IRIX™ Admin: System Configuration and Operation

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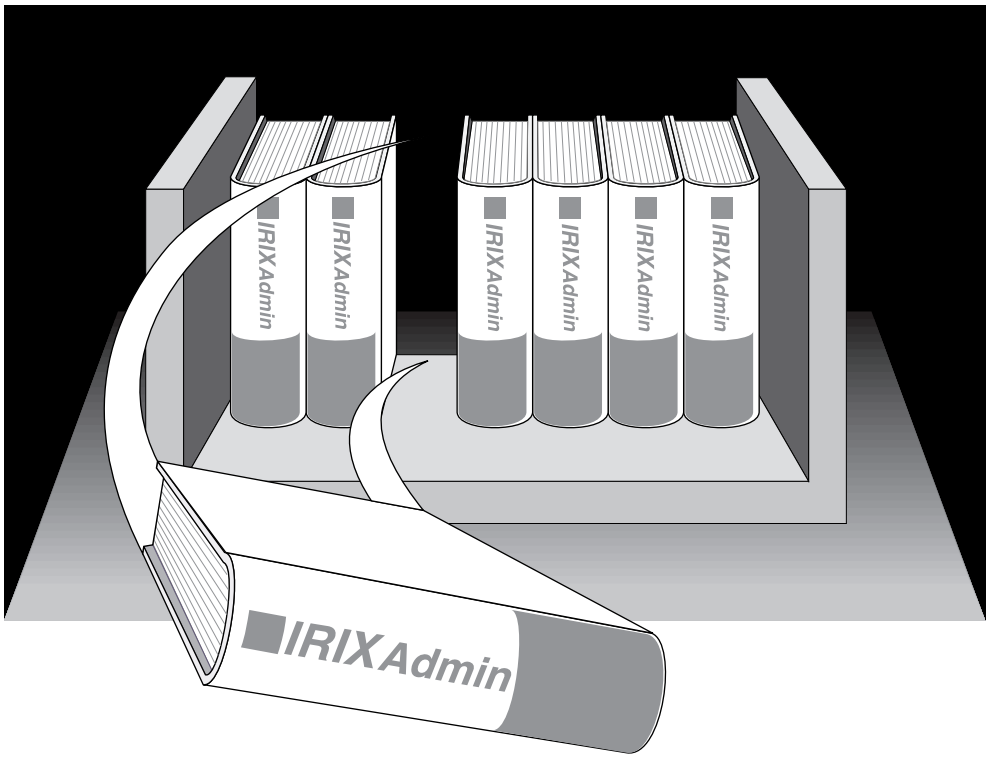

"About This Guide" includes brief descriptions of the contents of this guide and an explanation of typographical conventions used, and refers you to additional sources of information you might find helpful.

This guide explains how to perform general system configuration and operation tasks under the IRIX™ operating system used with Silicon Graphics® workstations and servers. It provides descriptions of a broad range of tasks, from turning on a system, to adding users, to tuning the operating system kernel.

If you have a graphics workstation, you may find it convenient to use the System Manager, which is described in the *Personal System Administration Guide*. That guide should be your first resource for administering graphics workstations. Regardless of whether you use the System Manager or the IRIX command-line interface, the results are the same. The System Manager does not create any new files on your system, unlike applications such as WorkSpace™.

If you have a server, the IRIX Administration manual set (of which this guide is part) is your primary guide to system administration, since without graphics you cannot use the System Manager. This guide does not describe the System Manager in great detail. Instead, it covers the traditional shell command approach to administering an IRIX operating system.

IRIX Admin Manual Set

This guide is part of the *IRIX Admin* manual set, which is intended for administrators: those who are responsible for servers, multiple systems, and file structures outside the user's home directory and immediate working directories. If you maintain systems for others or if you require more information about IRIX than is in the end-user manuals, these guides are for you. The *IRIX Admin* guides are available through the IRIS InSight™ online viewing system. The set consists of these volumes:

- *IRIX Admin: Software Installation and Licensing*—Explains how to install and license software that runs under IRIX, the Silicon Graphics implementation of the UNIX® operating system. Contains instructions for performing miniroot and live installations using Inst, the command line interface to the IRIX installation utility. Identifies the licensing products that control access to restricted applications running under IRIX and refers readers to licensing product documentation.
- *IRIX Admin: System Configuration and Operation*—Lists good general system administration practices and describes system administration tasks, including configuring the operating system; managing user accounts, user processes, and disk resources; interacting with the system while in the PROM monitor; and tuning system performance.
- *IRIX Admin: Disks and Filesystems*—Explains disk, filesystem, and logical volume concepts. Provides system administration procedures for SCSI disks, XFS™ and EFS filesystems, XLV logical volumes, and guaranteed-rate I/O.

- *IRIX Admin: Networking and Mail*—Describes how to plan, set up, use, and maintain the networking and mail systems, including discussions of sendmail, UUCP, SLIP, and PPP.
- *IRIX Admin: Backup, Security, and Accounting*—Describes how to back up and restore files, how to protect your system's and network's security, and how to track system usage on a per-user basis.
- *IRIX Admin: Peripheral Devices*—Describes how to set up and maintain the software for peripheral devices such as terminals, modems, printers, and CD-ROM and tape drives.
- *IRIX Admin: Selected Reference Pages* (not available in InSight)—Provides concise reference page (manual page) information on the use of commands that may be needed while the system is down. Generally, each reference page covers one command, although some reference pages cover several closely related commands. Reference pages are available online through the man(1) command.

What This Guide Contains

This guide has been prepared with the understanding that most readers will view it with the InSight online viewing system or a Web browser and use it as a reference work. It is not necessary to read this Guide in a linear fashion. All information relevant to a given topic is presented in the section of the Guide devoted to the topic. There is no prerequisite reading or knowledge other than that stated in this introductory chapter.

The *IRIX Admin: System Configuration and Operation* guide contains the following chapters:

Chapter 1, "Introduction to System Configuration and Operation"
: Describes the various tools available to the administrator and the various pieces of the administration documentation.

Chapter 2, "Making the Most of IRIX"
: Describes IRIX features that are useful for administrators and not common with all operating environments.

Chapter 3, "System Startup and Shutdown"
: Provides short instructions on booting up and shutting down your system.

Chapter 4, “Configuring the IRIX Operating System”
: Describes the tasks and processes necessary to configure a new or changing system.

Chapter 5, “Managing the Multiuser Environment”
: Describes the processes of adding and deleting user accounts, user groups, manipulating the user’s environment, and communicating with users.

Chapter 6, “Configuring Disk and Swap Space”
: Describes simple disk space management. Procedures for checking disk space and establishing user disk usage quotas are described, along with less intrusive strategies for maintaining reasonable disk usage. Also, techniques for managing system swap space are provided. This chapter does not describe the process for adding a disk or creating and maintaining filesystems. Those topics are covered in the *IRIX Admin: Disks and Filesystems* guide.

Chapter 7, “Managing User Processes”
: Describes how to monitor user’s CPU usage, set process priority, and terminate processes.

Chapter 8, “Troubleshooting the File Alteration Monitor,”
: Provides information about the *famd* alteration monitor daemon. This program provides information to applications concerning changes to files used simultaneously by several programs.

Chapter 9, “Using the Command (PROM) Monitor”
: Describes the boot-level utilities provided to configure and test your system. It describes the boot environment of the workstation and each of the Command Monitor commands.

Chapter 10, “System Performance Tuning”
: Describes how to analyze system performance and adjust system parameters to influence system performance.

Appendix A, “IRIX Kernel Tunable Parameters”
: Describes the various tunable parameters used in system performance tuning.

Appendix B, “Troubleshooting System Configuration Using System Error Messages”
: Provides some troubleshooting pointers related to common system error messages.

Appendix C, “IRIX Directories and Files”
: Provides a list of the directories and files that are important in IRIX administration.

Appendix D, “Encapsulated PostScript File v.3.0 vs. PostScript File Format”
: Describes two common PostScript® file formats used on IRIX systems.

Appendix E, “Bibliography and Suggested Reading”
: Provides a bibliography of commonly available books that are useful for the system administrator.

Conventions Used in This Guide

These type conventions and symbols are used in this guide:

Bold—C++ class names, C++ member functions, C++ data members, function names, language keywords and data types, literal command-line arguments (options / flags), nonalphabetic data types, operators, and subroutines

Italics—Backus-Naur Form entries, command monitor commands, executable names, filenames, glossary entries (online, these show up as underlined), IRIX commands, manual / book titles, new terms, onscreen button names, program variables, tools, utilities, variable command-line arguments, variable coordinates, and variables to be supplied by the user in examples, code, and syntax statements

`Fixed-width type`—
Error messages, prompts, and onscreen text

`Bold fixed-width type`—
User input, including keyboard keys (printing and nonprinting); literals supplied by the user in examples, code, and syntax statements (*see also* <>)

ALL CAPS—Environment variables, operator names, directives, defined constants, macros in C programs

“”—(Double quotation marks) Onscreen menu items and references in text to document section titles

()—(Parentheses) Following function names—surround function arguments or are empty if the function has no arguments; following IRIX commands—surround reference page (man page) section number

[]—(Brackets) Surrounding optional syntax statement arguments

#–IRIX shell prompt for the superuser (*root*)

%—IRIX shell prompt for users other than superuser

>>—Command Monitor prompt

This guide uses the standard UNIX convention for referring to entries in IRIX documentation. The entry name is followed by the section number in parentheses. For example, rcp(1C) refers to the *rcp* online reference page.

Target Audience of This Guide

This guide is intended for administrators who are responsible for one or more systems beyond the usual user responsibility for the user's home directory structure and immediate working directories. This guide and its companion guides have been written to provide directions for those who find themselves in the position of maintaining systems for themselves and others and who require more information about IRIX commands and system and network configuration.

The *IRIX Admin: System Configuration and Operation* guide is written for administrators who are responsible for performing tasks beyond the reasonable scope of "end users." Frequently, people who would consider themselves end users find themselves performing advanced administrative tasks. This book has been prepared to help both the new and experienced administrator successfully perform all operations necessary to configure IRIX systems. It is hoped that people who considered themselves end users in the past can, by using this book, gain experience and confidence in successfully performing advanced system administration tasks.

Additional Resources

For easy reference, this section lists guides and resources provided with your system and the specific focus and scope of each.

IRIX Reference Pages

The IRIX reference pages (often called “man” or “manual” pages) provide concise reference information on the use of IRIX commands, subroutines, and other elements that make up the IRIX operating system. This collection of entries is one of the most important references for an administrator. Generally, each reference page covers one command, although some reference pages cover several closely related commands.

The IRIX reference pages are available online through the *man* command if they’ve been installed or are mounted. To view a reference page, use the *man* command at the shell prompt. For example, to see the reference page for *diff*, enter:

```
man diff
```

It is a good practice to print those reference pages you consistently use for reference and those you are likely to need before major administrative operations and keep them in a notebook of some kind.

Each command, system file, or other system object is described on a separate page. The reference pages are divided into seven sections, as shown in Table i. When referring to reference pages, this document follows a standard UNIX convention: the name of the command is followed by its section number in parentheses. For example, cc(1) refers to the *cc* reference page in Section 1.

Table i shows the reference page sections and the types of reference pages that they contain.

Table i Outline of Reference Page Organization

Type of Reference Page	Section Number
General Commands	(1)
System Calls and Error Numbers	(2)
Library Subroutines	(3)
File Formats	(4)
Miscellaneous	(5)
Demos and Games	(6)
Special Files	(7)

When viewing this guide online with IRIS InSight, references to the reference page of a command are followed by its section number in parentheses, and these are links to the actual reference page. For example, clicking man(1), displays the reference page for the *man* command.

Release Notes

A product's release notes provide specific information about the current release, including release-specific exceptions to the information in the administration guides. Release Notes are available online through the *relnotes* command. Each optional product or application has its own set of release notes. The *grelnotes* command provides a graphical interface to the release notes of all products installed on your system.

IRIX Help System

Your IRIX system comes with a help system. This system provides help cards for commonly asked questions about basic system setup and usage. The command to initiate a help session is *desktophelp*.

Silicon Graphics' World Wide Web Site

The Silicon Graphics World-Wide Web (WWW) presence has been established to provide current information of interest to Silicon Graphics customers. The following URL addresses are accessible to most commercially available web browsers on the internet:

http://www.sgi.com—The Silicon Graphics general Web site, Silicon Surf

http://www.mips.com—The Silicon Graphics mips division server

http://www.studio.sgi.com—The Silicon Studio site

http://www.alias.com—The Alias server

http://www.sgi.com/Technology/TechPubs—The Silicon Graphics Technical Publications Library

From these sites, you can find all the Silicon Graphics Web-published information, including the suite of *IRIX Admin* guides.

Chapter 1

Introduction to System Configuration and Operation

Chapter 1 introduces you to the basics of effective system administration. The basic tools that you use are described here;, a quick reference to each of the following chapters and a thumbnail guide to the IRIX reference pages are also included. The following sections are provided:

- Principles of Good System Administration
- Tasks of the System Administrator
- Administration Tools

Chapter 1

Introduction to System Configuration and Operation

One of the first jobs of a system administrator is to bring a system online with an existing network (or standing alone), and to configure the system to meet the needs for which the system was installed. This configuration usually involves installing any necessary software and hardware, setting the name and network address of the system, creating accounts for the expected users, and generally taking a system from "out of the box" uniformity and customizing it to meet your preferences and your user's needs.

The tasks of installing necessary hardware are described in the documentation for the hardware. Software installation is described in the *IRIX Admin: Software Installation and Licensing* volume. This Guide describes the tasks you perform once the system has been powered-up, to bring a system from its initial distributed state to the state in which you or your users will use it.

This Guide assists you by describing the procedure you—the system administrator—use to configure systems and explaining the reasons why these procedures exist and why they work the way they do. Some of these tasks are typically performed only at times of major change—when a system is commissioned, when ownership changes, or when there has been a significant hardware upgrade. Others are ongoing tasks or tasks that may come up during standard usage of an installed system.

As system administrator, you should familiarize yourself with the graphical interface tools available through the System Manager. You can conveniently perform many common administrative tasks with this tool. This document does not describe the System Manager, but instead discusses how to use the command-line and file interface to perform administrative functions.

This chapter provides information on the general nature of IRIX system administration. There are many good books on system administration listed in Appendix E, "Bibliography and Suggested Reading" of this Guide, and these are available through computer bookstores. Silicon Graphics systems are similar to those described in many of these books, and they are different in significant areas as well. The principles of good system administration, though, are constant.

