  0.0  0.0   35.6   0   0
id8       0.0  0.1    0.2    0.7  0.0  0.0   47.8   0   0
id9       0.1  0.2    0.4    1.0  0.0  0.0   24.8   0   1
sd15      0.1  0.1    0.3    0.5  0.0  0.0   84.4   0   0
sd16      0.1  0.1    0.3    0.5  0.0  0.0   93.0   0   0
sd17      0.1  0.1    0.3    0.5  0.0  0.0   79.7   0   0
sd18      0.1  0.1    0.3    0.5  0.0  0.0   95.3   0   0
sd6       0.0  0.0    0.0    0.0  0.0  0.0  109.1   0   0
```

Use the `iostat -x 15` command to see the disk number for the extended disk statistics. In the next procedure you will use a `sed` script to translate the disk names into disk numbers.

The output for the extended disk statistics is:

`r/s`	Reads per second
`w/s`	Writes per second
`Kr/s`	Kbytes read per second
`Kw/s`	Kbytes written per second
`wait`	Average number of transactions waiting for service (queue length)
`actv`	Average number of transactions actively being serviced
`svc_t`	Average service time, (milliseconds)
`%w`	Percentage of time the queue is not empty
`%b`	Percentage of time the disk is busy

▼ To translate disk names into disk numbers

Use `iostat` and `sar`. One quick way to do this is to use a `sed` script:.

1. **Type in a `sed` script using a text editor similar to the following `d2fs.server sed` script.**
   Your `sed` script should substitute the file system name for the disk number.

   In this example, disk `id8` is substituted for `/var/mail` and disks `id9, id10, id11, id17, id18, id19, id25, id26, id27, id28, id33, id34, id35,` and `id36` are substituted for `/export/home`.

```
sed 's/id8 /var/mail/
    s/id9 /export/home/
    s/id10 /export/home/
    s/id11 /export/home/
    s/id17 /export/home/
    s/id18 /export/home/
    s/id25 /export/home/
    s/id26 /export/home/
    s/id27 /export/home/
    s/id28 /export/home/
    s/id33 /export/home/
    s/id34 /export/home/
    s/id35 /export/home/
    s/id36 /export/home/'
```

2. **Run the `iostat -xc 15` command through the `sed` script by typing `iostat -xc 15 | d2fs.server`.**

The options to the previous `iostat -xc 15 | d2fs.server` command are explained below.

`-x`	Supplies extended disk statistics
`-c`	Reports the percentage of time the system was in user mode (`us`), system mode (`sy`), waiting for I/O (`wt`), and idling (`id`)
`15`	Means disk statistics are gathered every 15 seconds

Code Example 3-1 Output for the `iostat -xc 15` Command

```
% iostat -xc 15 | d2fs.server
extended disk statistics          cpu
disk           r/s  w/s   Kr/s   Kw/s wait actv  svc_t  %w  %b  us sy wt id
export/home      0.1  0.2    0.4    1.0  0.0  0.0   24.1   0   1   0 11  2 86
export/home      0.1  0.2    0.4    0.9  0.0  0.0   24.5   0   1
export/home      0.1  0.2    0.4    1.0  0.0  0.0   31.1   0   1
export/home      0.1  0.2    0.4    1.0  0.0  0.0   24.6   0   1
export/home      0.1  0.2    0.4    0.9  0.0  0.0   24.8   0   1
id20             0.0  0.0    0.1    0.3  0.0  0.0   25.4   0   0
export/home      0.0  0.0    0.1    0.2  0.0  0.0   31.0   0   0
export/home      0.0  0.0    0.1    0.2  0.0  0.0   30.9   0   0
export/home      0.0  0.0    0.1    0.3  0.0  0.0   31.6   0   0
export/home      0.0  0.0    0.0    0.0  0.0  0.0    5.1   0   0
export/home      0.0  0.0    0.1    0.2  0.0  0.0   36.1   0   0
export/home      0.0  0.2    0.1    0.3  0.0  0.0   25.3   0   1
export/home      0.0  0.2    0.1    0.4  0.0  0.0   26.5   0   1
export/home      0.0  0.0    0.1    0.3  0.0  0.0   35.6   0   0
var/mail         0.0  0.1    0.2    0.7  0.0  0.0   47.8   0   0
id9              0.1  0.2    0.4    1.0  0.0  0.0   24.8   0   1
sd15             0.1  0.1    0.3    0.5  0.0  0.0   84.4   0   0
sd16             0.1  0.1    0.3    0.5  0.0  0.0   93.0   0   0
sd17             0.1  0.1    0.3    0.5  0.0  0.0   79.7   0   0
sd18             0.1  0.1    0.3    0.5  0.0  0.0   95.3   0   0
sd6              0.0  0.0    0.0    0.0  0.0  0.0  109.1   0   0
```

The following terms and abbreviations explain the output and headings of Code Example 3-1.

`disk`	Name of disk device
`r/s`	Average read operations per second
`w/s`	Average write operations per second

`Kr/s`	Average Kbytes read per second
`Kw/s`	Average Kbytes written per second
`wait`	Number of requests outstanding in the device driver queue
`actv`	Number of requests active in the disk hardware queue
`%w`	Occupancy of the wait queue
`%b`	Occupancy of the active queue—device busy
`svc_t`	Average service time in milliseconds for a complete disk request; includes wait time, active queue time, seek rotation, and transfer latency
`us`	CPU time
`sy`	System time
`wt`	Wait for I/O time
`id`	Idle time

3. **Run the** `sar -d 15 1000` **command through the** `sed` **script by typing** `sar -d 15 1000 | d2fs.server`**.**

Code Example 3-2 Output of the `sar -d 15 1000 | d2fs.server` Command

```
server% sar -d 15 1000 | d2fs.server
12:44:17  device   %busy     avque  r+w/s  blks/s avwait  avserv
12:44:18  export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          id20          0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          var/mail      0        0.0      0       0     0.0   0.0
          export/home   0        0.0      0       0     0.0   0.0
          sd15          7        0.1      4     127     0.0  17.6
          sd16          6        0.1      3     174     0.0  21.6
          sd17          5        0.0      3     127     0.0  15.5
```

The `sar -d` option reports the activities of the disk devices. The `15` means that data is collected every 15 seconds. The `1000` means that data is collected 1000 times. The following terms and abbreviations explain the output and headings of Code Example 3-2.

`device`	Name of the disk device being monitored
`%busy`	Percentage of time the device spent servicing a transfer request (same as `iostat %b`)
`avque`	Average number of requests outstanding during the monitored period (measured only when the queue was occupied) (same as `iostat actv`)
`r+w/s`	Number of read and write transfers to the device, per second (same as `iostat r/s + w/s`)
`blks/s`	Number of 512-byte blocks transferred to the device, per second (same as `iostat` 2*(`Kr/s + Kw/s`))
`avwait`	Average time, in milliseconds, that transfer requests wait idly in the queue (measured only when the queue is occupied) (`iostat wait` gives the length of this queue)
`avserv`	Average time, in milliseconds, for a transfer request to be completed by the device (for disks, this includes seek, rotational latency, and data transfer times)

4. **For file systems that are exported via NFS, check the** `%b/%busy` **value.**
   If it is more than 30%, check the `svc_t` value.

   The `%b` value, the percentage of time the disk is busy, is returned by the `iostat` command. The `%busy` value, the percentage of time the device spent servicing a transfer request, is returned by the `sar` command. If the `%b` and the `%busy` values are greater than 30 percent, go to Step 5. Otherwise, go on to "To collect data on a regular basis," which follows.

5. **Calculate the** `svc_t/(avserv + avwait)` **value.**
   The `svc_t` value, the average service time in milliseconds, is returned by the `iostat` command. The `avserv` value, the average time (milliseconds) for a transfer request to be completed by the device, is returned by the `sar` command. Add the `avwait` to get the same measure as `svc_t`.

   If the `svc_t` value, the average total service time in milliseconds, is more than 40 ms, the disk is taking a long time to respond. An NFS request with disk I/O will appear to be slow by the NFS clients. The NFS response time

should be less than 50 ms on average, to allow for NFS protocol processing and network transmission time. The disk response should be less than 40 ms.

The average service time in milliseconds is a function of the disk. If you have fast disks, the average service time should be less than if you have slow disks.

▼ To collect data on a regular basis

♦ **Uncomment the lines in the user's `sys crontab` file so that `sar` collects the data for one month.**

```
root# crontab -l sys
#ident"@(#)sys1.592/07/14 SMI"/* SVr4.0 1.2*/
#
# The sys crontab should be used to do performance collection.
# See cron and performance manual pages for details on startup.
0 * * * 0-6 /usr/lib/sa/sa1
20,40 8-17 * * 1-5 /usr/lib/sa/sa1
5 18 * * 1-5 /usr/lib/sa/sa2 -s 8:00 -e 18:01 -i 1200 -A
```

Performance data will be continuously collected to provide you with a history of `sar` results.

Note – A few hundred Kbytes will be used at most in `/var/adm/sa`.

▼ To spread the load out over the disks

- Use Solstice™ DiskSuite or Online: DiskSuite to stripe the file system over multiple disks if the disks are overloaded.
- Use a Prestoserve write cache to reduce the number of accesses and spread peak access loads out in time.

See the section "Using Solstice DiskSuite or Online: DiskSuite to Spread Disk Access Load" on page 67 in Chapter 4.

▼ To adjust the buffer cache if you have read-only file systems

♦ **Increase the buffer cache.**
See "Adjusting the Buffer Cache: bufhwm" on page 80 in Chapter 4.

▼ To identify NFS problems, display server statistics

♦ **Type `nfsstat -s` (see Code Example 3-3.)**
The `-s` option displays server statistics.

Code Example 3-3 Using the `nfsstat -s` Command to Display Server Statistics