Principles of Good System Administration

The following sections outline basic principles of good system administration. Each administrator must make individual decisions about the best practices for a site. The principles discussed here are generally considered to be wise and safe practices.

Create Passwords for Accounts

To make your site as secure as possible, each user should have an account, with a unique user ID number, and each account should have a password. Users should never give out their passwords to anyone else under any circumstances. For more information on passwords and system security, see the *IRIX Admin: Backup, Security, and Accounting* volume.

Restrict Access to the Superuser (root) Account

Most system administration is performed while the system administrator is logged in as root (the superuser). This account is different from an ordinary user account because root has access to all system files and is not constrained by the usual system of permissions that control access to files, directories, and programs. The root account exists so that the administrator can perform all necessary tasks on the system while maintaining the privacy of user files and the integrity of system files. Other operating systems that do not differentiate between users have little or no means of providing for the privacy of users' files or for keeping system files uncorrupted. UNIX-based systems place the power to override system permissions and to change system files only with the root account.

All administrators at your site should have regular user accounts for their ordinary user tasks. The root account should be used only for necessary system administration tasks.

To obtain the best security on a multiuser system, restrict access to the root account. On workstations, the primary user of the workstation can generally use the root account safely, though most users should not have access to the root account on other user's workstations.

Make it a policy to give root passwords to as few people as is practical. Some sites maintain locked file cabinets of root passwords so that the passwords are not widely distributed but are available in an emergency.

Maintain User Privacy

On a multiuser system, users may have access to personal files that belong to others. Such access can be controlled by setting file permissions with the chmod(1) command. Default permissions are controlled by the *umask* shell parameter. (See “Configuring Default File Permissions With umask” on page 111 for information on setting *umask*.)

By default, it is easy for users to exchange data because permission to read files is granted to everyone. Users can change this default for their own files. However, many users do not set their *umasks*, and they forget to change the access permissions of personal files. Make sure users are aware of file permissions and of your policy on examining other users’ personal files. You can make this policy as lenient or stringent as you deem necessary.

Check the Password File Regularly

At least once a week, run the pwck(1M) and grpck(1M) programs to check your */etc/passwd* and */etc/group* files for errors. You can automate this process using the cron(1) command, and you can direct *cron* to mail the results of the checks to your user account. For more information on using *cron* to automate your routine tasks, see “Automating Tasks With at, batch, and cron” on page 27.

The *pwck* and *grpck* commands read the password and group files and report any incorrect or inconsistent entries. Any inconsistency with normal IRIX operation is reported. For example, if you have */etc/passwd* entries for two user names with the same User Identification (UID) number, *pwck* reports this as an error. *grpck* performs a similar function on the */etc/group* file. The standard *passwd* file shipped with the system can generate several errors.

Monitor Hardware Changes

Be aware that changing hardware configurations can affect the system, even if the change you make seems simple. Make sure you are available to help users with problems after the system is changed in any way.

Monitor Software Upgrades

Changing the software also affects the system, even if the change you make is as trivial as a small upgrade to a new version of an application. Some software installations can overwrite customized configuration files. Users may have scripts that assume that a utility or program is in a certain directory, and a software upgrade may move the utility. Or the new version of the software simply may not work in the same way as the old version.

Whenever you change the software configuration of your systems, let your users know and be ready to perform some detective work if seemingly unrelated software suddenly stops working as a result. Make sure you are available to help users with problems after the system is changed in any way.

Before you upgrade a system to new software, check your user community to see which parts of the old software they use, and if they might be inconvenienced by the upgrade. Often users need extra time to switch from one release of an application to a newer version.

If possible, do not strand your users by completely removing the old software. Try to keep both versions on the system until everyone switches to the new version.

Notify Users of System Unavailability

In general, try to provide the user community as much notice as possible about events affecting the use of the system. When the system must be taken out of service, also tell the users when to expect the system to be available. Use the “message of the day” file */etc/motd* to keep users informed about changes in hardware, software, policies, and procedures.

Many administrative tasks require the system to be shut down to a run level other than the multiuser state. This means that conventional users cannot access the system. Just before the system is taken out of the multiuser state, users on the system are requested to log off. You should do these types of tasks when they interfere the least with the activities of the user community.

Sometimes situations arise that require the system to be taken down with little or no notice provided to the users. This is often unavoidable, but try to give at least 5 to 15 minutes notice, if possible.

At your discretion, the following actions should be prerequisites for any task that requires the system to leave the multiuser state:

- When possible, perform service tasks during periods of low system use. For scheduled actions, use */etc/motd* to inform users of future actions.
- Check to see who is logged in before taking any actions that would affect a logged-in user. You can use the */etc/whodo*, */bin/who*, or */usr/bsd/w* command to see who is on the system. You may also wish to check for large background tasks, such as background compilations, by executing *ps -ef*.
- If the system is in use, provide the users advanced warning about changes in system states or pending maintenance actions. For immediate actions, use the */etc/wall* command to send a broadcast message announcing that the system will be taken down at a given time. Give the users a reasonable amount of time (five to fifteen minutes) to terminate their activities and log off before taking the system down.

Set a Malicious Activity Policy

Set a policy regarding malicious activities that covers:

- deliberately crashing the system
- breaking into other accounts; for example, using password-guessing and password-stealing programs
- forging electronic mail from other users
- creating and unleashing malicious programs, such as worm and virus processes

Make sure that all users at the site are aware that these sorts of activities are potentially very harmful to the community of users on the system. Penalties for malicious behavior should be severe and the enforcement should be consistent.

The most important thing you can do to prevent malicious damage to the system is to restrict access to the root password.

Maintain a System Log Book

It is important to keep a complete set of records about each system you administer. A system log book is a useful tool when troubleshooting transient problems or when trying to establish system operating characteristics over a period of time. Keeping a hard copy book is important, since you cannot refer to an online log if you have trouble starting the system.

Some of the information to consider entering into the log book for each system you administer is:

- maintenance records (dates and actions)
- printouts of error messages and diagnostic phases
- equipment and system configuration changes (dates and actions), including serial numbers of various parts (if applicable)
- copies of important configuration files
- the output of *prtvtoc*(1M) for each disk on the system
- the */etc/passwd* file
- the */etc/group* file
- the */etc/fstab* file
- the */etc/exports* file

The format of the system log and the types of items noted in the log should follow a logical structure. Think of the log as a diary that you update periodically. To a large measure, how you use your system dictates the form and importance of maintaining a system log.

In addition to the system log, you may find it helpful to keep a user trouble log. The problems that users encounter fall into patterns. If you keep a record of how problems are resolved, you do not have to start from scratch when a problem recurs. Also, a user trouble log can be very useful for training new administrators in the specifics of your local system, and for helping them learn what to expect.

Collect User Requests

Provide a convenient way for your users to report problems. For example, set up a "trouble" mail alias, so that users with problems can simply send mail to *trouble* for assistance. Refer to *IRIX Admin: Networking and Mail* for more information on mail aliases.

System Administrator Tasks

The system administrator is responsible for all tasks that are beyond the scope of end users, whether for system security or other reasons. The system administrator can undoubtedly use the more advanced programs described in this guide.

A system administrator has many varied responsibilities. Some of the most common responsibilities addressed in this Guide are:

- Operations—Seeing that systems stay up and running, scheduling preventive maintenance downtime, adding new users, installing new software, and updating the */etc/motd* and */etc/issue* files. See Chapter 4, "Configuring the IRIX Operating System." Also see Chapter 5, "Managing the Multiuser Environment."
- Failure Analysis—Troubleshooting by reading system logs and drawing on past experience. See "Maintain a System Log Book" on page 8.
- Capacity Planning—Knowing the general level of system use and planning for additional resources when necessary. See Chapter 6, "Configuring Disk and Swap Space," and Chapter 10, "System Performance Tuning."
- System Tuning—Tuning the kernel and user process priorities for optimum performance. See Chapter 10, "System Performance Tuning."
- Resource Management—Planning process and disk accounting and other resource sharing. See the *IRIX Admin: Backup, Security, and Accounting* guide.
- Networking— Interconnecting systems, modems, and printers. See the *IRIX Admin: Networking and Mail* guide.
- Security—Maintaining sufficient security against break-ins as well as maintaining internal privacy and system integrity. See the *IRIX Admin: Backup, Security, and Accounting* guide.
- User Migration—Helping users work on all workstations at a site. See the *IRIX Admin: Networking and Mail* guide.

- User Education—Helping users develop good habits and instructing them in the use of the system. See Chapter 5, “Managing the Multiuser Environment.”
- Backups—Creating and maintaining system backups. See the *IRIX Admin: Backup, Security, and Accounting* guide.

Administration Tools

Depending on the exact configuration of your system, you may have the following tools available for performing system administration:

System Manager
: This tool, available on graphics workstations, provides easy access to system administration functions. It features a quick and easy method of performing most system administration tasks. The System Manager is available only on those systems that have graphics capability.

Command-line tools
: The IRIX system provides a rich set of system administration tools that have command-line interfaces. These are especially useful for automatically configuring systems with shell scripts and for repairing the system in unusual circumstances, such as when you must log in remotely from another system.

  For example, using command-line tools, a site administrator can alter the system automatically at designated times in the future (for instance, to distribute configuration files at regular intervals). These commands are available on all IRIX systems.

  The suite of *IRIX Admin* guides are primarily concerned with the command-line interface and direct system file manipulation. Refer to the *Personal System Administration Guide* for a GUI approach to system administration tasks.

Chapter 2

Making the Most of IRIX

Chapter 2 describes procedures that are helpful to you as you perform your system administration duties. These are features of IRIX that are documented elsewhere, but are brought together here as highlights that might otherwise be overlooked. The following features are described:

- IRIX shell shortcuts such as regular expressions and metacharacters and other specific shell shortcuts
- General IRIX shortcuts such as displaying a window on another system, creating custom windows, and automating tasks.
- Mouse shortcuts such as using the mouse to cut and paste text between windows.
- Instructions for creating your own reference pages and installing them on your system.

Chapter 2

Making the Most of IRIX

This chapter describes features of IRIX that are useful to the system administrator. Administrators coming to a UNIX-based system from other environments will find this chapter valuable in reducing the amount of time necessary to perform some tasks. Others may find hints and features that they did not previously know.

IRIX Shell Shortcuts

The IRIX shells provide the command-line interface to the system. The following features are provided as part of the IRIX command shells.

Using Regular Expressions and Metacharacters

There are shortcuts for referencing large numbers of files or directories in your commands. These shortcuts are known as “regular expressions.” Regular expressions are made up of a combination of alphanumeric characters and a series of punctuation characters that have special meaning to the IRIX shells. These punctuation characters are called metacharacters when they are used for their special meanings with shell commands.

These shortcuts are useful because they minimize keystrokes. While minimizing keystrokes may seem to be a minor concern at first glance, an administrator who issues lengthy and complex command lines repeatedly may find these shortcuts a handy and necessary time-saving feature.

Following is a list of the IRIX metacharacters:

Table 2-1 IRIX Metacharacters

Metacharacter	Meaning
*	Wildcard
?	Single-character wildcard
[]	Set definition marks

The asterisk (*) metacharacter is a universal wildcard. This means that the shell interprets the character to mean any and all files. For example, the command:

```
cat *
```

tells the shell to concatenate all the files in a directory, in alphabetical order by filename. The command:

```
rm *
```

tells the shell to remove everything in the directory (so be careful with this one!). Only files are removed—a different command, rmdir(1), is used to remove directories. Note that the asterisk character does not always have to refer to whole files. It can be used to denote parts of files as well. For example, the command:

```
rm *.old
```

removes all files with the suffix *.old* on their names.

The single-character wildcard is a question mark (?). This metacharacter denotes a single character. For example, if your directory contains the following files:

```
file1
file2
file3
file.different
```

and you wish to remove *file1*, *file2*, and *file3*, but not *file.different*, you could use the command:

```
rm file?
```

If you used an asterisk in place of the question mark, all your files would be removed, but since the question mark is a wildcard for a single space, *file.different* is not chosen.

Square brackets denote members of a set. For example, consider the list of files used in the example of the single-character wildcard. If you wanted to remove *file1* and *file2*, but not *file3* or *file.different*, use the following command:

```
rm file[12]
```

This command tells the shell to remove any files with names starting with *file* and with the character *1* or *2* following, and no other characters in the name. Each character in the brackets is taken separately. Thus, if the example directory had included a file named *file12*, it would not have been removed by the above command.

You can also use a dash (-) to indicate a span of characters. For example, to remove *file1*, *file2*, and *file3*, use the following command:

```
rm file[1-3]
```

Alphabet characters can be spanned as well, in alphabetical order. The shell distinguished between uppercase and lowercase letters, though, so to select all alphabet characters within square brackets, use the following syntax:

```
[a-z,A-Z]
```

You can use the square brackets with other metacharacters as well. For example, the command:

```
rm *[23]
```

removes any files with names ending with a *2* or *3*, but not *file1* or *file.different*.

C Shell Shortcuts

The IRIX C Shell (*/sbin/csh*) provides several features that can be used to minimize keystrokes for routine tasks. Complete information about these and many other features of the C shell is available in the csh(1) reference page. Among the features provided are:

Filename completion
: This feature is activated with the command:

  `set filec`

  Filename completion allows you to enter the first character or two of a command or filename and then press the Esc key to have the shell complete the name. This is useful when you have long filenames with many suffixes. If more than one file or directory or command matches the characters you have given, the shell completes as much as possible of the name, and then prompts you with a beep for more information. You can also use the Ctrl+D character to select all files or directories that match your given characters.

Shell scripts
: This feature allows you to create a program that will be executed by the shell. This feature is similar to a programming language in that it has a set syntax and set of instructions, yet it requires no compiler and produces no object file; it is directly executed by the shell. Many administrators use this feature for frequently performed procedures that require some planning and complex execution, such as finding large files and notifying the owners that such files cannot be kept on the system for long periods of time. The shell script programming rules are clearly presented on the csh(1) reference page.