```
server% nfsstat -s
Server rpc:
calls      badcalls   nullrecv   badlen     xdrcall
480421     0          0          0          0
Server nfs:
calls      badcalls
480421     2
null       getattr    setattr    root       lookup     readlink   read
95  0%     140354 29% 10782  2%  0  0%     110489 23% 286  0%    63095 13%
wrcache    write      create     remove     rename     link       symlink
0  0%      139865 29% 7188  1%   2140  0%   91  0%     19  0%     231  0%
mkdir      rmdir      readdir    statfs
435  0%    127  0%    2514  1%   2710  1%
```

The NFS server display shows the number of NFS calls received (`calls`) and rejected (`badcalls`), and the counts and percentages for the various calls that were made. The number and percentage of calls returned by the `nfsstat -s` command are described in Table 3-2 on page 54.

The following terms explain the headings in the output of Code Example 3-3.

`calls`	Total number of RPC calls received
`badcalls`	Total number of calls rejected by the RPC layer (the sum of `badlen` and `xdrcall`)
`nullrecv`	Number of times an RPC call was not available when it was thought to be received

`badlen`	Number of RPC calls with a length shorter than a minimum-sized RPC call
`xdrcall`	Number of RPC calls whose header could not be XDR decoded

Table 3-1 explains the `nfsstat -s` command output and what actions to take.

Table 3-1 Description of the `nfsstat -s` Command Output

If	Then
writes > 5%**	Install a Prestoserve NFS accelerator (SBus card or NVRAM-NVSIMM) for peak performance. See the section “Prestoserve NFS Accelerator” on page 75 in Chapter 4.
There are any `badcalls`	`Badcalls` are calls rejected by the RPC layer and are the sum of `badlen` and `xdrcall`. The network may be overloaded. Identify an overloaded network using network interface statistics.
`readlink` > 10% of total `lookup` calls on NFS servers	NFS clients are using excessive symbolic links that are on the file systems exported by the server. Replace the symbolic link with a directory. Mount both the underlying file system and the symbolic link’s target on the NFS client. See the procedure that follows “To eliminate symbolic links” on page 52.
`getattr` > 40%	Increase the client attribute cache using the `actimeo` option. Make sure that the DNLC and inode caches are large. Use `vmstat -s` to determine the percent hit rate (cache hits) for the DNLC and if needed increase `ncsize` in the `/etc/system` file. See the procedure “To show the Directory Name Lookup Cache (DNLC) hit rate,” in this chapter and the section “Directory Name Lookup Cache (DNLC)” on page 82 in Chapter 4.

**** The number of writes, 29% in the previous example, is very high.**

▼ To eliminate symbolic links

If `symlink` is greater than 10 percent in the output of the `nfsstat -s` command (see Code Example 3-3), eliminate symbolic links. In the following example, `/usr/tools/dist/sun4` is a symbolic link for `/usr/dist/bin`.

1. **Type** `rm /usr/dist/bin` **to eliminate the symbolic link for** `/usr/dist/bin`**.**

```
# rm /usr/dist/bin
```

2. **Type** `mkdir /usr/dist/bin` **to make** `/usr/dist/bin` **a directory.**

```
# mkdir /usr/dist/bin
```

3. **Mount the directories and type:**

```
client# mount server: /usr/dist/bin
client# mount server: /usr/tools/dist/sun4
client# mount
```

▼ To show the Directory Name Lookup Cache (DNLC) hit rate

1. **Type** `vmstat -s`**.**
   This command returns the hit rate (cache hits).

```
% vmstat -s
... lines omitted
79062 total name lookups (cache hits 94%)
16 toolong
```

2. **If the hit rate is less than 90 percent and there is no problem with the number of longnames, increase the variable,** `ncsize`**, in the** `/etc/system` **file:**

```
set ncsize=5000
```

Directory names less than 30 characters long are cached and names that are too long to be cached are also reported.

The default value of `ncsize` is:

`ncsize` (name cache) = 17 * `maxusers` + 90

- For NFS server benchmarks `ncsize` has been set as high as 16000.
- For `maxusers` = 2048 `ncsize` would be set at 34906.

For more information on the Directory Name Lookup Cache, see "Directory Name Lookup Cache (DNLC)" on page 82 in Chapter 4.

3. **Reboot the system.**

▼ To check the system state if the system has a Prestoserve NFS accelerator

♦ **Type** `/usr/sbin/presto`**.**
Verify that it is in the UP state.

```
server% /usr/sbin/presto
state = UP, size = 0xfff80 bytes
statistics interval: 1 day, 23:17:50  (170270 seconds)
write cache efficiency: 65%
All 2 batteries are ok
```

- If it is in the DOWN state, type `presto -u`.

```
server% presto -u
```

- If it is in the error state, see the *Prestoserve User's Guide*.

Table 3-2 describes the NFS operations and their functions.

Table 3-2 NFS Operations

Operation	Function
`create`	Creates a file system node; may be a file or symbolic link
`statfs`	Gets dynamic file system information
`getattr`	Gets file / directory attributes such as file type, size, permissions, and access times
`link`	Creates a hard link in the remote file system
`lookup`	Searches directory for file and return file handle
`mkdir`	Creates a directory
`null`	Does nothing; used for testing and timing of server response
`read`	Reads an 8-KByte block of data
`readdir`	Reads a directory entry
`readlink`	Follows a symbolic link on the server
`rename`	Changes the file's directory name entry
`remove`	Removes a file system node
`rmdir`	Removes a directory
`root`	Retrieves the root of the remote file system (not presently used)
`setattr`	Changes file or directory attributes
`symlink`	Makes a symbolic link in a remote file system
`wrcache`	Writes an 8 Kbyte block of data to the remote cache (not presently used)
`write`	Writes an 8 Kbyte block of data

Checking Each Client

The overall tuning process must include client tuning. Sometimes, tuning the client yields more improvement than fixing the server. For example, adding 4 Mbytes of memory to each of 100 clients dramatically decreases the load on an NFS server.

Following is an overview of the steps to check each client. These steps will be discussed in the following procedures:

1. Check the client statistics to see if the client is having NFS problems.
2. Display statistics for each NFS mounted file system.

▼ To check the client statistics to see if the client is having NFS problems

♦ **Type** `nfsstat -c` **at the % prompt (see Code Example 3-4).**
Look for errors and retransmits

Code Example 3-4 Output of the `nfsstat -c` Command

```
client % nfsstat -c
Client rpc:
calls      badcalls   retrans    badxids    timeouts   waits      newcreds
384687     1          52         7          52         0          0
badverfs   timers     toobig     nomem      cantsend   bufulocks
0          384        0          0          0          0
Client nfs:
calls      badcalls   clgets     cltoomany
379496     0          379558     0
Version 2: (379599 calls)
null       getattr    setattr    root       lookup     readlink   read
0 0%       178150 46% 614 0%     0 0%       39852 10%  28 0%      89617 23%
wrcache    write      create     remove     rename     link       symlink
0 0%       56078 14%  1183 0%    1175 0%    71 0%      51 0%      0 0%
mkdir      rmdir      readdir    statfs
49 0%      0 0%       987 0%     11744 3%
```

The output of Code Example 3-4 shows that there were only 52 retransmits (`retrans`) and 52 time-outs (`timeout`) out of 384687 calls.

The `nfsstat -c` display in Code Example 3-4 shows the following fields:

`calls`	Total number of calls sent
`badcalls`	Total number of calls rejected by RPC
`retrans`	Total number of retransmissions
`badxid`	Number of times that a duplicate acknowledgment was received for a single NFS request
`timeout`	Number of calls that timed out

`wait`	Number of times a call had to wait because no client handle was available
`newcred`	Number of times the authentication information had to be refreshed

Table 3-2, shown earlier in this chapter, describes the NFS operations. Table 3-3 explains the output of the `nfsstat -c` command and what action to take.

Table 3-3 Description of the `nfsstat -c` Command Output

If	Then
`retrans` > 5% of the calls	The requests are not reaching the server.
`badxid` is approximately equal to `badcalls`	The network is slow. Consider installing a faster network or installing subnets.
`badxid` is approximately equal to `timeouts`	Most requests are reaching the server but the server is slower than expected. Watch expected times using `nfsstat -m`.
`badxid` is close to 0	The network is dropping requests. Reduce `rsize` and `wsize` in the `mount` options.
`null` > 0	A large amount of `null` calls suggests that the automounter is retrying the mount frequently. The timeout values for the mount are too short. Increase the mount timeout parameter, `timeo`, on the automounter command line

The third-party tools you can use for NFS/networks include:

- NetMetrix (Hewlett-Packard)
- SharpShooter (AIM Technology)

▼ To display statistics for each NFS mounted file system

♦ **Type** `nfsstat -m`.
The statistics include the server name and address, mount flags, current read and write sizes, transmission count, and the timers used for dynamic transmission.