Input/output redirection
: This feature allows you to direct the output of a command into a file or into another command as input. You can also direct a command to take its input from a file. It is often used as part of a shell script, but is generally used on the command line to string together a series of commands. For example, consider the command line:

  `ps -ef | grep` *commandname*

The pipe character directs the shell to use the output of the *ps* command as the input to the *grep* command. The result is that all instances of the command *commandname* in the process list are printed on the screen, saving the administrator the effort of searching through the process listing. To save the output in a file rather than have it print on the screen, enter:

ps -ef | grep *commandname* **>** *filename*

Job control

This feature allows you to use a single screen (or shell window) to manage several programs running simultaneously. It is most useful for the server administrator who manages the system from a single character-based terminal.

Command aliasing

This feature allows you to create aliases for commonly used command strings, saving keystrokes. For example, suppose you frequently give the command:

```
ls -CF | more
```

This command line executes the *ls* command with certain options and ensures that if the output is greater than a screenful the display stops until you have read it. However, it would be tedious to type the whole command each time you wanted to see a directory listing in your preferred format. Therefore, you can create an alias. You can alias the above command line to any series of keystrokes you like. You can even alias it to "ls," thus bypassing the standard meaning of the *ls* command.

When you create the alias, however, be aware that any command that requires one or more arguments, or one such as *ls* that may or may not receive arguments, must have a provision made in the alias for those arguments. The standard provision made in aliases for possible arguments is the following regular expression:

```
\!*
```

The leading backslash escapes the initial meaning of the exclamation point to the shell and passes the exclamation point through to the command line, where it is interpreted by the shell to refer to arguments given on the aliased command line. The asterisk in the expression means that all characters typed in as arguments are to be passed through to the shell. As an example, the line you place in your *.cshrc* file to create the example alias is:

```
alias ls ‘ls -CF \!* | more‘
```

Then, when you type the command:

ls *filename*

at a shell prompt, the command is executed as:

ls -CF *filename* **| more**

Aliases can be used freely within shell scripts, with filename completion and full use of regular expressions and output redirection.

Command history

The shell maintains a log of past commands given during this login session. You can repeat or edit a previously given command to save keystrokes. The *history* command shows the numbered log of commands in order. The first command given in your login session is number 1, the second is number 2, and so on. You can set the number of commands the shell remembers in your *.cshrc* file. To execute the most recent command again, type:

```
!!
```

To execute the most recent command beginning with the letter **q**, use the command line:

```
!q
```

And to execute a command by its number in the history, give the command line:

!*n*

where *n* is the number of the command you want to reexecute.

Tcsh Shell Shortcuts

The */usr/bin/tcsh* program is an improved version of the C shell. In addition to the C shell features listed above, this shell offers many other features. A few of the most useful to system administrators are:

- Better command line editing using *emacs* and *vi* key commands
- Improved history mechanisms, including time stamps for each command
- Built-in mechanisms for listing directory contents and for executing commands at specific times or intervals.

There are many more features implemented in *tcsh*, and all of them are covered in the tcsh(1) reference page.

Bourne Shell Shortcuts

The Bourne shell (*/sbin/bsh*) provides fewer features than the C shell, but in its place offers a level of access to the shell that contains far fewer restrictions and intervening layers of interface. For example, you can write shell script programs directly from the shell prompt with Bourne shell. Input and output redirection and command aliasing are supported with the Bourne shell, but no command history, job control, or filename completions are available. For a complete discussion of the Bourne shell and its features, see the sh(1) reference page.

Korn Shell Shortcuts

The Korn shell was developed to provide the best features of both the C shell and the Bourne shell. The */sbin/sh* program provides the ease of shell programming found in the Bourne shell, along with the job control, history mechanism, filename completion, and other features found in the C shell. This shell has changed many of the ways these features are implemented, and also provides improved command-line editing facilities. See the ksh(1) reference page for complete information on this shell. Useful features include:

Emacs editing
: This mode is entered by enabling either the **emacs** or **gmacs** option. To edit, the user moves the cursor to the point needing correction and then inserts or deletes characters or words as needed as if the command line were a text file being edited using *Emacs*. All edit commands operate from any place on the line (not just at the beginning).

vi editing	To enter this mode, enable the **vi** option. There are two typing modes in this option. Initially, when you enter a command you are in the input mode. To edit, the user enters control mode by typing Esc, moves the cursor to the point needing correction, then inserts or deletes characters or words as needed as if the command line were a text file being edited using *vi*.
Job control	Lists information about each given process (**job**) or all active processes if the **job** argument is omitted. The **-l** flag lists process ID numbers in addition to the normal information. The **-n** flag displays only jobs that have stopped or exited since last notified. The **-p** flag causes only the process group to be listed. See the ksh(1) reference page for a description of the format of the **job** argument. The *bg* command puts each specified process into the background. The current process is put in the background if **job** is not specified. The *fg* command brings each process specified to the foreground. Otherwise, the current process is brought into the foreground.

General IRIX Shortcuts

The following sections describe general shortcuts provided by IRIX.

Displaying Windows on Alternate Workstations

You can invoke a graphical utility or application on a remote networked workstation and direct the window and all input and output to your own workstation. This is convenient when you perform maintenance on remote workstations from your own desk. The program you invoke runs on the remote workstation and the window is displayed on the specified display workstation.

You must allow the remote system access to your display. To do this, you can use the *xhost* command on the display workstation:

xhost +*remote_workstation*

Next, use rsh(1), rlogin(1), or telnet(1) to log in to the remote workstation with whatever privilege level is required to perform the maintenance on that system. This may be as simple as the guest account, or you may have your own user account on the system or you may require root permission. Choose the level of access appropriate to your task. Then, for *csh* and *tcsh* users, issue the command:

setenv DISPLAY *local_workstation***:0**

Or, *bsh* and *ksh* users enter:

DISPLAY=*local_workstation***:0 ; export DISPLAY**

The name of the workstation where the window is to be displayed is substituted for *local_workstation*. The name of the local workstation must be found in the */etc/hosts* file of the remote system, where the program is actually running.

Now, when you invoke the desired utility or application on the remote system the window displays on the local workstation. All input and output is handled through the local workstation. Remember that due to restrictions of network carrying capacity, response time in the program may be slower (in some cases, much slower) than usual.

When you are finished, exit the display program normally and log out of the remote system.

Creating a Custom Shell Window

IRIX allows you to create a shell window using any colors you like from the palette on a graphics workstation. You may also select any font you prefer from the font set on your system. The *xwsh* command creates the shell window, and the options to this command control the various fonts, colors, and other features available to you. The command shell used in the window is taken by default from the */etc/passwd* file entry, or it can be specified on the command line according to the instructions in the xwsh(1) reference page.

For a complete list of the features available with xwsh, see the xwsh(1) reference page. The most commonly used features are described in the following examples.

To create a simple shell window with a dark gray background and yellow text, issue the following command:

```
xwsh -fg yellow -bg gray40 &
```

The above command generates a new window and a new shell using the colors specified. The window uses the default font selection and window size, since these attributes were not specified. The command that created the shell was placed in the background, so the shell does not tie up the window where you gave the command. You can always place a command in the background by adding the ampersand character (&) to the end of the command line. For more information on placing processes in the background, see the csh(1) reference page.

There are 100 shades of gray available. Gray0 is the darkest, and is virtually black. Gray100 is the lightest and is virtually white. The effect of selecting foreground (text) in yellow and background in gray40 is similar to yellow chalk on a gray chalkboard. For a complete list of the available colors in your palette, use the *colorview* command. This brings up a window with the list of colors in a scrollable list, and a display window to show a patch of the currently selected color.

The next example, changes the colors to black on a sky blue background (high contrast between the foreground and background makes reading the screen easier), and adds a specification for the size of the window:

```
xwsh -fg black -bg skyblue -geometry 80x40 &
```

The first number in the *geometry* option is 80, indicating that the new shell window should be 80 characters wide (this is the default). The second number indicates the desired number of lines on the screen, in this case 40. Once again, the *xwsh* command has been placed in the background by adding the ampersand character to the end of the command line.

You can make a new shell come up on your desktop as an icon by adding the **-iconic** flag to any *xwsh* command.

To select a font other than the default, you can use the on-screen font selection utility, *xfontsel*, or you can specify the font on the command line. It is a great deal easier to use the utility, as you must specify a great number of attributes for the font on the command line. Also, it frequently takes a great number of selections before you settle on a font, a weight (regular or bold, condensed or normal), and a font size that appeal to you. Using the on-screen font utility, you can preview what each selection will look like on your windows.

Once you have made your selections, you can copy and paste the font selection information and the rest of your *xwsh* command into a shell script file for convenient future use. For example, here is an *xwsh* command line that specifies the IRIS-specific font *haebfix* in a medium weight with normal spacing, 15 pixels tall. The remaining information is generated by the font selection utility for the shell.

```
xwsh -iconic -fg yellow -bg grey40 -geometry 80x40 -fn \
-sgi-haebfix-medium-r-normal--15-150-72-72-m-90-iso8859-1 &
```

Remember, you may want to create an alias for this or any other IRIX command that you use a lot. See “C Shell Shortcuts” on page 16 or your shell documentation for more information.

Note that in the shell script, the above command appears all on one line. Due to formatting constraints, the command is broken across two lines in this example.

For complete information on using the font selection utility in *xwsh* and the *xfontsel* command, see Chapter 2 of the *IRIS Utilities Guide*.

Finding and Manipulating Files Automatically

The IRIX system provides several tools for manipulating large numbers of files quickly. Some of the most common are described below:

- The find(1) utility locates files and can invoke other commands to manipulate them.
- The sed(1) program edits files using pre-determined commands.
- Many other programs have recursive options, with which you can quickly operate on files that are in many levels of subdirectories.

Using find

Use the *find* command to find files and possibly execute commands on the files found. The command starts at a given directory and searches all directories below the starting directory for the specified files. A basic *find* command line looks like this:

find . -name *filename* **-print**

This command searches the current directory and all subdirectories downward from the current directory until it finds all filenames that match *filename* and then displays their locations on your screen. The **-name** option indicates that the next argument is the name of the file you are looking for, and the **-print** option tells *find* to display the pathname of the file when the file is located.

You can also use regular expressions (see “Using Regular Expressions and Metacharacters” on page 13) in your searches.

The following command line searches for files that have been changed after the time */tmp/file* was last modified. If you use *touch* (see touch(1)) to create */tmp/file* with an old date, this command can help you find all files changed after that date.

```
find / -local -newer /tmp/file -print
```

This example shows how to locate a file, called *missingfile*, in a user’s directory:

```
find /usr/people/trixie -name missingfile -print
```

You can use *find* to locate files and then to run another command on the found files. The next example shows how to change the permissions on all the files in the current directory and in all subdirectories:

```
find . -name '*' -local -exec chmod 644 {} \;
```

The option immediately following the *find* command is a period (.). This indicates to *find* that the search is to begin in the current directory and include all directories below the current one. The next flag, **-name**, indicates the name of the files that are being found. In this case, all files in the directory structure are selected through the use of the asterisk metacharacter (*). See “Using Regular Expressions and Metacharacters” on page 13 for more information on metacharacters and regular expressions.

The **-local** option indicates to *find* that the search is limited to files that physically reside in the directory structure. This eliminates files and directories that are mounted via the Network File System (NFS®). The **-exec** option causes *find* to execute the next argument as a command, in this case *chmod 644*. The braces, { }, refer to the current file that *find* is examining.

The last two characters in the command line are part of the *chmod* command that will be executed (with the **-exec** option) on all files that match the search parameters. The backslash (\ ) is necessary to keep the shell from interpreting the semicolon (;). The semicolon must be passed along to the *chmod* process. The semicolon indicates a carriage return in the *chmod* command.

The *find* command has many other useful options; among them are:

-inum *n* Locate files by their inode number (*n*) instead of their name.

-mtime *n* Identify files that haven't been modified within a certain amount of time (*n*).

-perm [-]|*onum*
Identify files with permissions matching *onum*, an octal number that specifies file permissions. See the chmod(1) reference page. Without the minus sign (-), only file permissions that match exactly are identified.

If you place a minus sign in front of *onum*, only the bits that are actually set in *onum* are compared with the file permission flags.

-type *x* Identifies files by type, where *x* specifies the type. Types can be *b*, *c*, *d*, *l*, *p*, *f*, or *s* for block special file, character special file, directory, symbolic link, FIFO (a named pipe), plain file, or socket, respectively.

-links *n* Matches files that have *n* number of links.

-**user** *uname* Identifies files that belong to the user *uname*. If *uname* is a number and does not appear as a login name in the file */etc/passwd*, it is interpreted as a user ID.

-**group** *gname* Identifies files that belong to the group *gname*. If *gname* is a number and does not appear in the file */etc/group*, it is interpreted as a group ID.

-**size** *n* [**c**] Identifies files that are *n* blocks long (512 bytes per block). If you place a **c** after the *n*, the size is in characters.

-**ok** *cmd* Works like -*exec*, except a question mark (?) prompts you to indicate whether you want the command (*cmd*) to operate on the file that is found. This is useful for operations such as selectively removing files.

The *find* and *cpio* commands can be used to easily and safely copy a directory or a directory hierarchy as long as the user has permission to access the directory. To copy a directory with all its files, or an entire hierarchy of directories and their files, use commands like the following:

mkdir *new_directory_name*

cd *the_directory_you_want_to_copy*

find . -print | cpio -pdlmv *full_path_including_new_directory_name*

This command sequence preserves the symbolic links in the new directory as well as transparently crossing filesystem boundaries.

Automated Editing with sed

You can use *sed*, the Stream Editor, to automate file editing. The *sed* command follows an editing script that defines changes to be made to text in a file. The *sed* command takes a file (or files), performs the changes as defined in the editing script, and sends the modified file to the standard output. This command is fully described in the sed(1) reference page, as well as standard UNIX documentation.

Recursive Commands Under IRIX

Recursive commands can save you a lot of time. For example, to change the ownership of all the files and directories in a directory recursively, and all of the files and directories in all of the subdirectories below that, you can use the recursive option with chown(1):

chown -R *username directory*

Some of the other commands in the IRIX system that have recursive options are:

ls -R

rm -r

chgrp -R

If you want to use a particular command recursively, but it does not have a recursive option, you can run the command using *find*. See “Using find” on page 24.

Note that using recursive options to commands can be very dangerous in that the command automatically makes changes to your files and filesystem without prompting you in each case. The *chgrp* command can also recursively operate up the filesystem tree as well as down. Unless you are sure that each and every case where the recursive command will perform an action is desired, it is better to perform the actions individually. Similarly, it is good practice to avoid the use of metacharacters (described in “Using Regular Expressions and Metacharacters” on page 13) in combination with recursive commands. Note that with the *rm* command, you can use the **-i** option to interactively prompt you for confirmation before removing any file.