```
client % nfsstat -m
/export/home from server:/export/home
 Flags:
vers=2,hard,intr,dynamic,rsize=8192,wsize=8192,retrans=5
 Lookups: srtt=10 (25ms), dev=4 (20ms), cur=3 (60ms)
 Reads:   srtt=9 (22ms), dev=7 (35ms), cur=4 (80ms)
 Writes:  srtt=7 (17ms), dev=3 (15ms), cur=2 (40ms)
 All:     srtt=11 (27ms), dev=4 (20ms), cur=3 (60ms)
```

The following terms, used In the output of the `nfsstat -m` command, are explained below:

`srtt`	Smoothed round-trip time
`dev`	Estimated deviation
`cur`	Current backed-off timeout value

The numbers in parentheses are the actual times in milliseconds. The other values are unscaled values kept by the operating system kernel. You can ignore the unscaled values. Response times are shown for lookups, reads, writes, and a combination of all of these operations (all). Table 3-4 shows the appropriate action for the `nfsstat -m` command.

Note – These statistics are only generated for NFS over UDP (the default for Version 2.) NFS over TCP does not need retransmit timers and is the default for Version 3.

Table 3-4 Results of the `nfsstat -m` Command

If	Then
`srtt` > 50 ms	That mount point is slow. Check the network and the server for the disk(s) that provide that mount point. See the steps earlier in this chapter.
You the message "`NFS server not responding`" is displayed	Try increasing the `timeo` parameter in the `/etc/vfstab` file to eliminate the messages and improve performance. Doubling the initial `timeo` parameter value is a good baseline. After changing the `timeo` value in the `vfstab` file, invoke the `nfsstat -c` command and observe the `badxid` value returned by the command. Follow the recommendations for the `nfsstat -c` command earlier in this section.
`Lookups: cur` > 80 ms	The requests are taking too long to process. This indicates a slow network or a slow server.
`Reads: cur` > 150 ms	The requests are taking too long to process. This indicates a slow network or a slow server.
`Writes: cur` > 250 ms	The requests are taking too long to process. This indicates a slow network or a slow server.

Configuring the Server and the Client to Maximize NFS Performance

This chapter provides configuration recommendations to maximize NFS performance. For troubleshooting tips see Chapter 5, “Troubleshooting.”

Tuning for NFS Performance Improvement

Check these items when tuning the system:

- Networks
- Disk drives
- Central processor units
- Memory
- Number of NFS threads in `/etc/init.d/nfs.server`
- `/etc/system` to modify kernel variables

Once you have profiled the performance capabilities of your server, begin tuning the system. Tuning an NFS server requires a basic understanding of how networks, disk drives, CPUs, and memory affect performance. To tuning the system determine which parameters to adjust to improve balance.

There are three steps to monitor and tune the server performance:

1. Collect statistics.
   See Chapter 3, “Analyzing NFS Performance.”
2. Identify a constraint or overutilized resource and reconfigure around it.
   Refer to this chapter and Chapter 3, “Analyzing NFS Performance” for tuning recommendations.
3. Measure the performance gain over a long evaluation period.

This chapter discusses tuning recommendations for these environments:

- Attribute-intensive environments, which are applications or environments where primarily small files (one to two hundred bytes) are accessed. Software development is an example of an attribute-intensive environment.
- Data-intensive environments, which are applications or environments, where primarily large files are accessed. A *large* file can be defined as a file that takes one or more seconds to transfer (roughly 1 Mbyte). CAD or CAE are examples of data-intensive environments.

Balancing NFS Server Workload

All NFS processing takes place inside the operating system kernel at a higher priority than user-level tasks. When the NFS load is high, any additional tasks performed by an NFS server will run slowly. For this reason, do not combine databases or time-shared loads on an NFS server.

Non-interactive workloads such as mail delivery and printing (excluding the SPARCprinter or other Sun printers based on the NeWSprint™ software) are good candidates for using the server for dual purpose (such as NFS and other tasks). If you have spare CPU power and a light NFS load, then interactive work will run normally.

Networking Requirements

Make sure that network traffic is well balanced across all client networks and that networks are not overloaded. If one client network is excessively loaded, watch the NFS traffic on that segment. Identify the hosts that are making the largest demands on the servers. Partition the work load, or move clients from one segment to another.

Simply adding disks to a system does not improve its NFS performance unless the system is truly disk I/O-bound. The network itself is likely to be the constraint as the file server grows, requiring adding more network interfaces to keep the system in balance.

Instead of attempting to move more data blocks over a single network, consider characterizing the amount of data consumed by a typical client and balance the NFS reads and writes over multiple networks.

Data-Intensive Applications

Data-intensive applications demand relatively few networks. However, the networks must be of high-bandwidth (such as FDDI, CDDI, SunATM™, or SunFastEthernet™). For more information on FDDI, see the *FDDI/S3.0 User's Guide*.

If your configuration has either of the following characteristics, then your applications require high-speed networking:

- Your clients require aggregate data rates of more than 1 Mbyte per second.
- More than one client must be able to simultaneously consume 1 Mbyte per second of network bandwidth.

Configuring the Network

Follow these suggestions to configure your network when your server's primary application is data-intensive.

- **Configure FDDI or another high-speed network.**

  If fiber cabling can't be used for logistical reasons, consider FDDI, CDDI, or SunFastEthernet over twisted-pair implementations. SunATM uses the same size fiber cabling as FDDI.

- **Configure one FDDI ring for each five to seven concurrent fully NFS-active clients**.

  Few data-intensive applications make continuous NFS demands. In typical data-intensive EDA and earth-resources applications, this results in 25-40 clients per ring.

  A typical use consists of loading a big block of data which is manipulated then writing the data back. These environments can have very high write percentages due to the step of writing the data back.

- **If your installation has Ethernet cabling, configure one Ethernet for every two active clients.**

  This almost always requires using a SPARCserver 1000, SPARCserver 1000E, SPARCcenter 2000, SPARCcenter 2000E system, or an Ultra Enterprise 3000, 4000, 5000, or 6000 system since useful communities require many networks. Configure a maximum of four to six client per network.

Attribute-Intensive Applications

In contrast, most attribute-intensive applications are easily handled with less expensive networks. But, attribute-intensive applications will need many networks. Use lower-speed networking media, such as Ethernet or Token Ring.

▼ To configure networking when your server's primary application is attribute-intensive

- **Configure on Ethernet or Token Ring**.
- **Configure one Ethernet network for eight to ten** *fully active clients.*

  More than 20 to 25 clients per Ethernet results in severe degradation when many clients are active. As a check, an Ethernet is able to sustain about 250-300 NFS ops/second on the SPECnfs_097 (LADDIS) benchmark, albeit at high collision rates. It is unwise to exceed 200 NFS ops/second on a sustained basis.

- **Configure one Token Ring network for each ten to fifteen active clients**.

  If necessary, 50 to 80 total clients per network are feasible on Token Ring networks, due to their superior degradation characteristics under heavy load (compared to Ethernet).

Systems with More Than One Class of Users

Mixing network types is not unreasonable. For example, both FDDI and Token Ring are appropriate for a server that supports both a document imaging application (data-intensive) and a group of PCs running a financial analysis application (most likely attribute-intensive).

The platform you choose is often dictated by the type and number of networks, as they may require many network interface cards.

To configure networking for servers that have more than one class of users, mix network types.

Disk Drives

Disk drive usage is frequently the tightest constraint in an NFS server. Even a sufficiently large memory configuration may not improve performance if the cache cannot be filled quickly enough from the file systems. Use `iostat` to determine disk usage. Look at the number of read and write operations per second (see “Checking the NFS Server” in Chapter 3).

Because there is little dependence in the stream of NFS requests, the disk activity generated contains large numbers of random access disk operations. The maximum number of random I/O operations per second ranges from 40-90 per disk.

Driving a single disk at more than 60 percent of its random I/O capacity creates a disk bottleneck.

Limiting Disk Bottlenecks

Disk bandwidth on an NFS server has the greatest effect on NFS client performance. Providing sufficient bandwidth and memory for file system caching is crucial to providing the best possible file server performance. Note that read/write latency is also important. For example, each NFSop may involve one or more disk accesses. Disk service times add to the NFSop latency, so slow disks mean a slow NFS server.

Follow these suggestions to ease the disk bottleneck.

- **Balance the I/O load across all disks on the system**.

  If one disk is heavily loaded and others are operating at the low end of their capacity, shuffle directories or frequently accessed files to less busy disks.

- **Partition the file system(s) on the heavily used disk and spread the file system(s) over several disks.**

  Adding disks provides additional disk capacity and disk I/O bandwidth.

- **Replicate the file system to provide more network-to-disk bandwidth for the clients if the file system used is read-only by the NFS clients, and contains data that doesn't change constantly.**

  See the following section "Replicating File Systems."

- **Size the operating system caches correctly, so that frequently needed file system data may be found in memory**.

  Caches for inodes (file information nodes), file system metadata such as cylinder group information, and name-to-inode translations must be sufficiently large, or additional disk traffic is created on cache misses. For example, if an NFS client opens a file, that operation generates several name-to-inode translations on the NFS server.

  If an operation misses the Directory Name Lookup Cache (DNLC), the server must search the disk-based directory entries to locate the appropriate entry name. What would nominally be a memory-based operation degrades into several disk operations. Also, cached pages will not be associated with the file.

Replicating File Systems

Commonly used file systems, such as the following, are frequently the most heavily used file systems on an NFS server:

- `/usr` directory for diskless clients
- Local tools and libraries
- Third-party packages
- Read-only source code archives

The best way to improve performance for these file systems is to replicate them. One NFS server is limited by disk bandwidth when handling requests for only one file system. Replicating the data increases the size of the aggregate "pipe" from NFS clients to the data.

Replication is *not* a viable strategy for improving performance with writable data, such as a file system of home directories. Use replication with read-only data.

Follow these suggestions to replicate file systems.

- **Identify the file or file systems to be replicated**.

  If several individual files are candidates, consider merging them in a single file system. The potential decrease in performance that arises from combining heavily used files on one disk is more than offset by performance gains through replication.

- **Use `nfswatch`, to identify the most commonly used files and file systems in a group of NFS servers**.

  Table A-1 in the *Appendix* lists performance monitoring tools, including `nfswatch`, and explains how to obtain `nfswatch`.

- **Determine how clients will choose a replica**.

  Specify a server name in the `/etc/vfstab` file to create a permanent binding from NFS client to the server. Alternatively, listing all server names in an automounter map entry allows completely dynamic binding, but may also lead to a client imbalance on some NFS servers. Enforcing "workgroup" partitions, in which groups of clients have their own replicated NFS server, strikes a middle ground between the extremes and often provides the most predictable performance.

- **Choose an update schedule and mechanism for distributing the new data**.

  The frequency of change of the read-only data determines the schedule and the mechanism for distributing the new data. File systems that undergo a complete change in contents, for example, a flat file with historical data that is updated monthly, may be best handled by copying data from the distribution media on each machine, or using a combination of `ufsdump` and `restore`. File systems with few changes can be handled using management tools such as `rdist`.

  Evaluate what penalties, if any, are involved if users access stale data on a replica that is out of date. One possible way of doing this is with the Solaris 2.x JumpStart™ facilities in combination with `cron`.

Adding the Cache File System

Adding the cache file system to client mounts provides a local replica for each client. Unlike a replicated server, the cache file system can be used with writable file systems, but performance will degrade as the percent of writes climb. If the percent of writes is too high, the cache file system may decrease NFS performance. The `/etc/vfstab` entry for the cache file system looks like this:

```
#device      device   mount    FS  fsck       mount     mount
#to mount    to fsck  point    type pass      at boot   options
server:/usr/dist/cache /usr/dist    cachefs  3yes
ro,backfstype=nfs,cachedir=/cache
```

Configuring Rules for Disk Drives

Follow these general guidelines for configuring disk drives. In addition to the following general guidelines, more specific guideline for configuring disk drives in data-intensive environments and attribute-intensive environments follows.

- Configure additional drives on each host adapter without degrading performance (as long as the number of active drives does not exceed SCSI standard guidelines.)

- Use Online: DiskSuite to spread disk access load across many disks. See the section, “Using Solstice DiskSuite or Online: DiskSuite to Spread Disk Access Load.”
- Use the fastest zones of the disk when possible. See the section, “Using the Optimum Zones of the Disk.”

Keep these rules in mind when configuring disk drives in data-intensive and attribute-intensive environments.

To configure disk drives in data-intensive environments:

- Configure no more than four to five fully active 2.9 Gbyte disks per fast / wide SCSI host adapter.
- Configure at least three disk drives for every active client on FDDI.
- Configure one drive for every client on Ethernet or Token Ring.

To configure disk drives in attribute-intensive environments:

- Configure no more than four to five fully active 1.05 Gbyte or 535 Mbyte disks per fast SCSI host adapter.
- Configure at least one disk drive for every two fully active clients (on any type of network.)
- Configure no more than six to seven 2.9 Gbyte disk drives for each fast / wide SCSI host adapter.

Using Solstice DiskSuite or Online: DiskSuite to Spread Disk Access Load

A common problem in NFS servers is poor load balancing across disk drives and disk controllers. Balance loads by physical usage instead of logical usage. Use Solstice DiskSuite or Online: DiskSuite to spread disk access across disk drives transparently by using its striping and mirroring functions. Disk concatenation accomplishes a minimum amount of load balancing as well but only when disks are relatively full.

If your environment is data-intensive, stripe with a small interlace to improve disk throughput and distribute the service load. Disk striping improves read and write performance for serial applications. Use 64 Kbytes per number of disks in the stripe as a starting point for interlace size.

If your environment is attribute-intensive, where random access dominates disk usage, the default interlace (one disk cylinder) is most appropriate.

The disk mirroring feature of Solstice DiskSuite or Online: DiskSuite improves disk access time and reduces disk usage by providing access to two or three copies of the same data. This is particularly true in environments dominated by read operations. Write operations are normally slower on a mirrored disk since two or three writes must be accomplished for each logical operation requested.

Use the `iostat` and `sar` commands to report disk drive usage. Attaining even disk usage usually requires some iterations of monitoring and data reorganization. In addition, usage patterns change over time. A data layout that works when installed may perform poorly a year later. For more information on checking disk drive usage, see the section "Checking the NFS Server" in Chapter 3.

Using Log-Based File Systems with Solstice DiskSuite or Online: DiskSuite 3.0

The Solaris 2.4 and later software environments and the Online: Disk Suite 3.0 software support a log-based extension to the standard UNIX file system, which behaves like a disk-based Prestoserve NFS accelerator.

In addition to the main file system disk, a small (typically 10 Mbytes) section of disk is used as a sequential log for writes. This speeds up the same kind of operations as a Prestoserve NFS accelerator with two advantages:

- In dual-machine high-available configurations, the Prestoserve NFS accelerator cannot be used. The log can be shared so that it can be used.
- After an operating system crash, the `fsck` of the log-based file system involves a sequential read of the log only. The sequential read of the log is almost instantaneous, even on very large file systems.

Note – You cannot use the Prestoserve NFS accelerator and the log on the same file system.

Using the Optimum Zones of the Disk

When you analyze your disk data layout, consider *zone bit recording*.

All of Sun's current disks (except the 207 Mbyte disk) use this type of encoding which uses the peculiar geometric properties of a spinning disk to pack more data into the parts of the platter closest to its edge. This results in the lower disk addresses (corresponding to the outside cylinders) usually outperforming the inside addresses by 50 percent. You put the data in the lowest-numbered cylinders, since the zone bit recording data layout makes those cylinders the fastest ones.

This margin is most often realized in serial transfer performance, but also affects random access I/O. Data on the outside cylinders (zero) not only moves past the read/write heads more quickly, but the cylinders are also larger. Data will be spread over fewer large cylinders, resulting in fewer and shorter seeks.

Central Processor Units

This section explains how to determine CPU usage and provides guidelines for configuring CPUs in NFS servers.

▼ To determine CPU usage

♦ **Type `mpstat 30` at the `%` prompt to get 30 second averages.**

```
zardoz-12% mpstat 30
CPU minf mjf xcal  intr ithr  csw icsw migr smtx  srw syscl  usr sys  wt idl
  0    6   0    0   114   14   25    0    6    3    0    48    1   2  25  72
  1    6   0    0    86   85   50    0    6    3    0    66    1   4  24  71
  2    7   0    0    42   42   31    0    6    3    0    54    1   3  24  72
  3    8   0    0     0    0   33    0    6    4    0    54    1   3  24  72
```

The `mpstat 30` command reports statistics per processor. Each row of the table represents the activity of one processor. The first table summarizes all activities since the system was last booted. Each subsequent table summarizes activity for the preceding interval. All values are rates (events per second).

Look at the following data in the `mpstat` output (see Table 4-1 on page 70):

- `usr` Percent user time
- `sys` Percent system time (can be caused by NFS processing)
- `wt` Percent wait time (treat as for idle time)
- `idl` Percent idle time

If sys is greater than 50 percent, there is a lot of NFS processing going on. Add CPU power to improve NFS performance.

Table 4-1 describes guidelines for configuring CPUs in NFS servers.

Table 4-1 Guidelines for Configuring CPUs in NFS Servers

If	Then
Your environment is predominantly attribute-intensive, and you have 1 to 3 medium-speed Ethernet or Token Ring networks.	A uniprocessor system is sufficient. For smaller systems, the UltraServer 1, SPARCserver 5, or SPARCserver 2 systems have sufficient processor power.
Your environment is predominantly attribute-intensive and you have between 4 to 60 medium-speed Ethernet or Token Ring networks.	Use an UltraServer 2, SPARCserver 10, or SPARCserver 20 system.
You have larger attribute-intensive environments and SBus and disk expansion capacity is sufficient.	Use multiprocessor models of the UltraServer 2, SPARCserver 10 or the SPARCserver 20 systems.
You have larger attribute-intensive environments.	Use dual-processor systems such as: – SPARCserver 10 system Model 512 – SPARCserver 20 system – SPARCserver 1000or 1000E system – Ultra Enterprise 3000, 4000, 5000, or 6000 system – SPARCcenter 2000/2000E system. Either the 40 MHz/1Mbyte or the 50MHz/2 Mbyte module work well for an NFS work load in the SPARCcenter 2000 system. You will get better performance from the 50 MHz/2Mbyte module.
Your environment is data-intensive and you have a high-speed network.	Configure 1 SuperSPARC processor per high-speed network (such as FDDI).

Table 4-1 Guidelines for Configuring CPUs in NFS Servers

If	Then
Your environment is data-intensive and you must use Ethernet due to cabling restrictions.	Configure 1 SuperSPARC processor for every 4 Ethernet or Token Ring networks.
Your environment is a pure NFS installation.	You do not need to configure additional processors, beyond the recommended number, on your server(s).
Your servers perform tasks in addition to NFS processing.	Add additional processors to increase performance significantly.

Memory

Since NFS is a disk I/O-intensive service, a slow server can suffer from I/O bottlenecks. Adding memory eliminates the I/O bottleneck by increasing the file system cache size.

The system could be waiting for file system pages, or it may be paging process images to and from the swap device. The latter effect is only a problem if additional services are provided by the system, since NFS service runs entirely in the operating system kernel.

If the swap device is not showing any I/O activity, then all paging is due to file I/O operations from NFS reads, writes, attributes, and lookups.

Determining if an NFS Server Is Memory Bound

Paging filesystem data from the disk into memory is a more common NFS server performance problem. Follow these suggestions to determine if the server is memory bound:

- **Watch the scan rate reported by** `vmstat 30`.

  If the scan rate (`sr`, the number of pages scanned) is often over 200 pages/second, then the system is short of memory (RAM). The system is trying to find unused pages to be reused and may be reusing pages that should be cached for rereading by NFS clients.

- **Add memory**.

Adding memory eliminates repeated reads of the same data and allows the NFS requests to be satisfied out of the page cache of the server. To calculate the memory required for your NFS server, see the section, “Calculating Memory,” which follows.

The memory capacity required for optimal performance depends on the average working set size of files used on that server. The memory acts as a cache for recently read files. The most efficient cache matches the current working set size as closely as possible.

Because of this memory caching feature, it is not unusual for free memory in NFS servers to be in the 3-4 Mbyte range (0.5 Mbytes to 1.0 Mbytes for the Solaris 2.4 and later software environments) if the server has been active for a long time. Such activity is normal and desirable. Having enough memory allows you to service multiple requests without blocking.

The actual files in the working set may change over time. However, the size of the working set may remain relatively constant. NFS creates a *sliding window* of active files, with many files entering and leaving the working set throughout a typical monitoring period.

Calculating Memory

You can calculate memory according to general or specific memory rules. The following sections contain suggestions for calculating memory.

General Memory Rules

- Virtual memory = RAM (main memory) + Swap space
- Calculate the amount of memory according to the five-minute rule: Memory is sized at 16 Mbytes plus memory to cache the data, which will be accessed more often than once in five minutes.

Note – These general memory rules are different from the SunOS 4.x operating system where virtual memory = swap space. Swap space must always be greater than RAM with the SunOS 4.x operating system.

Specific Memory Rules

- If your server primarily provides user data for many clients, configure relatively minimal memory.

  For small installations, this will be 32 Mbytes; for large installations, this will be about 128 Mbytes. In multiprocessor configurations, provide at least 64 Mbytes per processor. Attribute-intensive applications normally benefit slightly more from memory than data-intensive applications.

- If your server normally provides temporary file space for applications that use those files heavily, configure your server memory to about 75 percent of the size of the active temporary files in use on the server.

For example, if each client's temporary file is about 5 Mbytes, and the server is expected to handle 20 fully active clients, configure it as follows:

(20 clients x 5 Mbytes) / 75% = 133 Mbytes of memory
Note that 128 Mbytes is the most appropriate amount of memory that is easily configured.

- If your server's primary task is to provide only executable images configure server memory to be equal to approximately the combined size of the heavily-used binary files (including libraries).

  For example, a server expected to provide `/usr/openwin` should have enough memory to cache the X server, CommandTool, `libX11.so`, `libview.so` and `libXt`. This NFS application is considerably different from the more typical `/home`, `/src` or `/data` server in that it normally provides the same files repeatedly to all of its clients; hence is able to effectively cache this data. Clients will not use every page of all of the binaries, which is why it is reasonable to configure only enough to hold the frequently-used programs and libraries. Use the cache file system on the client, if possible, to reduce the load and RAM needs on the server.

- If the clients are DOS PCs or Macintosh machines, add more RAM cache on the Sun NFS server. These systems do much less caching than UNIX system clients.

Swap Space

Configure at least 64 Mbytes virtual memory (RAM plus swap space). For example:

16 Mbytes RAM	48 Mbytes swap space
32 Mbytes RAM	32 Mbytes swap space
64 or more Mbytes RAM	No swap space

Configure enough swap space to allow the applications to run properly. For more information, see the manual, *File System Administration*.

Prestoserve NFS Accelerator

Adding a Prestoserve™ NFS accelerator is yet another way to improve NFS performance. The NFS version 2 protocol requires that all writes must be written to stable storage before the operation is replied. The Prestoserve NFS accelerator allows high-speed NVRAM instead of slow disks to satisfy the stable storage requirement. The two types of NVRAM used by the Prestoserve NFS accelerator are the SBus and the NVRAM-NVSIMM.

NVRAM-NVSIMM

In cases where you can use either NVRAM hardware, use the NVRAM-NVSIMM as the Prestoserve cache. The NVRAM-NVSIMM and SBus hardware are functionally identical. However, the NVRAM-NVSIMM hardware is slightly more efficient and doesn't use up one of your SBus slots. The NVRAM-NVSIMMs reside in memory and the NVRAM-NVSIMM cache is larger than the SBus hardware.

NVRAM SBus

The NVRAM SBus board contains only a 1 Mbyte cache. The NVRAM-NVSIMM SIMM module contains 2 Mbytes of cache and is supported by the SPARCcenter 2000, SPARCcenter 2000E, SPARCserver 1000, SPARCserver 1000E, SPARCstation 20, and SPARCstation 10 systems. The SPARCserver 1000 and the SPARCcenter 2000 support up to 8 Mbytes and 16 Mbytes of NVRAM, respectively.

For the Ultra Enterprise 3000, 4000, 5000, and 6000 systems, instead of upgrading NVSIMM SIMM modules, upgrade the NVRAM in the SPARCstorage Arrays connected to the server as an alternate method to improve NFS performance. Upgrading the NVRAM in a SPARCstorage Array performs in a comparable manner to upgrading the NVSIMM SIMM modules.

NFS servers can significantly increase performance of NFS write operations by using nonvolatile memory (NVRAM), which is typically much faster than local disk writes. The Prestoserve NFS accelerators take advantage of the fact that the NFS version 2 protocol requires synchronous writes to be written to nonvolatile memory, instead of requiring them to be written directly to disk. As long as the server returns data acknowledged from previous write operations, it can save the data in nonvolatile memory.

Both types of Prestoserve NFS accelerators speed up NFS server performance by:

- Providing faster selection of file systems
- Caching writes for synchronous I/O operations
- Intercepting synchronous write requests to disk and storing the data in nonvolatile memory

Adding the SBus Prestoserve NFS Accelerator

The SBus Prestoserve NFS accelerator resides on the SBus. You can add the SBus Prestoserve NFS accelerator to any SBus-based server, except the SPARCserver 1000(E) system, the SPARCcenter 2000(E) system, or the Ultra Enterprise 3000, 4000, 5000, or 6000 server systems.

Note – The Ultra Enterprise 3000, 4000, 5000, and 6000 server systems do not support the SBus Prestoserve NFS accelerator.

Systems on which you can add the SBus Prestoserve NFS accelerator:

- SPARCclassic system
- SPARCserver LX system
- SPARCserver 5 system
- SPARCserver 10 system
- SPARCserver 20 system
- Ultra Enterprise 1 system
- Ultra Enterprise 2 system
- SPARCserver 600 series

Adding the NVRAM-NVSIMM Prestoserve NFS Accelerator

The NVRAM-NVSIMM Prestoserve NFS accelerator significantly improves the response time seen by NFS clients of heavily loaded or I/O-bound servers. Add the NVRAM-NVSIMM Prestoserve NFS accelerator to the following platforms to improve performance:

- SPARCserver 10 system
- SPARCserver 20 system
- SPARCserver 1000 or 1000E system
- SPARCcenter 2000 or 2000E system

For Ultra Enterprise 3000, 4000, 5000, and 6000 server systems enable SPARCstorage Array NVRAM fast writes. Turn on fast writes by invoking the `ssaadm` command.

Note – The introduction of Version 3 reduces the need for Prestoserve capability.

Tuning Parameters

This section describes how to set the number of NFS threads. It also covers tuning the main NFS performance-related parameters in the `/etc/system` file. Tune these `/etc/system` parameters carefully, considering the physical memory size of the server and kernel architecture type.

Note – Arbitrary tuning creates major instability problems, including an inability to boot.

Setting the Number of NFS Threads in `/etc/init.d/nfs.server`

All NFS server configurations must set the number of NFS threads. Each thread is capable of processing one NFS request. A larger pool of threads allows the server to handle more NFS requests in parallel. The default setting, 16, in Solaris 2.3 and later software environments, results in less than desired NFS response times. Scale the setting with the number of processors and networks. Increase the number of NFS server threads by editing the invocation of `nfsd` in `/etc/init.d/nfs.server`:

```
/usr/lib/nfs/nfsd -a 64
```

This example specifies that the maximum allocation of demand-based NFS threads is 64.

There are three ways to size the number of NFS threads. Each method results in about the same number if you followed the configuration guidelines in this manual. Extra NFS threads do not cause a problem.

To set the number of NFS threads:

Take the *maximum* of the following three suggestions:

- Use 2 NFS threads for each active client process.
  A client workstation usually only has one active process. However, a time-shared system that is an NFS client may have many active processes.
- Use 16 to 32 NFS threads for each CPU.
  Use roughly 16 for a SPARCclassic or a SPARCstation 5 system. Use 32 NFS threads for a system with a 60 MHz SuperSPARC processor.
- Use 16 NFS threads for each 10 Mbits of network capacity.
  For example, if you have FDDI, set the number of NFS threads to 160 `nfsd`s.

Identifying Buffer Sizes and Tuning Variables

The number of fixed-size tables in the kernel has been reduced in each release of the Solaris software environment. Most are now dynamically sized or are linked to the `maxusers` calculation. Extra tuning to increase the DNLC and inode caches is required for the Solaris 2.2, and later software environments. For Solaris version 2.2, 2.3, and 2.4 you must tune the pager. Tuning the pager is not necessary for the Solaris 2.5 version.

Using `/etc/system` *to Modify Kernel Variables*

The `/etc/system` file is read by the operating system kernel at start-up. It configures the search path for loadable operating system kernel modules and allows kernel variables to be set. For more information, see the man page for `system(4)`.

Note – Be very careful with set commands in `/etc/system`. The commands in `/etc/system` cause automatic patches of the kernel.

If your machine will not boot and you suspect a problem with `/etc/system`, use the `boot -a` option. With this option, the system prompts (with defaults) for its boot parameters. One of these is the configuration file `/etc/system`. Either enter the name of a backup copy of the original `/etc/system` file or enter `/dev/null`. Fix the file and immediately reboot the system to make sure it is operating correctly.

Adjusting Cache Size: `maxusers`

The `maxusers` parameter determines the size of various kernel tables such as the process table. The `maxusers` parameter is set in the `/etc/system` file. For example:

```
set maxusers = 200
```

Solaris 2.2 Software Environment

In the Solaris 2.2 software environment, `maxusers` is dynamically sized based upon the amount of RAM configured in the system. The automatic configuration of `maxusers` in the Solaris 2.2 software environment is based upon the value of *physmem*, which is the amount of memory (in pages) after the kernel allocates its own code and initial data space of around 2 Mbytes. The automatic scaling stops when memory exceeds 128 Mbytes.

For systems with 256 Mbytes or more of memory, set `maxusers` to the generic safe maximum of 200, or leave it and set the individual kernel resources directly. The actual safe maximum level is hardware-dependent, and varies with the operating system kernel architecture.

Table 4-2 `Maxusers` Settings in the Solaris 2.2 Software Environment

RAM Configuration	Maxusers	Processes	Name Cache
Up to and including 16 Mbytes	8	138	226
Up to and including 32 Mbytes	32	522	634
Up to and including 64 Mbytes	40	650	770
Up to and including 128 Mbytes	64	1034	1178
Over 128 Mbytes	128	2058	2266

Note – The operating system kernel uses about 1.5 Mbytes. Therefore, over 130 Mbytes of memory will be required for `maxusers` to be set to 128.

The name cache size is the number used for:

`ncsize`	Number of directory name entries in the DNLC
`ufs_ninode`	Inactive inode cache size limit

Solaris 2.3 and Later Software Environment

In the Solaris 2.3 and later software environments, `maxusers` is dynamically sized based upon the amount of RAM configured in the system. The sizing method used for `maxusers` is:

`maxusers` = Mbytes of RAM configured in the system

The number of Mbytes of RAM configured into the system is actually based upon *physmem* which does not include the 2 Mbytes or so that the kernel uses at boot time. The minimum limit is 8 and the maximum automatic limit is 1024, corresponding to systems with 1 Gbyte or more of RAM. It can still be set manually in `/etc/system` but the manual setting is checked and limited to a maximum of 2048. This is a safe level on all kernel architectures, but uses a large amount of operating system kernel memory.

Parameters Derived from `maxusers`

Table 4-3 describes the default settings for the performance-related inode cache and name cache operating system kernel parameters.

Table 4-3 Default Settings for Inode and Name Cache Parameters

Kernel Resource	Variable	Default Setting
Inode Cache	`ufs_ninode`	17 * `maxusers` + 90
Name Cache	`ncsize`	17 * `maxusers` + 90

Adjusting the Buffer Cache: `bufhwm`

The `bufhwm` variable, set in the `/etc/system` file, controls the maximum amount of memory allocated to the buffer cache and is specified in Kbytes. The default value of `bufhwm` is 0, which allows up to 2 percent of system memory to be used. This can be increased up to 20 percent. It may need to be increased to 10 percent for a dedicated NFS file server with a relatively small memory system. On a larger system the `bufhwm` variable may need to be limited to prevent the system from running out of the operating system kernel virtual address space.

The buffer cache is used to cache inode, indirect block, and cylinder group related disk I/O only. Following is an example of a buffer cache (`bufhwm`) setting in the `/etc/system` file that will allow up to 10 Mbytes of cache. This is the highest value to which you should set `bufhwm`.