Automating Tasks With at, batch, and cron

You can use the *at*, *batch*, and *cron* utilities to automate many of your usual tasks, both as an administrator and as a user (unless user *cron* and *at* permissions have been disabled—see crontab(1)). These utilities perform similar functions. All execute commands at a later time. The difference between the commands is that *at* executes the given command at one specific time; *cron* sets up a schedule and executes the command or commands as often as scheduled; and *batch* executes the commands when system load levels permit. The following sections provide some examples of the use of these utilities. For complete information, refer to the at(1), batch(1), and cron(1M) reference pages.

at Command

If you have a task to process once at a later point in time, use *at*. For example, if you wish to close down permissions on a public directory at midnight of the current day, but you do not need to be present when this occurs, use the command string:

```
at 2400
chmod 000 /usr/public
Ctrl+D
```

It is required that the *at* command itself and the date and time of the command be placed alone on a line. When you press Enter, you do not see a prompt; *at* is waiting for input. Enter the command to be executed just as you would type it at a shell prompt. After entering the command, press Enter again and enter Ctrl+D to tell *at* that no more commands are forthcoming. You can use a single *at* command to execute several commands at the appointed time. For example, if you want to close the public directory at noon on July 14th and change the message of the day to reflect this closure, you can create the new message of the day in the file */tmp/newmesg*, and then issue the following command string:

```
at 1200 July 14
chmod 000 /usr/public
mv /etc/motd /etc/oldmotd
mv /tmp/newmesg /etc/motd
Ctrl+D
```

By default, any output of commands executed using *at* is mailed to the executing user through the system electronic mail. You can specify a different location for the output by using the standard output redirects, such as pipes (|) and file redirects (>). See your command shell documentation for a complete description of redirecting the standard output.

For complete information on the *at* command, see the at(1) reference page.

batch Command

The *batch* command works just like the *at* command, except that you do not specify a time for the command or commands to be executed. The system determines when the overall load is low enough to execute the commands, and then does so. As with all other *cron* subsystem commands, the output of the commands is mailed to you unless you specify otherwise. *batch* is useful for large CPU-intensive jobs that slow down the system or cripple it during peak periods. If the job can wait until a non-peak time, you can place it on the *batch* queue until the system executes it. For complete information on the *batch* command, see the batch(1) reference page.

cron Command

If you want a command to execute regularly on schedule, the *cron* command and subsystem provide a precise mechanism for scheduled jobs. The *at* and *batch* commands are technically part of the *cron* subsystem and use *cron* to accomplish their tasks. The *cron* command itself, though, is the most configurable command of the subsystem.

You use *cron* by setting up a *crontab* file, where you list the commands you would like to have executed and the schedule for their execution. Complete information on setting up your *crontab* file is available in the cron(1M) and crontab(1) reference pages.

The *cron* facility is useful for scheduling network backups, checking the integrity of the password file, and any other regular tasks that do not require interaction between you and the system. By default, *cron* mails the results or output of the command to the user who submitted the *crontabs* file, so if you use *cron* to schedule something like a pwck(1M), the results of the test are mailed to you and you can interpret them at your convenience.

Note that you must restart *cron* after each change to a *crontabs* file, whether made through the *cron* utility or the *at* command, for the changes to take effect.

As administrator, you can control access to the *at* and *batch* commands by using the *cron.allow*, *cron.deny, at.allow*, and *at.deny* files in */etc/cron.d*. Specific users or all users can be denied use of the commands. Refer to the reference pages for at(1) and crontab(1) for more information.

/etc/nologin File

The */etc/nologin* file prevents any user from logging in. This feature of the login(1) program is designed to allow the system administrator to have the system running in full multiuser mode, but with no users logged in. This is useful when you want to perform complete backups of the system or when you want to do some testing that may cause the operating system to halt unexpectedly. Of course, it is always best to do this sort of work during non-peak system usage hours.

To disable logins, simply create a file called *nologin* in the */etc* directory. (You must be logged in as root to create files in */etc*.) In addition to disallowing logins, the *login* program displays the contents of */etc/nologin* when it denies access to the user. To allow logins again, simply remove the */etc/nologin* file. A suggested format for the message in */etc/nologin* is:

```
The system is unavailable for a few moments while we perform some
routine maintenance. We will be done shortly and regret any
inconvenience this may cause you. -Norton
```

Using Mouse Shortcuts

The system hardware for graphical workstations (and some X-terminals) can provide you with shortcuts. These may not be available to server administrators who rely solely on character-based terminals for their administration. Using the graphics console of your system, you can cut and paste between windows without using pulldown or popup menus of any sort. Using the popup menu, you can manipulate windows completely.

You can customize the action of your mouse buttons. All examples in this section assume the default mouse button meanings are used. If you have modified your mouse action, you must allow for that modification before you use these techniques.

For complete information on using the pop-up windows, see the online *IRIS Essentials* book.

Using the Mouse to Copy and Paste Text

The most common mouse shortcut is to cut/copy and paste between windows on your screen. Here is how you do it:

1. Find the cursor controlled by your mouse on your screen. It should appear as a small arrow when it is positioned in the working area of one of your windows, or as some other figure when it is positioned on the frame of a window or in the working area of an application's window. If you can't locate the cursor immediately, move the mouse around a bit and look for motion on your screen. You should find the cursor easily.

2. Place the cursor at the beginning of the text you wish to paste between windows and press the leftmost key on the top of the mouse. Now, keeping the mouse button pressed, move the cursor to the end of the text you wish to paste. The text highlights to show it is selected. If you are selecting a large section of text, it is not necessary to move the cursor over every space. You may move the cursor directly to the end point and all intervening text is selected. It is not possible to select “columns” of text or several disconnected pieces of text at once. When you have moved the cursor to the desired end point, release the mouse button. The text remains highlighted.
3. Now move the cursor to the window you want to paste the text into and make certain the window is ready to receive the pasted text. For example, if you are pasting a long command line, make certain that there is a shell prompt waiting with no other command already typed in. If the pasted matter is text into a file, make certain that the receiving file has been opened with an editor and that the editor is in a mode where text can be inserted.
4. To paste the text, place the cursor in the receiving window and press the middle mouse button once quickly. Each time you press the middle button, the selected text is pasted into the receiving window. Sometimes it takes a moment for the text to appear, so be patient. If you press the button several times before the text appears, you will paste several copies of your text.
5. You can also paste your selected text in the bottom of a window (including the window from which you selected the text). Press the rightmost mouse button while the cursor is in that window and choose the Send option from the popup menu that appears.

The text you originally selected remains selected until you select new text somewhere else or until you place the cursor back in the original window and click once on the leftmost mouse button.

Using the Mouse to Create a New Shell Window

If you need a new shell window, you can use the mouse to create one. Follow these steps:

1. With the cursor in a shell window, press and hold the rightmost button on your mouse. A popup menu appears:

Figure 2-1 Shell PopUp Menu

2. The last item on the popup menu is the Clone option. There is a small triangle to the right of this option. This triangle indicates that there is a submenu available with choices. While keeping the button on the mouse pressed, move the mouse down until the Clone option is highlighted and the submenu pops up, showing various shell window cloning options. These options create another shell window functionally identical to the one in use. This is why the option is called cloning. The text and background colors of the current window are carried forward to the cloned window, and the selections in the sub-menu specify the number of lines in the new window. You can choose to have the same number of lines in the cloned window as in the current window, or to have 24, 40, or 60 lines.

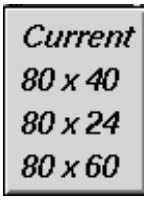

Figure 2-2 Shell Window Cloning Submenu

3. Choose the size you want by moving the mouse down the options and releasing the mouse button when the option you desire is highlighted. The new window appears on your screen. You may repeat this process as often as you like on any shell window.

Creating New Reference Pages

Reference pages are online IRIX command descriptions. A full set of reference pages for the programs, utilities, and files in the standard IRIX distribution is provided online, and these pages are available through the man(1) command. In addition, you can create your own custom reference pages using the following procedure. Any time you create a script, utility, program, or application for your users, you should also create a reference page. This provides a convenient way for your users to learn to use your new tools, and also makes future maintenance easier.

Not all sites have the optional Documenter's Workbench™ software product installed, but you can create a facsimile of a reference page using only the text editor of your choice. See the following section for details.

Creating a Pure-Text Reference Page

Note: To create a pure-text reference page without Documenter's Workbench (no embedded *nroff* commands that would format the text) simply use the *vi* editor (or the editor of your choice) and document your script or program according to the style found in the standard reference pages. Name your reference page file after the script or program it documents with the suffix **.l** to designate the page as a local reference page.

Note: Use the letter "l" as your suffix, not the numeral one "1."

When you have completed your reference page, you must place it in the */usr/man* directory structure for the *man* command to be able to display the new page. Place the reference pages in a local directory, such as */usr/man/manl*. (Again, use the **l** to designate local reference pages.) If the directory does not already exist, create it with this command (you must be logged in as root):

```
mkdir /usr/man/manl
```

Long reference pages should be packed to save disk space. Use the *pack* command to pack the text file into a more compact form. For example, to pack the reference page you made for a user script called "program", enter:

```
pack program.l
mv program.l.z /usr/man/manl/program.l.z
```

Note: The *man* program automatically unpacks the pages for reading.

Test your reference page with the command:

```
man l program
```

The command should display the reference page specified (this assumes that */usr/man* is in your $MANPATH environment variable.) For more information, refer to the man(1) reference page.

Individual System Monitoring Tools

IRIX provides a set of detailed programs to assist you in debugging potential system problems. This software is briefly described here. Complete documentation is available in the relevant reference pages and through the help system files and release notes distributed with the software. The *savecore*, *icrash*, *fru*, and *sysmon* software work together to provide a picture of what happens to your system in an error condition that results in an operating system crash.

savecore Utility

Your system may or may not automatically save the image of system memory (if possible) at the time of a crash depending on the *chkconfig* setting for *savecore*. Here is what happens depending upon the two possible settings to *savecore*:

- savecore on—The system attempts to automatically save the image of system memory at a system crash. The image is stored in */var/adm/crash/vmcore.N*, where *N* is a sequential number assigned to the most recent core file. A successful dump may then be studied with the *icrash* utility described below.
- savecore off —A core dump is not saved by the system The *icrash* utility may still be run on */unix* and */dev/swap* in order to get a report of what happened when the system crashed. In this case, systems do not have to use the disk space on a core dump in order to get a report.

To determine the current status of the **savecore** option, enter:

```
chkconfig | grep savecore
```

The default setting is `savecore on`.

Refer to savecore(1M) and the discussion of *icrash* below for more information.

icrash Utility

The icrash(1M) utility interactively generates detailed kernel information in an easy-to-read format. The *icrash* command can also generate reports about system crash dumps created by *savecore*.

Two report files are created when *icrash* runs, with *N* being the bounds number for the core dump:

analysis.N An analysis of the core dump is created containing items of interest, such as the *putbuf* dump, *fru* information, stack traces, and so on. This is a verbose description of what happened when the system crashed, and it is meant to be used to perform a preliminary analysis of the system before any hardware or software changes are made. See the icrash(1M) reference page for more information.

summary.N The summary report contains the panic string, the crash time, and the *fru* information in one file for *availmon*. See the availmon(1M) reference page for more information.

Depending on the type of system crash dump, *icrash* can create a unique report that contains information about what happened when the system crashed. The *icrash* command can be run on both live systems or with any namelist file and *core* file specified on the command line. The namelist file must contain symbol table information needed for symbolic access to the system memory image being examined.

Each version of *icrash* is specific to the operating system release that it came from, and does not work on any other operating system release. Do not copy *icrash* to any other IRIX system unless the operating system versions are identical (including patch levels). Running *icrash* on a live system can sometimes generate random results, as the information being viewed is volatile at the time it is displayed.

A brief list of some of the functionality that *icrash* offers:

- System crash reports created on system panics
- Field replacement unit (FRU) information provided with each crash on eligible hardware
- Direct access to a broad list of kernel structures
- Disassembly of kernel functions
- Documented set of commands (see the *help* system within *icrash*)
- Command-line editing and history

fru (Field Replacement Unit) Analyzer

The *fru* (Field Replacement Unit) command (described fully in the fru(1M) reference page) displays field replacement unit analysis on Challenge® L and XL, Onyx® L and XL, and POWER CHALLENGE™ and POWER Onyx™ systems only. The program considers the hardware state during an error situation and attempts to determine if the error results from faulty hardware. The analysis is based on the hardware error state created in the kernel crash dump. If no hardware error state is dumped, no *fru* analysis is displayed.

Each board is analyzed separately based on the hardware error state. After the analysis is completed, the board (or boards) with the highest confidence levels is displayed. Currently the boards analyzed include the IO4, MC3, IP19, and IP21. Note that you should also check the version of *fru* output from release to release, because later versions may report a different analysis.

When a confidence level is displayed, it is based on the amount of confidence that the *fru* analyzer has in the board listed as being the problem. Note that there are only a few levels of confidence, and it is important to recognize what the percentages mean:

10%	The board was witnessed in the hardware error state only.
30%	The board has a possible error, with a low likelihood.
40%	The board has a possible error, with a medium likelihood.
70%	The board has a probable error, with a high likelihood.
90%	The board is a definite problem.
95%	The board is a definite problem, an exact error match.

There is a possibility of multiple boards being reported, so the field engineer must be cautious when deciding to replace boards. For example, if two boards are reported at 10%, that is not enough confidence that the boards listed are bad. If there is one board at 70% or better, there is a good likelihood that the board listed is a problem, and should be replaced. Boards at 30% to 40% are questionable, and should be reviewed based on the frequency of the failure of the specific board (in the same slot) between system crashes.

The objective of *fru* is to uncover real hardware problems, rather than to replace boards at random. Each *icrash* report for each kernel core dump on an eligible system has a *fru* analysis in it, which should be reviewed by field engineers before any boards are replaced.