```
set bufhwm=10240
```

You can monitor the buffer cache using `sar -b` which reports a read (`%rcache`) and. a write hit rate (`%wcache`) for the buffer cache

Code Example 4-1 Output of the `sar -b 5 10` Command

```
# sar -b 5 10
SunOS hostname 5.2 Generic sun4c    08/06/93
23:43:39 bread/s lread/s %rcache bwrit/s lwrit/s %wcache pread/s pwrit/s
Average        0      25     100       3      22      88       0       0
```

If there is a significant (greater than 50) number of reads and writes per second and if the read hit rate (`%rcache`) falls below 90 percent or if the write hit rate (`%wcache`) falls below 65 percent, increase the buffer cache size, `bufhwm`.

In the previous `sar -b 5 10` command output, the read hit rate (`%rcache`) and the write hit rate (`%wcache`) did not fall below 90 percent or 65 percent respectively.

The following lists the arguments to the `sar` command shown in Code Example 4-1.

`b`	Checks buffer activity
`5`	Time. Every 5 seconds. (must be at least 5 seconds)
`10`	Number of times the command gathers statistics

Note – If you increase your buffer cache too much, your server may hang, as other device drivers could suffer from a shortage of operating system kernel virtual memory.

Directory Name Lookup Cache (DNLC)

Size the directory name lookup cache (DNLC) to a default value using `maxusers`. A large cache size (`ncsize`) significantly helps NFS servers, with many clients.

▼ **To show the DNLC hit rate (cache hits), type** `vmstat -s`

```
% vmstat -s
... lines omitted
79062 total name lookups (cache hits 94%)
16 toolong
```

Directory names less than 30 characters long are cached and names that are too long to be cached are reported as well. A cache miss means that a disk I/O may be needed to read the directory when traversing the path name components to get to a file. A hit rate of much less than 90 percent needs attention.

Cache hit rates can significantly affect NFS performance. `getattr`, `setattr` and `lookup` usually represent greater than 50 percent of all NFS calls. If the requested information isn't in cache, the request will generate a disk operation, resulting in a performance penalty as significant as that of a `read` or `write` request. The only limit to the size of the DNLC cache is available kernel memory.

If the hit rate (cache hits) is less than 90 percent and there is no problem with too many longnames, tune the variable, `ncsize`. See the procedure "To reset ncsize" on page 83. The variable `ncsize` refers to the size of the DNLC in terms of the number of name and vnode translations that can be cached. Each DNLC entry causes about 50 bytes of extra kernel memory to be used.

▼ **To reset** `ncsize`

1. **Set** `ncsize` **in the** `/etc/system` **file to values higher than the default (based on** `maxusers`**.)**
   As an initial guideline, since dedicated NFS servers do not need a lot of RAM, `maxusers` will be low and the DNLC will be small. Double its size.

```
set ncsize=5000
```

   The default value of `ncsize` is:

   `ncsize` (name cache) = 17 * `maxusers` + 90

   - For NFS server benchmarks, set it as high as 16000.
   - For `maxusers = 2048,` set it at 34906.

2. **Reboot the system.**

See the section “Increasing the Inode Cache,”which follows.

Increasing the Inode Cache

A memory-resident inode is used whenever an operation is performed on an entity in the file system. The inode read from disk is cached in case it is needed again. The maximum number of active and inactive inodes that the system will cache is set by `ufs_ninode`.

The inodes are kept on a linked list, rather than a fixed-size table. It is possible that the number of open files in the system can cause the number of active inodes to exceed the limit. Raising the limit allows *inactive* inodes to be cached in the Solaris 2.3 software environment in case they are needed again. In the Solaris version 2.4 and later, the `ufs_ninode` count applies only to *inactive* inodes.

Every entry in the DNLC cache points to an entry in the inode cache, so both caches should be sized together. The inode cache should be at least as big as the DNLC cache. For best performance, it should be the same size in the Solaris version 2.4 and later, but twice the DNLC in the Solaris versions 2.2 and 2.3.

Since it is just a limit, `ufs_ninode` can be tweaked with `adb` on a running system with immediate effect. The only upper limit is the amount of kernel memory used by the inodes. The tested upper limit corresponds to `maxusers = 2048`, which is the same as `ncsize` at 34906.

Use `sar -k` to report the size of the kernel memory allocation. Each inode uses 512 bytes of kernel memory from the `lg_mem pool` in the Solaris versions 2.2 and 2.3. In the Solaris version 2.4, each inode uses 300 bytes of kernel memory from the `lg_mem pool`. In Solaris version 2.5.1, each inode uses 320 bytes of kernel memory from the `lg_mem pool`.

Tuning `ncsize` *in the Solaris 2.5.1 and Later Software Environments*

In Solaris version 2.5.1, `ufs_ninode` is automatically adjusted to be at least `ncsize`. With Solaris version 2.5.1 and later, tune `ncsize` to get the hit rate up. Allow the system to pick the default `ufs_ninodes`.

▼ To increase the inode cache

Note – This procedure applies to Solaris software environments through the Solaris 2.5 software environment. If you have the Solaris 2.5.1 or later software environments, see “Tuning ncsize in the Solaris 2.5.1 and Later Software Environments” on page 84.

If the inode cache hit rate is below 90 percent, or if the DNLC requires tuning for local disk file I/O workloads:

1. **Increase the size of the inode cache.**
   Change the variable `ufs_ninode` in your `/etc/system` file to the same size as the DNLC (`ncsize`). For example, for the Solaris version 2.4:

```
set ufs_ninode=5000
```

For Solaris releases prior to Solaris 2.4:

```
set ufs_ninode=10000
```

The default value of the inode cache is the same as that for `ncsize`:

`ufs_ninode` (default value) = 17 * `maxusers` + 90.

Caution – Do not set `ufs_ninode` less than `ncsize`.

The Solaris 2.x software environment versions, up to the Solaris version 2.3, run more efficiently with the `ufs_ninode` set to twice `ncsize`. In Solaris version 2.4 and later, `ufs_ninode` now limits only the number of inactive inodes, rather than the total number of active and inactive inodes.

2. **Reboot the system.**

Increasing Read Throughput

If you are using NFS over a high speed network, such as FDDI, SunFastEthernet, or SunATM, you will obtain better read throughput by increasing the number of read-aheads on the NFS client. The read-ahead functionality is a new feature of Solaris 2.4.

Increasing read-aheads is *not* recommended in these conditions:

- The client is very short of RAM.
- The network is very busy.
- File accesses are randomly distributed.

When free memory is low, read-ahead will not be performed.

The read-ahead is set to 1 block, by default (8 Kbytes). For example, a read-ahead set to 2 blocks fetches an additional 16 Kbytes from a file while you are reading the first 8 Kbytes from the file. In other words, the read-ahead stays one step ahead of you and fetches information in 8 Kbyte increments to stay ahead of information you need.

The read throughput stops getting faster after setting the number of read-aheads to 6 or 7 blocks. When setting the number of read-aheads, throughput does not usually increase with more than eight read-aheads (8 blocks).

Note – In the following procedures "To increase the number of read-aheads in the Solaris 2.4 version and later with NFS Version 2" and "To increase the number of read-aheads in Solaris 2.5 version and later with NFS Version 3the `nfs_nra` and the `nfs3_nra` values can be tuned independently.

If a client is running the Solaris version 2.5 or later, the client may need to tune `nfs_nfs` (NFS Version 2). This happens if the client is talking to a server that does not support Version 3.

▼ To increase the number of read-aheads in the Solaris 2.4 version and later with NFS Version 2

1. **Add the following line to `/etc/system` on the NFS client.**

```
set nfs:nfs_nra=4
```

2. **Reboot the system to implement the read-ahead value.**

▼ To increase the number of read-aheads in Solaris 2.5 version and later with NFS Version 3

1. **Add the following line to `/etc/system` on the NFS client.**

```
set nfs:nfs3_nra=6
```

2. **Reboot the system to implement the read-ahead value.**

Troubleshooting 5

Table 5-1 lists the actions to perform when you encounter a tuning problem.

Table 5-1 Troubleshooting Tuning Problems

Command/Tool	Command Output/Result	Action
`netstat -i`	`Collis+Ierrs+Oerrs/Ipkts + Opkts > 2%`	Check the Ethernet hardware.
`netstat -i`	`Collis/Opkts > 10%`	Add Ethernet interface and distribute client load.
`netstat -i`	`Ierrs/Ipks > 25%`	The host may be dropping packets, causing high input error rate. To compensate for bandwidth-limited network hardware: reduce the packet size; set the read buffer size, `rsize` and/or the write buffer size `wsize` to 2048 when using `mount` or in the `/etc/vfstab` file. See "To find the number of packets and collisions or errors on each network" in Chapter 3, "Analyzing NFS Performance."
`nfsstat -s`	`readlink > 10%`	Replace symbolic links with mount points.
`nfsstat -s`	`writes > 5%`	Install a Prestoserve NFS accelerator (SBus card or NVRAM-NVSIMM) for peak performance. See "Prestoserve NFS Accelerator" on page 75 in Chapter 4.
`nfsstat -s`	There are any `badcalls`.	The network may be overloaded. Identify an overloaded network using network interface statistics.

Table 5-1 Troubleshooting Tuning Problems *(Continued)*

Command/Tool	Command Output/Result	Action
`nfsstat -s`	`getattr` > 40%	Increase the client attribute cache using the `actimeo` option. Make sure the DNLC and inode caches are large. Use `vmstat -s` to determine the percent hit rate (cache hits) for the DNLC and if needed increase `ncsize` in the `/etc/system` file. See "Directory Name Lookup Cache (DNLC)" on page 82 in Chapter 4.
`vmstat -s`	Hit rate (cache hits) < 90%	Increase `ncsize` in the `/etc/system` file.
Ethernet monitor, for example: SunNet Manager™, SharpShooter, NetMetrix	Load > 35%	Add an Ethernet interface and distribute client load.

Table 5-2, Table 5-3, and Table 5-4 show potential client bottlenecks.

Table 5-2 Client Bottlenecks

Symptom(s)	Command/Tool	Cause	Solution
`NFS server` *hostname* `not responding` or slow response to commands when using NFS-mounted directories	`nfsstat`	User's path variable	List directories on local file systems first, critical directories on remote file systems second, and then the rest of the remote file systems.
`NFS server` *hostname* `not responding` or slow response to commands when using NFS-mounted directories	`nfsstat`	Running executable from an NFS-mounted file system	Copy the application locally (if used often).
`NFS server` *hostname* `not responding;` `badxid` >5% of total calls and `badxid` = `timeout`	`nfsstat -rc`	Client times out before server responds	Check for server bottleneck. If server's response time isn't improved, increase the `timeo` parameter in the `/etc/vfstab` file of clients. Try increasing `timeo` to 25, 50, 100, 200 (tenths of seconds). Wait one day between modifications and check to see if the number of time-outs decreases.
`badxid` = 0	`nfsstat -rc`	Slow network	Increase `rsize` and `wsize` in the `/etc/vfstab` file. Check interconnection devices (bridges, routers, gateways).

Table 5-3 Server Bottlenecks

Symptom(s)	Command/Tool	Cause	Solution
NFS server *hostname* not responding	vmstat -s or iostat	Cache hit rate is <90%	Adjust the suggested parameters for DNLC, then run to see if the symptom is gone. If not, reset the parameters for DNLC. Adjust the parameters for the buffer cache, then the inode cache, following the same procedure as for the DNLC.
NFS server *hostname* not responding	netstat -m or nfsstat	Server not keeping up with request arrival rate	Check network. If the problem is not network, add appropriate Prestoserve NFS accelerator, or upgrade the server.
High I/O wait time or CPU idle time. Slow disk access times or NFS server *hostname* not responding	iostat -x	I/O load not balanced across disks. The svc_t value is greater than 40 ms	Take a large sample (~2 weeks). Balance the load across disks; add disks as necessary. Add a Prestoserve NFS accelerator for synchronous writes. To reduce disk and network traffic, use tmpfs for /tmp for both server and clients. Measure system cache efficiencies. Balance load across disks; add disks as necessary.
Slow response when accessing remote files	netstat -s or snoop	Ethernet interface dropping packets	If retransmissions are indicated, increase buffer size. For information on how to use snoop, see “snoop” on page 96 in Appendix A.

Table 5-4 Potential Network-Related Bottlenecks

Symptoms	Command/Tool	Cause	Solution
Poor response time when accessing directories mounted on different subnets or `NFS server` *hostname* `not responding`	`netstat -rs`	NFS requests being routed	Keep clients on subnet directly connected to server.
Poor response time when accessing directories mounted on different subnets or `NFS server` *hostname* `not responding`	`nfsstat`	Dropped packets	Make protocol queues deeper.
Poor response time when accessing directories mounted on different subnets or `NFS server` *hostname* `not responding`	`netstat -s` shows incomplete or bad headers, bad data length fields, bad checksums.	Network problems	Check network hardware.
Poor response time when accessing directories mounted on different subnets or `NFS server` *hostname* `not responding`; sum of input and output packets per second for an interface is over 600 per second	`netstat -i`	Network overloaded	The network segment is very busy. If this is a recurring problem, consider adding another (`le`) network interface.
Network interface collisions are over 120 per second	`netstat -i`	Network overloaded	Reduce the number of machines on the network or check the network hardware.
Poor response time when accessing directories mounted on different subnets or `NFS server` *hostname* `not responding`	`netstat -i`	High packet collision rate (`Collis/Opkts` >.10)	– If packets are corrupted, it may be due to a corrupted MUX box; use the Network General Sniffer product or another protocol analyzer to find the cause. – Check for overloaded network. If there are too many nodes, create another subnet. – Check network hardware; could be bad tap, transceiver, hub on 10base-T. Check cable length and termination.

5

Using NFS Performance-Monitoring and Benchmarking Tools

This appendix discusses tools that help you to monitor NFS and network performance. These tools generate information that may be used in tuning to improve performance. See Chapter 3, “Analyzing NFS Performance,” and Chapter 4, “Configuring the Server and the Client to Maximize NFS Performance.”

For more detailed information about these tools, refer to their `man` pages (where applicable) and the manual *Security, Performance, and Accounting Administration* written by SunSoft. For third-party tools, refer to the product documentation.

This chapter also describes LADDIS, an NFS file server benchmarking tool.

A

NFS Monitoring Tools

Table A-1 describes the tools that you can use to monitor NFS operations and performance.

Table A-1 NFS Operations and Performance-Monitoring Tools

Tool	Function
`iostat`	Reports I/O statistics, including disk I/O activity
`nfsstat`	Reports NFS statistics: NFS and RPC (Remote Procedure Call) interfaces to the kernel; can also be used to initialize statistical information
`nfswatch`	Shows NFS transactions classified by file system. `nfswatch` is a public domain tool with source code available on `uunet.uu.net` under the directory `usr/spool/ftp/networking`; the file name is `nfswatch3.0.tar.Z`
`sar`	Reports system activity, such as CPU utilization, buffer activity, disk and tape device activity
SharpShooter (AIM Technology)	Pinpoints bottlenecks, balances NFS load across clients and servers; shows effect of distributed applications and balances network traffic across servers; accounts for disk usage by user or group
`vmstat`	Reports virtual memory statistics including disk activity

Network Monitoring Tools

Table A-2 describes the tools that can be used to monitor network performance as it relates to NFS.

Table A-2 Network Monitoring Tools

Tool	Function
`snoop`	Displays information about specified packets on Ethernet
`netstat`	Displays the contents of network-related data structures
`ping`	Sends `ICMP ECHO_REQUEST` packets to network hosts
NetMetrix Load Monitor	Allows network load monitoring real time or over time, and characterization of load in terms of time, source, destination, protocol and packet size
SunNet Manager	Performs network device monitoring and troubleshooting. SunNet Manager is a management and monitoring tool
LAN analyzers: Network General Sniffer, Novell/Excelan Lanalyzer	Performs packet analysis

A

snoop

The `snoop` command is part of the Solaris 2.x software environment. The `snoop` command must run by `root` (#) to capture packets in promiscuous mode. To capture packets in non-promiscuous mode or to analyze packets from a capture file, you do not need to be `superuser`.

In promiscuous mode, the interface turns off its filter and lets you see all packets on the subnet, whether or not they are addressed to your system. You can passively observe other packets not destined for your system. Promiscuous mode is limited to `root`.

Using the `snoop` command turns a Sun system into a network sniffer, which can detect network problems. The `snoop` command also captures a certain number of network packets, allows you to trace the calls from each client to each server, and displays the contents of the packets. You can also save the contents of the packets to a file to inspect at a later time.

The `snoop` command logs or displays packets selectively, provides accurate time stamps for checking network RPC (for example, NIS) response time, and formats packets and protocol information in a user-friendly manner.

The `snoop` command can display packets in a single-line summary or in expanded form. In summary form, only the data pertaining to the highest level protocol is displayed. For example, an NFS packet will have only NFS information displayed. The underlying RPC (Remote Procedure Call), UDP (User Datagram Protocol), IP (Internet Protocol), and network frame information is suppressed, but can be displayed if you choose either of the verbose (`-v` or `-V`) options.

The `snoop` command uses both the packet filter and buffer modules of the Data Link Provider Interface (DLPI) to provide efficient capture of packets transmitted to or received from the network. To view or capture all traffic between any two systems, run `snoop` on a third system.

The `snoop` command is a useful tool if you are considering subnetting, since it is a packet analysis tool. The output of the `snoop` command can be used to drive scripts that accumulate load statistics. The program is capable of breaking the packet header out in order to debug it, and to see what might be the source of incompatibility problems.

Following are some examples of how to use snoop.

Looking at Selected Packets in a Capture File, pkts

The statistics show which client is making a read request, and the left-hand column shows the time in seconds, with a resolution of about 4 microseconds.

When a read or write request is made, be sure the server doesn't time-out. If it does, the client has to re-send again, and the client's IP code will break up the write block into smaller UDP blocks. The default write time is .07 seconds. The time-out factor is a tunable parameter in the mount command.

Code Example A-1 Output of the snoop -i pkts -p99, 108 Command

```
# snoop -i pkts -p99,108
99   0.0027   boutique -> sunroof     NFS C GETATTR FH=8E6C
100   0.0046   sunroof -> boutique     NFS R GETATTR OK
101   0.0080   boutique -> sunroof     NFS C RENAME FH=8E6C MTra00192 to .nfs08
102   0.0102   marmot -> viper          NFS C LOOKUP FH=561E screen.r.13.i386
103   0.0072   viper -> marmot          NFS R LOOKUP No such file or directory
104   0.0085   bugbomb -> sunroof    RLOGIN C PORT=1023 h
105   0.0005   kandinsky -> sparky    RSTAT C Get Statistics
106   0.0004   beeblebrox -> sunroof  NFS C GETATTR FH=0307
107   0.0021   sparky -> kandinsky    RSTAT R
108   0.0073   office -> jeremiah        NFS C READ FH=2584 at 40960 for 8192
```

The following (see Code Example A-1) shows the arguments to the snoop command.

-i pkts	Displays packets previously captured in the file, pkts
-p99,108	Selects packets 99 through 108 to be displayed from a capture file; the first number 99, is the first packet to be captured; the last number, 108, is the last packet to be captured; the first packet in a capture file is packet 1

To obtain more information on a packet, type:

```
# snoop -i pkts -v 101
```

The command `snoop -i pkts -v 101` obtains more detailed information on packet 101. The following describes the previous `snoop` command arguments.

`-i pkts` Displays packets previously captured in the file, `pkts`.

`-v` Verbose mode; prints packet headers in detail for packet 101; use this option only when you need information on selected packets

The output of the `snoop -i pkts -v 101` command follows showing the Ethernet, IP, UDP, RPC, and NFS headers captured in `snoop`.

Code Example A-2 Output of the `snoop -i pkts -v 101` Command

```
ETHER:  ----- Ether Header -----
         ETHER:
         ETHER:  Packet 101 arrived at 16:09:53.59
         ETHER:  Packet size = 210 bytes
         ETHER:  Destination = 8:0:20:1:3d:94, Sun
        ETHER:  Source      = 8:0:69:1:5f:e,  Silicon Graphics
         ETHER:  Ethertype = 0800 (IP)
         ETHER:
         IP:   ----- IP Header -----
         IP:
         IP:   Version = 4, header length = 20 bytes
         IP:   Type of service = 00
         IP:         ..0. .... = routine
         IP:         ...0 .... = normal delay
         IP:         .... 0... = normal throughput
         IP:         .... .0.. = normal reliability
         IP:   Total length = 196 bytes
         IP:   Identification 19846
         IP:   Flags = 0X
         IP:   .0.. .... = may fragment
         IP:   ..0. .... = more fragments
         IP:   Fragment offset = 0 bytes
         IP:   Time to live = 255 seconds/hops
         IP:   Protocol = 17 (UDP)
         IP:   Header checksum = 18DC
         IP:   Source address = 129.144.40.222, boutique
         IP:   Destination address = 129.144.40.200, sunroof
         IP:
         UDP:  ----- UDP Header -----
         UDP:
         UDP:  Source port = 1023
         UDP:  Destination port = 2049 (Sun RPC)
         UDP:  Length = 176
         UDP:  Checksum = 0
         UDP:
         RPC:  ----- SUN RPC Header -----
         RPC:
         RPC:  Transaction id = 665905
         RPC:  Type = 0 (Call)
         RPC:  RPC version = 2
        RPC:  Program = 100003 (NFS), version = 2, procedure = 1
         RPC:  Credentials: Flavor = 1 (Unix), len = 32 bytes
```

Code Example A-2 Output of the `sp -i pkts -v 101` Command *(Continued)*