Below are some *fru* output examples. Please note that each *fru* command output below comes from a unique core dump. Your output is likely to vary significantly:

```
>> fru

   FRU ANALYZER (2.0.1):
   ++ PROCESSOR BOARD
   ++   IP21 board in slot 2: 40% confidence.
   ++ END OF ANALYSIS

>> fru

   FRU ANALYZER (1.6.5):
   ++ MEMORY BOARD
   ++   MC3 board in slot 1: 70% confidence.
   ++ END OF ANALYSIS

>> fru

   FRU ANALYZER (1.6.5):
   ++ CPU slice 3 (CC CHIP)
   ++  and/or Integral component (A CHIP)
   ++   on the IP19 board in slot 5: 40% confidence.
   ++ CPU slice 3 (CC CHIP)
   ++  and/or Integral component (A CHIP)
   ++   on the IP19 board in slot 7: 40% confidence.
   ++ CPU slice 2 (CC CHIP)
   ++  and/or Integral component (A CHIP)
   ++   on the IP19 board in slot 9: 40% confidence.
   ++ CPU slice 3 (CC CHIP)
   ++  and/or Integral component (A CHIP)
   ++   on the IP19 board in slot 11: 40% confidence.
   ++ END OF ANALYSIS

>> fru

   FRU ANALYZER (2.0.1):  No errors found.
```

sysmon System Log Viewer

The *sysmon* utility is part of the Desktop System Monitor. It can be launched from the System menu by choosing View System Log. You see a window similar to that shown in Figure 2-3:

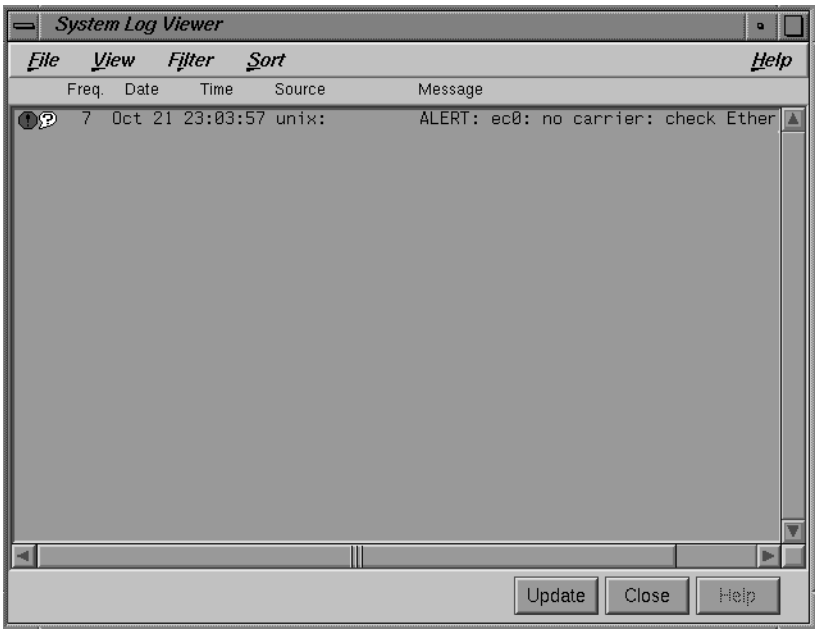

Figure 2-3 sysmon System Log Browser

You can choose View, Filter and Sort options through the pulldown menus on this window. Your selections are saved in your *$HOME/.sysmonrc* file. For additional information on these options, consult the online help available through this window or the *sysmon* Release Notes.

The *sysmon* utility allows a user to browse the system log file (*/var/adm/SYSLOG*). The 8 SYSLOG priorities (see the syslog(3B) reference page) are simplified into 4 priority levels.

Table 2-2 shows how SYSLOG priorities map into the *sysmon* simplified priority scheme:

Table 2-2 sysmon Priority Table

sysmon Priority	SYSLOG Priority	Numerical Priority
CRITICAL	LOG_EMERG	0
CRITICAL	LOG_ALERT	1
ERROR	LOG_CRIT	2
ERROR	LOG_ERR	3
WARNING	LOG_WARNING	4
WARNING	LOG_NOTICE	5
INFO	LOG_INFO	6
INFO	LOG_DEBUG	7

Monitoring Systems With availmon

The availability monitor (described completely in the availmon(5) reference page) is a software package that together with *icrash* and the FRU analyzer, provides a technology platform for system availability and diagnostic data gathering and distribution.

The *availmon* system collects system availability information and crash diagnosis information. The availability information can be used to evaluate system reliability and availability. The crash diagnosis information is an automated aid to debugging.

The *availmon* software is embedded in the system boot and shutdown processes. The software is capable of differentiating controlled shutdowns, system panics, system hangs, power cycles, and power failures. Your system's uptime is estimated by a daemon process, and diagnostic information is collected from icrash(1M), */usr/adm/SYSLOG*, and sysmon(1M), hinv(1M), versions(1M), and gfxinfo(1G). All aspects of *availmon* operation are fully configurable.

You can choose to participate in a system availability database that assists Silicon Graphics support in providing reliable service. All availability and diagnostic data for cooperating systems will be maintained in an Silicon Graphics database which provides overall reliability data, and specific histories for individual participating systems. This is the primary function of *availmon*.

Registering and Configuring availmon

You must issue the *amregister* command to set up *availmon* configuration, turn on **autoemail**, and register your system with the Silicon Graphics Availmon Database.

To register your system, log in as *root* and issue the command:

```
/usr/etc/amregister -r
```

Depending on your system type, you may need to enter the serial number of your system by hand. See the amregister(1M) reference page for further information.

The *availmon* software is enabled through the chkconfig(1M) command, described in "Checking Options With chkconfig" on page 70. The flags are:

availmon Controls the activation of the entire availmon software package. By default, this option is on.

The other configuration flags are set using the *amconfig* utility, which is similar to *chkconfig*, but uses a different record file. There are four flags:

autoemail Enables automatic distribution of reports. By default, this option is off, but is turned on by *amregister*.

hinvupdate Enables a daemon that checks for changes reported by *hinv* and *gfxinfo*. By default, this option is on for large systems and off for all others.

shutdownreason
Directs the system to query the Superuser for a reason for each system shutdown. By default, this option is on for large systems and off for all others.

tickerd Enables the daemon that monitors system uptime. By default, this option is on for large systems and off for all others.

There is also an e-mail list configuration file, */var/adm/avail/config/autoemail.list*, used to control the report type, e-mail format, and e-mail addresses for *availmon* reports. The e-mail list is edited and maintained through the *amconfig* command. By default, this file is configured to send diagnosis reports to Silicon Graphics.

For sites with multiple systems participating, the *amconfig* command can be executed on one system to set up a common e-mail configuration file (*/var/adm/avail/autoemail.list*), and then this file can be copied onto all participating systems. Then run *amregister -r* on each system.

Configuring an availmon Site Log File

If you want a site log file for one or more systems, a pseudo e-mail alias can be created. This alias pipes availability reports to *amreceive*, whose output is then appended to the site log file. This procedure should be done before registering all the systems, because initial availability reports are sent out when registering.

After setting up *availmon*, *amreport* can be executed on each system to view the availability statistics and reports for that system, or it can be run with the site log file as input to view overall availability statistics for all systems, and availability reports for any system.

If you want a site log file, perform the following steps in order:

1. Create an e-mail alias on one system and pipe all availability reports to *amreceive*. For example, if the site log file is */disk/amrlog*, add this line to the mail server system's */etc/aliases* file:

   ```
   amrlog: "| /var/adm/avail/amreceive >> /disk/amrlog"
   ```

   and then run the *newaliases* command to set up this e-mail alias.

2. Run the *amconfig* command on the mail server system to configure the standard e-mail lists. For this example log file, add the entry:

   ```
   availability(text): amrlog
   ```

   Then, copy the resulting */var/adm/avail/config/autoemail.list* on this system to the rest of the systems at your site.

3. Run *amregister* to register all your systems as described in “Registering and Configuring availmon” on page 40.
4. Run the command:

   ```
   amreport -s  /disk/amrlog
   ```

   It shows the overall statistics, system statistics, and individual availability reports for all participating systems.

Running availmon on Other Systems

The *availmon* software is part of your standard IRIX distribution. The *availmon* software on your distribution may not work with some older releases of IRIX.

Administering availmon

Three examples are provided to illustrate the administration of *availmon*. One is for general customers who send reports out automatically; the other two are for secure sites with and without internal report sending.

Using availmon With Automatic Reporting

If *availmon* is installed on a single system, reboot the system after installation. Then, run *amregister* without any argument to register and configure the e-mail lists. This turns on **autoemail** and sends registration reports to all configured addresses when complete. If your system does not have an IP19, IP21, IP22, or IP25 processor, *amregister* prompts you to input your system’s serial number manually.

The **shutdownreason** and **tickerd** configuration options can be turned on or off anytime. The default *autoemail.list* is:

```
availability(compressed,encrypted):
availability(compressed):
availability(text):
diagnosis(compressed,encrypted): availmon@csd.sgi.com
diagnosis(compressed):
diagnosis(text):
```

In addition, you may want to add the following entries:

```
availability(text): local_sysadmin
diagnosis(compressed,encrypted): local_support
```

In the above optional entries, replace the strings <local_sysadmin> and <local_support> with the appropriate e-mail addresses for your system administrator and Silicon Graphics support representative, respectively.

If encrypted data in e-mail is prohibited by law at your site, move addresses in "(compressed,encrypted)" entries to "(compressed)" entries.

Using availmon at Secure Sites With Internal Report Mailing

If your site is under security restrictions, you may use the following procedures to set up and use *availmon*. The setup procedure is similar to that found in "Registering and Configuring availmon" on page 40, except that the addresses outside your site should be deleted.

After your system administrators receive *availmon* reports, they can check the latest diagnosis report, */var/adm/crash/diagreport*, on the system just rebooted, delete sensitive data, and use *amsend* to mail the filtered report to *availmon@csd.sgi.com* and to any Silicon Graphics support address they require. If the diagnosis report contains any *icrash*, *syslog*, *hinv*, *versions*, or *gfxinfo* data, use the command:

```
amsend -i -z -x availmon@csd.sgi.com ...
```

to mail the report. If there is no such data in the report, use the command:

```
amsend -d -z -x availmon@csd.sgi.com ...
```

If encrypted data in e-mail is prohibited by law at your site, remove **-x** from the command line.

Using availmon at Secure Sites Without Report Mailing

If outside report mailing is not possible at your site, no special actions need to be taken to use *availmon*. However, for those platforms not using IP19, IP21, IP22, and IP25 processors, *amregister* should still be run and then you should turn off **autoemail** so that reports generated on these systems are not sent automatically. The **shutdownreason** and **tickerd** options can also be turned on or off as you choose.

Since no external report is mailed after the system reboots, system administrators need to check if the system has been down, and then check the report files to determine the reason. If the system crashes more than once before checking, old reports are overwritten by the new ones (core dumps and *icrash* reports are kept until removed explicitly). Therefore, internal report mailing is recommended for secure sites.

Diagnosis reports can be sent to Silicon Graphics using *amsend*. See the section titled "Using availmon at Secure Sites With Internal Report Mailing." Another method is to run *amconfig* to configure standard e-mail lists so that when reports need to be sent, *amnotify* can be used to send reports according to those lists.

availmon Reports

There are two types of reports produced by *availmon*: availability and diagnosis. Availability reports consist of system start time, stop time, stop reason, uptime, re-start time, and a summary of the likely reason for any system crash (where relevant). A standard availability report is shown here:

```
------------------------------ whizkid ---------------------------
Report Version ......... 0.1
Internet Address ....... whizkid
Reason for Shutdown .... Hang
Started at ............. Mon Oct  3 16:56:08 1994
Stopped at ............. Unknown instant
Uptime ................. 4304 minutes (2 days 23 hrs 44 mins)
------------------------------------------------------------------
Press <enter> to display summary ...
```

When you press Enter, you see information similar to the following:

```
======================= SUMMARY for whizkid ==========================
Controlled Shutdowns ... 0
Hangs .................. 1
Panics ................. 0
Average Uptime ......... 2189 minutes (1 day 12 hrs 29 mins)
Least Uptime ........... 74 minutes (1 hr 14 mins) (*)
Most Uptime ............ 4304 minutes (2 days 23 hrs 44 mins)
Availability ........... 0.7870%
Logging started at ..... Mon Oct  3 16:56:08 1994
System has been up for . 74 minutes (1 hr 14 mins)
Last boot at ........... Tue Oct 24 23:03:44 1995
======================================================================
```

Diagnosis reports additionally contain *icrash* analysis report (including the FRU analyzer result), important *syslog* messages, and system hardware / software configuration and version information.

Availability information is permanently stored in */var/adm/avail/availlog*. Files in */var/adm/avail* are maintained by *availmon* and should not be deleted, modified, or moved. The most recent availability and diagnostic reports are stored in */var/adm/crash/availreport* and */var/adm/crash/diagreport*, and should be treated comparably to core dumps.

Mailing availmon Reports

There are two ways to configure the sending of *availmon* reports: automatic or manual. If you select automatic mailing, you can configure any number of recipients for each type of report. The recommended configuration is to send diagnosis reports to the Silicon Graphics Availmon Database and to Silicon Graphics Field Service, and to send availability reports to your local system administration team. You can also send copies of all reports to a local log account.

If you select manual mailing, the two types of reports are created in the directory */var/adm/crash*. You can then edit or filter the reports, and use the *amsend* command to send the approved reports.

The *availmon* software can be configured to compress and encode data. The receiving agent (using the *amreceive* command) decodes, uncompresses, and stores the data in a database at Silicon Graphics. Data encryption is recommended if it is not prohibited at your site.

Viewing availmon Reports

The amreport(1M) utility is provided to review *availmon* reports and to provide statistical availability information. This program can process local availability log files or received aggregate availability reports (such as a site log file) from different systems.

The *amreport* utility shows the statistical reports and availability reports hierarchically from overall statistics for all systems, a table of statistics for all systems (however, if the input is a local log file, information for all systems is not provided), statistics for each system, a table of all reboot instances for each system, and availability reports for each system. See the amreport(1M) reference page for full information on this utility.

Chapter 3

System Startup and Shutdown

Chapter 3 covers the tasks of starting up and shutting down the IRIX operating system. The following topics are covered:

- Starting the System
- Shutting Down the System
- IRIX Operating Levels—how to set and use the system operating levels

Chapter 3

System Startup and Shutdown

This chapter describes the procedures for starting and stopping your system, bringing your system to the various default levels of operation, and creating your own custom levels of operation. The main sections are:

- Starting an IRIX system. See “Starting the System” on page 49.
- Shutting down an IRIX system. See “Shutting Down the System” on page 50.
- Definition of the operating system run levels; how they are controlled and how to change them. See “IRIX Operating Levels” on page 52.