```
RPC:      Time = 06-Mar-90 07:26:58
          RPC:      Hostname = boutique
          RPC:      Uid = 0, Gid = 1
          RPC:      Groups = 1
          RPC:   Verifier    : Flavor = 0 (None), len = 0 bytes
          RPC:
          NFS:   ----- SUN NFS -----
          NFS:
          NFS:   Proc = 11 (Rename)
          NFS:   File handle = 000016430000000100080000305A1C47
          NFS:                 597A00000008000020463l4AFC450000
          NFS:   File name = MTra00192
          NFS:   File handle = 000016430000000100080000305A1C47
          NFS:                 597A00000008000020463l4AFC450000
          NFS:   File name = .nfs08
          NFS:
```

To view NFS packets, type:

```
# snoop -i pkts rpc nfs and sunroof and boutique
1   0.0000   boutique -> sunroof    NFS C GETATTR FH=8E6C
2   0.0046    sunroof -> boutique   NFS R GETATTR OK
3  0.0080  boutique -> sunroof   NFS C RENAME FH=8E6C MTra00192 to .nfs08
```

This example gives a view of the NFS packets between the systems `sunroof` and `boutique`. The arguments to the previous `snoop` command are described below.

`-i pkts`	Displays packets previously captured in the file, `pkts`
`rpc nfs`	Displays packets for an RPC call or reply packet for the NFS protocol; the option following `nfs` is the name of an RPC protocol from `/etc/rpc` or a program number
`and`	Performs a logical and operation between two boolean values; for example, `sunroof boutique` is the same as `sunroof and boutique`

To save packets to a new capture file, type:

```
# snoop -i pkts -o pkts.nfs rpc nfs sunroof boutique
```

The arguments to the previous `snoop` command are described below.

`-i pkts` Displays packets previously captured in the file, `pkts`

`-o pkts.nfs` Saves the displayed packets in the output file, `pkts.nfs`

`rpc nfs` Displays packets for an RPC call or reply packet for the NFS protocol; the option following `nfs` is the name of an RPC protocol from `/etc/rpc` or a program number

See the `snoop man` page for additional details on options used with the `snoop` command and additional information about using `snoop`.

LADDIS

SPEC SFS 1 (0.97 LADDIS) is a NFS file server benchmark incorporated by SPEC as a member of the System-level File Server (SFS) Benchmark Suite. Two reference points are considered when reporting 097.LADDIS.

- **NFS operation throughput**
  The peak number of NFS operations the target server can complete in a given number of milliseconds. The larger the number of operations an NFS server can support, the more users it can serve.

- **Response time**
  The average time needed for an NFS client to receive a reply from a target server in response to an NFS request. The response time of an NFS server is the client's perception of how fast the server is.

LADDIS is designed so that its workload can be incrementally increased until the target server performance falls below a certain level. That point is defined as an average response time exceeding 50ms. This restriction is applied when deriving `SPECnfs_A93`, the maximum throughput in NFS operations per second for which the response time does not exceed 50 ms.

If throughput continues to increase with the workload, the throughput figure at 50 ms is reported. In many cases, throughput will start to fall off at a response time below the 50 ms limit. In these cases, the tables in this chapter report the response time at the point of maximum throughput.

LADDIS Benchmark

The SPEC SFS 1 (0.97 LADDIS) benchmark is a synthetic NFS workload based on an application abstraction, an NFS operation mix, and an NFS operation request rate. The workload generated by the benchmark emulates an intensive software development environment at the NFS protocol level. The LADDIS benchmark makes direct RPC calls to the server, eliminating any variation in NFS client implementation. This makes it easier to control the operation mix and workload, especially for comparing results between vendors. However, this also hides the benefits of special client implementations, such as the cache file system client implemented in the Solaris 2.3 and later software environments.

Table A-3 shows the NFS operations mix. These percentages indicate the relative number of calls made to each operation.

Table A-3 NFS Operations Mix by Call

NFS Operation	Percent Mix
Lookup	34
Read	22
Write	15
GetAttr	13
ReadLink	8
ReadDir	3
Create	2
Remove	1
Statfs	1
SetAttr	1

The LADDIS benchmark for NFS file systems uses an operation mix that is 15 percent write operations. If your NFS clients generate only one to two percent write operations, LADDIS underestimates your performance. The greater the similarity between the operation mixes, the more reliable `SPECnfs_A93` will be as a reference.

Running the benchmark requires that the server being benchmarked have at least two NFS clients (the NFS load generators), and one or more isolated networks. The ability to support multiple networks is important because a single network may become saturates before the server maximum performance point is reached. One client is designated as the LADDIS Prime Load Generator. The prime load generator controls the execution of the LADDIS load generating code on all load generating clients. It typically controls the benchmark. In this capacity, it is responsible for collecting throughput and response time data at each of the workload points and for generating results.

To improve response time, configure your NFS server with the NVRAM-NVSIMM Prestoserve NFS accelerator. NVSIMMs provide storage directly in the high-speed memory subsystem. Using NVSIMMs results in considerably lower latency and reduces the number of disks required to attain a given level of performance.

Since there are extra data copies in and out of the NVSIMM, the ultimate peak throughput is reduced. Because NFS loads rarely sustain peak throughput, the better response time using the NVSIMMs is preferable. For information on the Prestoserve NFS accelerator, see the section “Prestoserve NFS Accelerator” on page 75 in Chapter 4.”

Interpreting LADDIS Results

Two factors to consider when analyzing LADDIS results are throughput and response time. Although response time increases with throughput, a well-designed NFS server delivers a range of throughput results while maintaining a more or less constant response time.

Figure A-1 illustrates an idealized LADDIS baseline result. At point A, there is minimal load on the system. Response time is limited by the hardware characteristics of the I/O subsystem. At point D, the LADDIS benchmark reports the SPECnfs_A93 single figure of merit. Between points B and C, workload increases about five times without impacting client performance.

The more a NFS server LADDIS benchmark graph of average NFS response time versus NFS throughput resembles Figure A-1, the better the NFS server can meet the average performance requirements to handle burst activity.

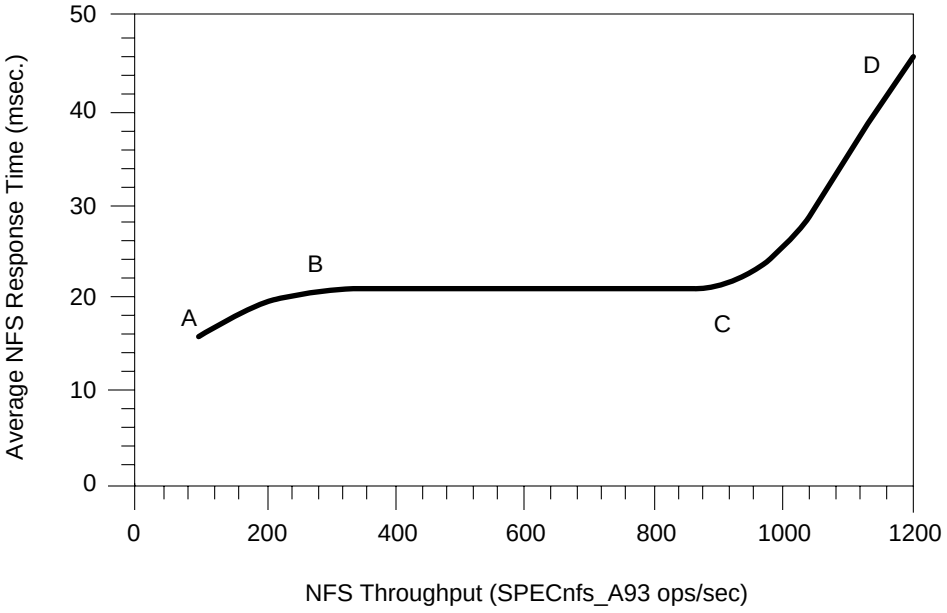

Figure A-1 Idealized LADDIS Baseline Result, Case 1

Figure A-2 shows a second baseline case of average NFS response time vs. NFS throughput. Point C in Figure A-1 shows a response time of 20 milliseconds. However, point C in Figure A-2 shows a response time of 35 milliseconds.

Compared to case 1 (Figure A-1), a case 2 client (Figure A-2) can experience an extra 15 second delay for each 1000 NFS operations transacted on an NFS server throughput rate of 1000 NFSops. For example, when executing a long listing of the `ls` command (`ls -l`) on a NFS mounted file system, the system can easily request over 1000 NFS operations. Both cases report the same LADDIS result at point D.

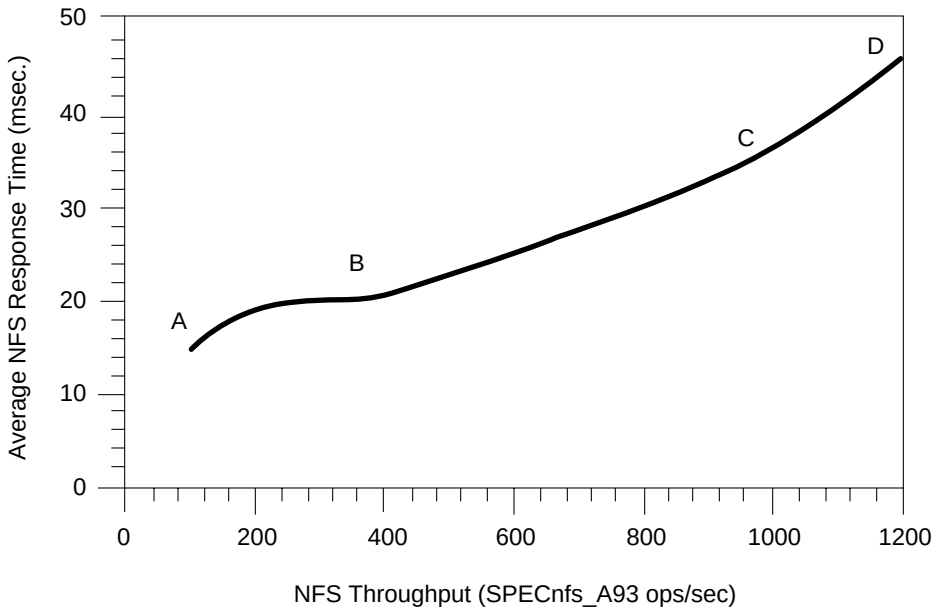

Figure A-2 Idealized LADDIS Baseline Result, Case 2

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