Starting the System

To start up a system, follow these steps:

1. Make sure all cables (such as power, display monitor, and keyboard) are properly connected. See your owner’s guide and hardware guide for complete information about cabling your particular workstation or server.
2. Turn on the power switches on the display monitor (or console terminal) and the computer.

   The computer runs power-on diagnostics and displays some copyright messages and some system startup information. These messages appear on the *console* screen or on the screen of a *diagnostics terminal* (an ASCII terminal connected to the first serial port) of a server. A copy of these messages is also written to the */var/adm/SYSLOG* file in case you miss them.

   If you are restarting the system after a power loss or other unexpected shutdown, you may see an error message regarding your SCSI bus or other hardware problem. This may be a temporary condition based on the disks’ need to spin up to speed, or the SCSI bus may simply need a moment to reset itself. Wait 30 seconds and attempt to boot the operating system again.

If the operating system determines that the filesystems need checking, it checks them with the *fsck* program (EFS only). *fsck* fixes any problems it finds before the operating system mounts the filesystems. *fsck* will run if the system is not shut down properly, such as in the event of a power failure. For information about using *fsck*, see the *IRIX Admin: Disks and Filesystems* guide and the fsck(1M) reference page. Note that it is not necessarily a problem if *fsck* runs, it is merely a precaution.

The system now comes up in multiuser mode and you can log in. You should leave your system running at all times. The IRIX operating system works best when it is allowed to run continuously, so that scheduled operations and "housekeeping" processes can be performed on schedule.

Shutting Down the System

This section describes how to turn off a workstation or server from multiuser or single-user mode.

Shutting Down From Multiuser Mode

To shut down the system from multiuser mode:

1. Use the who(1) command to determine which users are logged in to the operating system, if any:

   ```
   who
   ```

   Notify any users that the system is shutting down. Issue the wall(1M) command:

   ```
   wall
   ```

   Enter your message. For example, you might enter:

   ```
   There is a problem with the building's power system.
   I will be shutting down the system in 10 minutes.
   Please clean up and log off.
   Sorry for the inconvenience,
   norton
   ```

2. When you finish entering your message, type Ctrl+D. The message is sent to all users on the system. They see something like this:

   ```
   Broadcast Message from root Tue Oct 17 17:02:27...
   There is a problem with the building's power system.
   I will be shutting down the system in 10 minutes.
   Please clean up and log off.
   Sorry for the inconvenience,
   norton
   ```

3. Enter the */etc/shutdown* command:

   `/etc/shutdown -y -i0 -g600`

   The above command specifies a 10 minute (600 second) grace period to allow users to clean up and log off. The other flags indicate that the system is to be completely shut down (**-i0**) and that the system can assume that all answers to any prompts regarding the shutdown are "yes" (**-y**). You see the following message:

   ```
   Shutdown started. Fri Aug 28 17:10:57...
   Broadcast Message from root (console) Fri Aug 28 17:10:59
   The system will be shut down in 600 seconds.
   Please log off now.
   ```

   After ten minutes, you see this message:

   ```
   INIT: New run level: 0
   The system is coming down. Please wait.
   ```

   The Command Monitor prompt or System Maintenance menu appears. Wait for a Command Monitor prompt or System Maintenance menu to appear before turning off power to the workstation or you may damage your hard disk.

4. Turn off the power.

For more information on shutting down the system, see the halt(1M) and shutdown(1M) reference pages. Remember: Shut down the system only when something is wrong or if modifications to the software or hardware are necessary. IRIX is designed to run continuously, even when no users are logged in and the system is not in use.

Turning Off From Single-User Mode

If the system is in single-user mode, follow these steps:

1. Use the *shutdown* command to turn off the system and guarantee filesystem integrity. As root, enter the command:

   shutdown -y -i0 -g0

   where:

   -y assumes yes answers to all questions, **-i0** goes to state 0 (System Maintenance Menu), and **-g0** allows a grace period of 0 seconds.

   You see a display similar to this one:

   ```
   Shutdown started. Fri Aug 28 17:11:50 EDT 1987
   INIT: New run level: 0
   The system is coming down. Please wait.
   ```

   The system stops all services and the Command Monitor prompt or System Maintenance Menu appears.

   Wait for the Command Monitor prompt or System Maintenance menu to appear or for a message that the system can be powered off before turning off power to the computer. Doing so prematurely may damage your hard disk.

2. Turn off power to the computer.

IRIX Operating Levels

The IRIX system can run in either single-user or multiuser mode. In single-user mode, only a few processes are active on the system, no graphics are available, and only a single login is allowed. In multiuser mode, there can be multiple login sessions, many files open at once, and many active processes, including numerous background daemons.

The *init* program controls whether the system is in the multiuser or single-user state. Each possible state that the system can be in is assigned a label, either a number or a letter. The shutdown state is state *0*. Single-user mode is state *s*.

Multiuser state labeling is more complex, because there can be great variations in multiuser states. For example, in one multiuser state, there can be unlimited logins, but in another state there can be a restricted number of logins. Each state can be assigned a different number.

The state of the system is controlled by the file */etc/inittab*. This file lists the possible states, and the label associated with each.

When you bring the system to standard multiuser mode, *init* state 2, the following happens:

- The filesystems are mounted.
- The *cron* daemon is started for scheduled tasks.
- Network services are started, if they are turned on.
- The serial-line networking functions of *uucp* are available for use.
- The spooling and scheduling functions of the *lp* package (if it is added to the system) are available for use.
- Users can log in.

Not all activities can or should be performed in the multiuser state. Some tasks, such as installing software that requires the miniroot and checking filesystems must be done with the system in single-user mode.

There are many synonyms for the system state. These include:

- init state
- run state
- run level
- run mode
- system state

Likewise, each system state may be referred to in a number of ways; for example, single-user mode may be called:

- single user
- single-user mode
- run level 1

Table 3-1 shows the various possible states of the operating system as it is shipped. You can, of course, create your own custom states.

Table 3-1 System States

Run Level	Description
0	Power-off state.
1, s, or S	Single-user mode is used to install / remove software utilities, run filesystem backups / restores, and check filesystems. This state unmounts everything except root, and kills all user processes except those that relate to the console.
2	Multiuser mode is the normal operating mode for the system. The default is that the *root* (*/*) and user (*/usr*) filesystems are mounted in this mode. When the system is powered on, it is put in multiuser mode.
6	Reboot mode is used to bring down the system and then bring it back up again. This mode is useful when you are changing certain system configuration parameters.

How init Controls the System State

The *init* process is the first general process created by the system at startup. It reads the file */etc/inittab*, which defines exactly which processes exist for each run level.

In the multiuser state (run level 2), *init* scans the file for entries that have a tag (also 2) for the run level and executes everything after the third colon on the line containing the tag. For complete information, see the inittab(4) reference page.

The system */etc/inittab* looks something like this:

```
is:2:initdefault:
fs::sysinit:/etc/bcheckrc </dev/console >/dev/console 2>&1
mt::sysinit:/etc/brc </dev/console >/dev/console 2>&1
s0:06s:wait:/etc/rc0 >/dev/console 2>&1 </dev/console
s1:1:wait:/etc/shutdown -y -iS -g0 >/dev/console 2>&1 </dev/console
s2:23:wait:/etc/rc2 >/dev/console 2>&1 </dev/console
s3:3:wait:/etc/rc3 >/dev/console 2>&1 </dev/console
or:06:wait:/etc/umount -ak -b /proc,/debug > /dev/console 2>&1
of:0:wait:/etc/uadmin 2 0 >/dev/console 2>&1 </dev/console
RB:6:wait:echo "The system is being restarted." >/dev/console
rb:6:wait:/etc/uadmin 2 1 >/dev/console 2>&1 </dev/console
#
```

This display has been edited for brevity; the actual */etc/inittab* file is lengthy. If */etc/inittab* is removed by mistake and is missing during shutdown, *init* enters the single-user state (*init s*). While entering single-user state, */usr* remains mounted, and processes not spawned by *init* continue to run. Immediately replace */etc/inittab* before changing states again. The format of each line in *inittab* is:

id:*level*:*action*:*process*

where:

- *id* is one or two characters that uniquely identify an entry.
- *level* is zero or more numbers and letters (0 through 6, s, a, b, and c) that determine in what *level*(s) *action* is to take place. If *level* is null, the *action* is valid in all levels.
- *action* can be one of the following:
  - **sysinit**

    Run *process* before *init* sends anything to the system console (Console Login).
  - **bootwait**

    Start *process* the first time *init* goes from single-user to multiuser state after the system is started. (If **initdefault** is set to 2, the process runs right after the startup.) *init* starts the process, waits for its termination and, when it dies, does not restart the process.
  - **wait**

    When going to *level*, start *process* and wait until it has finished.

  - **initdefault**

    When *init* starts, it enters *level*; the *process* field for this *action* has no meaning.

  - **once**

    Run *process* once. If it finishes, don't start it again.

  - **powerfail**

    Run *process* whenever a direct power-off of the computer is requested.

  - **respawn**

    If *process* does not exist, start it, wait for it to finish, and then start another.

  - **ondemand**

    Synonymous with *respawn*, but used only with *level* a, b, or c.

  - **off**

    When in *level*, kill *process* or ignore it.

- *process* is any executable program, including shell procedures.
- # can be used to add a comment to the end of a line. *init* ignores all lines beginning with the # character.

When changing levels, *init* kills all processes not specified for that level.

Entering the Multiuser State from System Shutdown

When your system is up and running, it is usually in multiuser mode. It is only in this mode that the full power of IRIX is available to your users.

Powering On the System

When you power on your system, it enters multiuser mode by default. (You can change the default by modifying the **initdefault** line in your *inittab* file.) In effect, going to the multiuser state follows these stages (see Table 3-1 on page 54):

1. The operating system loads and the early system initializations are started by *init*.
2. The run-level change is prepared by the */etc/rc2* procedure.
3. The system is made public through the spawning of *getty* processes along the enabled terminal lines and, for networked systems, network access is enabled.

Early Initialization

Just after the operating system is first loaded into physical memory through the specialized boot programs that are resident in the PROM hardware, the *init* process is created. It immediately scans */etc/inittab* for entries of the type *sysinit*:

```
fs::sysinit:/etc/bcheckrc </dev/console >/dev/console 2>&1
mt::sysinit:/etc/brc </dev/console >/dev/console 2>&1
```

These entries are executed in sequence and perform the necessary early initializations of the system. Note that each entry indicates a standard input/output relationship with */dev/console*. This establishes communication with the system console before the system is brought to the multiuser state.

Preparing the Run-Level Change

Now the system is placed in a particular run level. First, *init* scans the table to find an entry that specifies an *action* of the type **initdefault**. If it finds one, it uses the run level of that entry as the tag to select the next entries to be executed. In the example */etc/inittab*, the **initdefault** entry is run level 2 (the multiuser state):

```
is:2:initdefault:
s2:23:wait:/etc/rc2 >/dev/console 2>&1 </dev/console
co:23:respawn:/etc/gl/conslog
t1:23:respawn:/etc/getty -s console ttyd1 co_9600 #altconsole
t2:23:off:/etc/getty ttyd2 co_9600 # port 2
t3:23:off:/etc/getty ttyd3 co_9600 # port 3
t4:23:off:/etc/getty ttyd4 co_9600 # port 4
```

The other entries shown above specify the actions necessary to prepare the system to change to the multiuser run level. First, */etc/rc2* is executed which executes all files in */etc/rc2.d* that begin with the letter S (see “Run-Level Directories” on page 58 for more information). When */etc/rc2* is executed, it accomplishes (among other things) the following:

- Sets up and mounts the filesystems
- Starts the *cron* daemon
- Makes *uucp* available for use
- Makes the line printer (*lp*) system available for use, if installed
- Starts accounting, if installed and configured to be on
- Starts networking, if installed and configured to be on

- Starts *sar*, if installed and configured on
- Starts the mail daemon
- Starts the system monitor

init then starts a *getty* for the console and starts *getty* on the lines connected to the ports indicated.

At this point, the full multiuser environment is established, and your system is available for users to log in.

Changing Run Levels

To change run levels, the system administrator can use the telinit(1M) command that directs *init* to execute entries in */etc/inittab* for a new run level. Then key procedures, such as *shutdown*, */etc/rc0*, and */etc/rc2*, are run to initialize the new state. The *telinit* command is executed in the scripts *single*, *multi*, and *reboot*.

For example, to go from single-user mode to multiuser mode, enter:

```
multi
```

Refer to multi(1M), single(1M), and reboot(1M) for more information.

Note that the preferred method to change to a lower run state, such as single-user mode, is described in “Going to Single-User Mode From Multiuser Mode” on page 60.

The new state is reached. If it is state 1 (single-user mode), the system administrator can continue.

Run-Level Directories

Run levels 0, 2, and 3 each have a directory of files that are executed in transitions to and from that level. These directories are *rc0.d*, *rc2.d*, and *rc3.d*, respectively. All files in these directories are linked to files in */etc/init.d*. The run-level filenames look like this:

S*NN*name

or

K*NN*name

The filenames can be split into three parts:

S or K	The first letter defines whether the process should be started (**S**) or killed (**K**) upon entering the new run level.
NN	The next two characters are a number from 00 to 99. They indicate the order in which the files will be started (S00, S01, S02, and so on) or stopped (K00, K01, K02, and so on).
name	The rest of the filename is the */etc/init.d* filename to which this file is linked.

For example, the *init.d* file *cron* is linked to the *rc2.d* file *S75cron* and the *rc0.d* file *K15cron*. When you enter init 2, *S75cron* is executed with the **start** option: **sh S75cron start**. When you enter *init 0, K75cron* is executed with the **stop** option: **sh K70cron stop**. This particular shell script executes */sbin/cron* when run with the **start** option and kills the *cron* process when run with the **stop** option.

Because these files are shell scripts, you can read them to see what they do. You can modify these files, though it is preferable to add your own since the delivered scripts may change in future releases. To create your own scripts, follow these rules:

- Place the script in */etc/init.d*.
- Symbolically link the script to files in appropriate run-state directories, using the naming convention described above (that is, symbolically link the script *file* in */etc/init.d* with S*NNfile* and K*NNfile* in the directories corresponding to the run levels at which you want to start and stop the script—usually */etc/rc2.d* and */etc/rc0.d*, respectively).
- Be sure the script accepts the **start** and / or **stop** options to perform the start and stop.

Note that it may prove easier to simply copy an existing script from the directory and make appropriate changes. Look at the scripts and links in */etc/init.d*, */etc/rc0.d,* and */etc/rc2.d* for examples of how to write the scripts.

Going to Single-User Mode From Multiuser Mode

Sometimes you must perform administrative functions, such as backing up the *root* filesystem, in single-user mode. To do so, use the *shutdown* command. This procedure executes all the files in */etc/rc0.d* by calling the */etc/rc0* procedure. The *shutdown* command performs the following functions, among others:

- Closes all open files and stops all user processes
- Stops all daemons and services
- Writes all system buffers to the disk
- Unmounts all filesystems except root

The entries for single-user processing in the sample */etc/inittab* are:

```
s1:1:wait:/etc/shutdown -y -iS -g0 >/dev/console 2>&1 </dev/console
```

There are three recommended ways to start the shutdown to single-user mode:

1. You can enter the *shutdown -i1* command (recommended). The option **-g** specifies a grace period between the first warning message and the final message.
2. You can enter the *single* command, which runs a shell script that switches to single-user mode and turns the *getty* processes off.
3. You can enter the *init 1* command, which forces the *init* process to scan the table. The first entry it finds is the **s1** entry, and *init* starts the shutdown process according to that entry.

Now the system is in the single-user environment, and you can perform the appropriate administrative tasks.

/etc/inittab and Power Off

The following entries in */etc/inittab* power off the system:

```
s0:06s:wait:/etc/rc0 >/dev/console 2>&1 </dev/console
of:0:wait:/etc/uadmin 2 0 >/dev/console 2>&1 </dev/console
```

Always attempt to shut the system down gracefully. You can either enter the *powerdown* command, the *init 0* command, or directly invoke the */etc/shutdown -i0* command.

In any case, the */etc/shutdown* and */etc/rc0* procedures are called to clean up and stop all user processes, daemons, and other services and to unmount the filesystems. Finally, the */sbin/uadmin* command is called, which indicates that the last step (physically removing power from the system) is under firmware control.

Chapter 4

Configuring the IRIX Operating System

Chapter 4 provides information on general system configuration. These tasks include setting most system features:

- Checking your current system hardware and software configuration
- Altering the system configuration with *chkconfig*
- Setting the system display
- Changing processors on multiprocessor systems
- Changing the name of a system
- Setting the network address
- Setting the default printer
- Setting the time zone
- Changing the date and time

Chapter 4

Configuring the IRIX Operating System

This chapter provides information on the settings and files that need to be set and edited to customize your system for use. It is not necessary to change all listed settings and names on all systems. You are free to customize your systems as much or as little as necessary to suit your purposes. The following topics are covered in this chapter.

- “Checking System Configuration” on page 65 provides information on determining what hardware and software are installed and active, and reporting the current system software settings.
- “Altering the System Configuration” on page 73 provides information on making changes to basic system settings and options.

Checking System Configuration

IRIX provides two commands that allow you to check your system hardware and software configurations. The hinv(1M) and versions(1M) commands display the hardware and software inventories, respectively. Other commands are presented that report on graphics hardware, the system name, configured printers, and basic system settings.

Checking Installed Hardware With hinv

The *hinv* command displays the system’s hardware inventory table which is created at boot time. This command can be run from the Command (PROM) Monitor or from your system shell prompt. Pertinent information such as the processor type, amount of main memory, and all disks, tape drives, and other devices is included.

For example, with the **-v** and **-m** options, hinv produces verbose output including board name, part number, barcode number, and the physical location of each board as a path under */hw* (see "Checking Installed Hardware in /hw" on page 68 and the reference page for hwgraph(4D) for more information.) A sample *hinv* output from the IRIX shell prompt is:

```
% hinv -vm
Location: /hw/module/1/slot/n2/node
[missing mfg. info:  page A data not available] Laser 0000000aacc9
Location: /hw/module/1/slot/n1/node
   8P/12MIDPLANE Board: barcode CDZ039     part 013-1547-002 rev  B
[missing mfg. info:  page A data not available] Laser 0000000aa9ef
Location: /hw/module/1/slot/r2/router
[missing mfg. info:  page A data not available] Laser 00000004da53
Location: /hw/module/1/slot/io1/xwidget
           IO6P1 Board: barcode CFD979     part 030-0734-001 rev  D
FPU: MIPS R10010 Floating Point Chip Revision: 0.0
CPU: MIPS R10000 Processor Chip Revision: 2.5
6 200 MHZ IP27 Processors
CPU 0 at Module 1/Slot 3/Slice 0: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 1 MB
CPU 1 at Module 1/Slot 3/Slice 1: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 1 MB
CPU 2 at Module 1/Slot 2/Slice 0: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 4 MB
CPU 3 at Module 1/Slot 2/Slice 1: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 4 MB
CPU 4 at Module 1/Slot 1/Slice 0: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 4 MB
CPU 5 at Module 1/Slot 1/Slice 1: 200 Mhz MIPS R10000 Processor Chip (enabled)
  Processor revision: 2.5. Seconday cache size: 4 MB
Main memory size: 3072 Mbytes
Memory at Module 1/Slot 3: 1024 MB (enabled)
  Bank 0 contains 128 MB (Standard) DIMMS (enabled)
  Bank 1 contains 128 MB (Standard) DIMMS (enabled)
  Bank 2 contains 128 MB (Standard) DIMMS (enabled)
  Bank 3 contains 128 MB (Standard) DIMMS (enabled)
  Bank 4 contains 128 MB (Standard) DIMMS (enabled)
  Bank 5 contains 128 MB (Standard) DIMMS (enabled)
  Bank 6 contains 128 MB (Standard) DIMMS (enabled)
  Bank 7 contains 128 MB (Standard) DIMMS (enabled)
Memory at Module 1/Slot 2: 1024 MB (enabled)
  Bank 0 contains 128 MB (Standard) DIMMS (enabled)
  Bank 1 contains 128 MB (Standard) DIMMS (enabled)
  Bank 2 contains 128 MB (Standard) DIMMS (enabled)
```

```
  Bank 3 contains 128 MB (Standard) DIMMS (enabled)
  Bank 4 contains 128 MB (Standard) DIMMS (enabled)
  Bank 5 contains 128 MB (Standard) DIMMS (enabled)
  Bank 6 contains 128 MB (Standard) DIMMS (enabled)
  Bank 7 contains 128 MB (Standard) DIMMS (enabled)
Memory at Module 1/Slot 1: 1024 MB (enabled)
  Bank 0 contains 128 MB (Standard) DIMMS (enabled)
  Bank 1 contains 128 MB (Standard) DIMMS (enabled)
  Bank 2 contains 128 MB (Standard) DIMMS (enabled)
  Bank 3 contains 128 MB (Standard) DIMMS (enabled)
  Bank 4 contains 128 MB (Standard) DIMMS (enabled)
  Bank 5 contains 128 MB (Standard) DIMMS (enabled)
  Bank 6 contains 128 MB (Standard) DIMMS (enabled)
  Bank 7 contains 128 MB (Standard) DIMMS (enabled)
Instruction cache size: 32 Kbytes
Data cache size: 32 Kbytes
Secondary unified instruction/data cache size: 4 Mbytes
Secondary unified instruction/data cache size: 4 Mbytes
Secondary unified instruction/data cache size: 4 Mbytes
Secondary unified instruction/data cache size: 4 Mbytes
Secondary unified instruction/data cache size: 1 Mbyte
Secondary unified instruction/data cache size: 1 Mbyte
Integral SCSI controller 0: Version QL1040B
Integral SCSI controller 1: Version unknown
  Disk drive: unit 1 on SCSI controller 1
  Disk drive: unit 2 on SCSI controller 1
  Disk drive: unit 3 on SCSI controller 1
  Disk drive: unit 4 on SCSI controller 1
  Disk drive: unit 5 on SCSI controller 1
Integral Ethernet: ef0, version 1
EPC external interrupts
```

If a piece of peripheral hardware installed on your system does not appear in the *hinv* output, it may or may not be an indication of trouble with your hardware. Some peripherals connected to the system by a board on a VME bus are not identified when running *hinv* from the Command Monitor. To list the missing peripheral, enter *hinv* at a system shell prompt. If your peripheral is still not recognized, reseat the board or device in its socket and check that it is using the correct SCSI address. If this does not relieve the problem, the hardware itself may be defective. Note also that most devices are not recognized by *hinv* until after the *MAKEDEV* command has been run after their installation.

Checking Installed Hardware in /hw

The contents of the */hw* directory structure are updated as necessary by the *ioconfig* command run from */etc/brc* at boot time (see “Entering the Multiuser State from System Shutdown” on page 56 and ioconfig(1M) for more information). All recognized hardware should be represented by an entry under */hw*, and some of these entries will have symbolic links in other parts of the */hw* structure as well as */dev*.

For example, the system root partition may appear in the following entries:

```
/hw/scsi_ctlr/1/target/1/lun/0/disk/partition/0/block
/hw/disk/root
/dev/root
```

The first entry (*/hw/scsi_ctlr/* and so on) represents the physical location of the board as described in hwgraph(4D). The second and third paths shown above (*/hw/disk/root* and */dev/root*) are symbolic links to the long physical pathname (the first path above). The symbolic links serve as a convenient shorthand for the various system commands that need to reference the device.

Checking Installed Software With versions

The *versions* command gives you an inventory of software packages that have been installed using *inst*. This command can be run only at the system shell prompt, not from the Command Monitor. Software installed by other means is not included in the *versions* output. Along with the names of the software products, the release revision level numbers are displayed. By default, the output of *versions* includes all the products and their subsystems and is typically several hundred lines long, so it is often convenient to redirect the output to a file that you can view at your convenience. For a more general look at the products you have installed, without the list of specific subsystems, use the **-b** (brief) flag.

A sample *versions -b* output reads as follows (an actual listing is much longer):

```
I = Installed, R = Removed
   Name                 Date      Description
I  4Dwm                 07/18/96  Desktop Window Manager, 6.2 (based on
                                  OSF/Motif 1.2.4)
I  demos                07/18/96  Graphics Demonstration Programs, 6.2
I  desktop_base         07/18/96  IndigoMagic Desktop Base Software,
                                  6.2
I  desktop_eoe          07/18/96  IndigoMagic Desktop, 6.2
I  desktop_tools        07/18/96  Desktop Tools, 6.2
I  dps_eoe              07/18/96  Display PostScript/X, 2.0.5 based on
                                  PostScript Level 2
I  eoe                  07/22/96  IRIX Execution Environment, 6.2
I  insight              07/18/96  IRIS InSight Viewer, 2.3.3
I  nfs                  07/18/96  Network File System, 6.2 with IMPACT
                                  10000
```

Checking Graphics Hardware With gfxinfo

The *gfxinfo* command is useful for determining the graphics hardware installed in the system. It is in the */usr/gfx* directory, which is not on any of the standard search paths. Thus *gfxinfo* typically needs the full pathname to be specified for successful execution. The command requires no arguments to run.

An sample *gfxinfo* output for an Indy® workstation:

```
% /usr/gfx/gfxinfo
Graphics board 0 is "NG1" graphics.
        Managed (":0.0") 1280x1024
        24 bitplanes, NG1 revision 3, REX3 revision B,
        VC2 revision A
        MC revision C, xmap9 revision A, cmap revision C,
        bt445 revision A
        Display 1280x1024 @ 60Hz, monitor id 12
```

This command provides more information about the graphics system than the *hinv* command (*hinv* would simply return “Indy 24-bit”). From the output of *gfxinfo* you can determine the number of screens and their pixel resolutions, bitplane configurations, component revision levels, and monitor types. There is no reference page for *gfxinfo*. Servers without graphics capability do not have this command installed.

Basic System Identification With uname

The *uname* command returns information such as the operating system version and hostname. The **-a** option gives a complete list of the *uname* output. See the reference page for a description of all the *uname* options and fields.

Getting Printer Status With lpstat

lpstat with the **-a** option shows all the printers configured for the *lp* spooling system and gives their status. See the *IRIX Admin: Peripheral Devices* and the lpadmin(1M) and lpstat(1) reference pages for detailed information on printer administration.

Checking Options With chkconfig

You can quickly check the configuration of a workstation or server with chkconfig(1). The */sbin/chkconfig* command reports the state of various process daemons (that is, whether or not they are supposed to be active).

For example, enter the *chkconfig* command:

```
chkconfig
```

You see a display similar to this:

```
Flag                State
====                =====
acct                off
audit               off
automount           on
gated               off
lockd               on
mrouted             off
named               off
network             on
nfs                 on
noiconlogin         off
nsr                 on
quotacheck          off
quotas              off
routed              on
rtnetd              off
```

```
rwhod               off
sar                 on
snmpd               on
timed               on
timeslave           off
verbose             off
visuallogin         on
windowsystem        off
yp                  on
ypmaster            off
ypserv              off
```

This example is typical for a networked workstation with the Network File System (NFS) option installed. The left column of the output describes a system feature, and the right column indicates whether it is on or off. The following list provides more specific information about each system feature:

acct — Detailed system accounting is turned on or off.

audit — The System Audit Trail is turned on or off.

automount — The NFS automount(1M) daemon is turned on or off. This configuration option is available only if you have NFS installed on the workstation.

gated — The gated(1M) daemon, which manages multiple routing protocols is turned on or off.

lockd — The Network File System (NFS) lock daemon is turned on or off. This configuration option is available only if you have NFS installed on the workstation.

mrouted — The Stanford IP multicast routing daemon is turned on or off.

named — named(1M), the Internet domain name server, is turned on or off.

network — The network is turned on or off.

nfs — NFS is turned on or off. This configuration option is available only if you have NFS installed on the workstation.

noiconlogin — The visual login program, pandora(1), displays icons that represent users on the system. This feature does not enable or disable *pandora*; it affects whether or not *pandora* displays icons. It is turned on or off. To enable or disable *pandora*, use the *visuallogin* feature.

nsr — IRIS NetWorker™ backup utility. This configuration option is available only if you have NetWorker installed on the workstation.

quotacheck	The disk space quota checker is enabled or disabled.
quotas	Disk quotas are enabled or disabled.
routed	routed(1M), which manages the network routing tables, is turned on or off.
rtnetd	rtnetd(1M), which allows higher priority real-time processes to preempt processing of incoming network packets, is turned on or off.
rwhod	rwhod(1M) is turned on or off.
sar	sar(1), the system activity reporter, is turned on or off.
snmpd	The Simple Network Management Protocol Daemon is turned on or off.
timed	timed(1M), the 4.3 BSD time server daemon, is turned on or off.
timeslave	The Silicon Graphics time server daemon is turned on or off. Like *timed*, this attaches a workstation's clock to a different clock, usually master time server for a group of workstations or for the entire site.
verbose	If this feature is enabled, as the system boots or is shut down, daemons print information about their functions. If this feature is disabled, less information is printed when the system is started and shut down.
visuallogin	The visual login program, pandora(1), is turned on or off.
windowsystem	The window manager is turned on or off.
yp	The network information service (NIS) is on or off. This is called "yp" for historical reasons. NIS is available with the NFS software. This configuration option is available only if you have NFS installed on the workstation.
ypmaster	NIS master services are turned on or off. This configuration option is available only if you have NFS installed on the workstation.
ypserv	NIS server and bind processes are turned on or off. This configuration option is available only if you have NFS installed on the workstation.

Altering the System Configuration

The following sections describe how to set the various options available to customize your IRIX operating system.

Setting Options With chkconfig

You can use the chkconfig(1M) command to change some aspects of system configuration. To determine which aspects of a system you can alter with *chkconfig*, enter the *chkconfig* command:

```
chkconfig
```

You see a list of configuration options, which are described in “Checking Options With chkconfig” on page 70. If you use the **-s** option, you see a list that is sorted by whether the configuration item is on or off.

To change a configuration option, use the *chkconfig* command with two arguments: the name of the option you wish to change and the new status of the configuration (on or off). You must have root privilege to change a system configuration.

For example, to turn on detailed process accounting, log in either as root or as the system administrator, and enter:

```
chkconfig acct on
```

To turn off process accounting, enter:

```
chkconfig acct off
```

Some aspects of system configuration do not take effect until the system is shut down and rebooted because startup scripts, which are in the directory */etc/init.d*, are run when the system is booted and brought to multiuser mode. These scripts read the files that *chkconfig* sets to determine which daemons to start.

Some configuration items that can be controlled by *chkconfig* may not be displayed by *chkconfig*. These include:

nostickytmp Sets "sticky" behavior for the directory */tmp*. When the directory is sticky, (with *nostickytmp* set to **off**), users may not remove files from the directory unless they own the files, have explicit permission to remove the files (write permission), or have superuser privileges.

The opposite behavior allows users to remove or replace files in */tmp*, which is a publicly writable directory, even if they do not own the files. This is handy behavior if you have users who need to create large temporary files and you are short on disk space. But it is better to increase disk space to avoid important files being removed.

nocleantmp Controls whether or not the directory */tmp* is cleaned out each time the system is booted. If *nocleantmp* is on, */tmp* is not cleaned. If *nocleantmp* is off, all files in */tmp* are removed each time the system is started.

If you want to see these flags in the *chkconfig* menu, you can use the **-f** option to force *chkconfig* to create a configuration file for the options:

```
chkconfig -f nocleantmp on
```

In this example, *chkconfig* creates a configuration file called *nocleantmp* in the directory */etc/config*, which flags the system not remove files from */tmp* at reboot.

Changing Other System Defaults

These systemwide defaults affect programs and system functions:

- the system display
- the time zone
- the name of the system
- the network address
- the default system printer

Some of these defaults are described more thoroughly in specific sections of this guide, but they are all presented here to provide an overview of the IRIX system.

Setting the System Display

You can make the output of programs and utilities running on one system appear on the screen of another system on the same network by changing the DISPLAY environment variable. This is useful if your network includes graphical systems and non-graphical servers. In order to view information from the server graphically, you reset the display to a graphics workstation.

For example, if your server has only a character-based terminal as its console and you wish to run *gr_osview* to visually inspect your CPU usage, you would issue this command on the server (for *csh* and *tcsh* shells):

setenv DISPLAY *graphics_system***:0**
gr_osview

or this command for *ksh* and *sh* shells:

DISPLAY=*graphics_system***:0; export DISPLAY**

and also issue an *xhost* command on the graphics system to allow the server to display on it:

xhost +*server_system*

When you invoke *gr_osview* on the server, the window with the output will appear on the graphics system name you specify. In this example, *graphics_system* was used in place of the system name. The **:0** used after the system name indicates that display monitor 0 (the graphics console) should be used to display the output. When you have finished using the graphics console, be sure to reset the display by issuing this command on the server:

setenv DISPLAY *local_server***:0**

where *local_server* is the name of your server. If you logged-in from the graphics system to the server and set the *DISPLAY* variable that way, simply log out when you are finished.

Changing Processors on Multi-Processor Systems

If you have a multi-processor system, the mpadmin(1M) and pset(1M) commands allow you to change the way programs are assigned to the various processors on your system. To determine if your system is multi-processor, use the hinv(1M) command. A multi-processor system returns information similar to the following in its *hinv* output:

```
Processor 0: 40 MHZ IP7
Processor 1: 36 MHZ IP7
Processor 2: 40 MHZ IP7
Processor 3: 40 MHZ IP7
Processor 4: 40 MHZ IP7
Processor 5: 40 MHZ IP7
Processor 6: 40 MHZ IP7
Processor 7: 40 MHZ IP7
```

Or, alternately, output similar to the following:

```
8 40 MHZ IP7 Processors
```

A single-processor system returns information similar to the following for the *hinv* command:

```
1 100 MHZ IP22 Processor
```

If you have only one processor on your system (and the vast majority of systems have only one processor), these commands still operate, though they have no useful purpose.

The *mpadmin* command allows you to “turn off” processors, report various states of the processors, and move system functions such as the system clock to specific processors. The *pset* command is used both to display and modify information concerning the use of processor sets and programs running in the current system. The *pset* command provides a much more detailed level of control of processes and processors.

For complete information on mpadmin(1M) and pset(1M), see the respective reference pages.

Changing the Name of a System

The name of the system is stored in several places. If you want to change the name of your system, you must change all these files together or your system does not function correctly:

- in the file */etc/sys_id*
- in the file */etc/hosts* (for networking purposes)
- in a kernel data structure, which you read and set with either *hostname* or *uname*
- in an NIS map on the NIS master server, if you are running NIS

Note: Do not arbitrarily change the name of a running workstation. Many programs that are started at boot time depend on the name of the workstation.

To display the name of the system, use the *hostname* command with no arguments:

```
hostname
```

This displays the name of the system. The *uname* command also displays the name of the system, along with other information.

To change the name of the workstation, follow these steps:

1. Log in as root.
2. Edit the file */etc/sys_id*. Change the name of the host to the new name. Write and exit the editor.
3. You must also change the name of the host in any network files, such as */etc/hosts*, and possibly in the NIS map on the master NIS server.
4. Reboot your system.

All programs that read the hostname when they are started at boot time now use the correct hostname.

For information about the Internet address of a workstation, see *IRIX Admin: Networking and Mail*. For more information about the name of the system, see the hostname(1) and uname(1) reference pages.

Setting the Network Address

The system's network address (IP address) is covered more thoroughly in the *IRIX Admin: Networking and Mail*. To set the network address, follow these steps:

1. Place the network address in */etc/hosts* on the same line as the system name. For example

   ```
   194.45.54.4 magnolia
   ```

2. If you use the network information service (NIS), place the name of your domain in the file */var/yp/ypdomain*, if it is installed.
3. Use the nvram(1M) command to set the variable *netaddr* to the IP number of the system. For example:

   ```
   nvram netaddr 194.45.54.4
   ```

Setting the Default Printer

The lpadmin(1M) command sets the default printer. This command sets the default printer to *laser*:

```
lpadmin -dlaser
```

Note that the printer *laser* must already exist and be configured. For complete information on setting up printers, see the *IRIX Admin: Peripheral Devices*.

Setting the Time Zone

To set the time zone of the system, edit the file */etc/TIMEZONE*. For a site on the east coast of the United States, the file might look something like this:

```
# Time Zone
TZ=EST5EDT
```

The line `TZ=EST5EDT` means:

- The current time zone is Eastern Standard Time.
- It is 5 hours to the west of Greenwich Mean Time.
- Daylight saving time applies here (EDT).

The TZ environment variable is read by init(1) when the system boots, and the value of TZ is passed to all subsequent processes. The time zone designation (such as EST) is simply passed through for your convenience. The important parts of the designation are the specification of the deviation from Greenwich Mean Time and the presence of the daylight savings time indicator. The following tables provide convenient time zone information for the majority of North America, Europe, Asia, the Middle East, South America, and Australia and New Zealand.

Table 4-1 North America Time Zones

Region	GMT Differential	Abbreviation
Newfoundland	-3:30	NST
Atlantic	-4:00	AST
Eastern	-5:00	EST
Central	-6:00	CST
Saskatchewan	-6:00	CST
Mountain	-7:00	MST
Pacific	-8:00	PST
Yukon	-9:00	YST
Alaska	-10:00	AST
Hawaii	-10:00	HST
Bering	-11:00	BST
Baja Norte	-8:00	PST
Baja Sur	-7:00	MST
Mexico (General)	-6:00	CST

Table 4-2 Europe Time Zones

Region	GMT Differential	Abbreviation
Ireland	0:00	BST
The United Kingdom	0:00	BST
Western Europe	0:00	WET
Iceland	0:00	WET
Middle Europe	1:00	MET
Poland	1:00	MET
Eastern Europe	2:00	EET
Turkey	3:00	EET
Western Russia	3:00	WSU

Table 4-3 Asia Time Zones

Region	GMT Differential	Abbreviation
Rep. of China	8:00	CST
Hong Kong	8:00	HKT
Japan	9:00	JST
Rep. of Korea	9:00	ROK
Singapore	8:00	SST

Table 4-4 Middle East Time Zones

Region	GMT Differential	Abbreviation
Israel	2:00	IST
Egypt	2:00	EET

Table 4-5 South America Time Zones

Region	GMT Differential	Abbreviation
Brazil / East	-3:00	EST
Brazil / West	-4:00	WST
Brazil / Acre	-5:00	AST
Brazil / De Noronha	-2:00	FST
Chile / Continental	-4:00	CST
Chile / Easter Island	-6:00	EST

Table 4-6 Australia and New Zealand Time Zones

Region	GMT Differential	Abbreviation
Australia / Tasmania	10:00	EST
Australia / Queensland	10:00	EST
Australia / North	9:30	CST
Australia / West	8:00	WST
Australia / South	9:30	CST
Australia / Victoria	10:00	EST

Table 4-6 (continued) Australia and New Zealand Time Zones

Region	GMT Differential	Abbreviation
Australia / NSW	10:00	EST
New Zealand	12:00	NZT

For complete information about setting your time zone, see the timezone(4) reference page.

Changing the Date and Time

Use the date(1) command to set the date and time. For example, to set the date to April 1st, 1999, and the time to 09:00, log in as *root* and enter:

```
date 0401090099
```

Changing the date and time on a running system can have unexpected consequences. Users and administrators use system scheduling utilities (*at*, *cron*, and *batch*) to perform commands at specified times. If you change the effective date or time on the system, these commands may not execute at the desired times. Similarly, if your users use the *make* utility provided with the system, the commands specified in Makefiles may perform incorrectly. Always try to keep your system date and time accurate within reason. Random changes of the date and time can be extremely inconvenient and possibly destructive to users' work.

If *timed* is running on the system, and it is a slave system, the time is reset by *timed* and not the *date* command. For more information, see the timed(1M) reference page.

Controlling Access Permission

In general, IRIX file access permissions are set to allow ease of use among multiple users while maintaining system security. This section discusses how you can change file access permissions to permit or deny read, write, and execution permission for users, groups, or everyone. Note that users can also configure a umask to control default access to their own files (see "Configuring Default File Permissions With umask" on page 111 for more information.)

To see the current status of a file's permission settings, use the *ls -l* command. For example, to see the status of permission on the file *review*, enter:

```
ls -l review
-rw-r--r--    1 jones engr 1015 Aug 14 16:20 review
```

Permissions are shown as read (r), write (w), and execute (x), for each of user, group, and other, respectively. That is, each of the user, group, and everyone has some combination of read, write, and execute access to the file. After the first character (in this example, a dash), the next three characters give the read, write, and execute permission for the user, the next three characters give the read, write, and execute access for the group, and the last three characters give the read, write, and execute access for everyone else. So in the example, user jones has read (r) and write (w), access to the file *review*, while the group has only read (r) access, and other also has only read (r) access. Nobody has execute (x) permission.

The superuser or owner of the file can change these permission settings. As superuser, you can give everyone write access to a file with the *chmod* command. For example, to add write access for the group and others to the *review* file, use the **go+w** (**g** for group, **o** for other, and **+w** to permit writing) option as follows:

```
chmod go+w review
```

Now the access permissions should look like this:

```
-rw-rw-rw-    1 jones engr 1015 Aug 14 16:20 review
```

Another way of controlling permission settings is with the octal number representation obtained by using 7 as representing read, write and execute permission (4+2+1). In this way, to give complete read, write, and execute permissions to a file, use the *chmod 777* command, and to give just read permission to the owner and no other permissions at all, use *chmod 400*. For complete information on setting access permissions on files and directories, refer to the chmod(1) reference page.

Note: If you use *chmod* on a device file, edit the */etc/ioperms file* to reflect the change, or the device file returns to the default access permissions after a reboot. The format of an entry in */etc/ioperms* is:

device_name owner group nnn

where *device_name* is the device filename, *owner* is the file owner, *group* is the group, and *nnn* is the octal permission setting as described above and in the chmod(1) reference page. Refer to the ioconfig(1M) reference page for details on device permission settings in the */etc/ioperms* file.

Chapter 5

Managing the Multiuser Environment

Chapter 5 describes the tasks associated with managing user accounts on your system and dealing with your users. Topics described in this chapter include:

- Creating and deleting user accounts
- Changing user account information
- Configuring a user's login environment
- Communicating important information to users
- Information on the user ID (UID) and group (GID).

Chapter 5

Managing the Multiuser Environment

This chapter describes how to configure and maintain the system to support your users. It includes a discussion of adding user accounts, configuring user environments, and enabling communication between users.

User Account Administration

Creating and deleting user accounts are two of the most common system administration tasks. It is recommended that you read and understand this section before you set up or change user accounts. The graphical System Manager tool (available on graphics workstations only) is the most convenient tool for these tasks. The System Manager is described in the *Personal System Administration Guide*. The command-line method for performing these tasks is described here.

User ID Numbers

Each user account has a user ID number. These numbers are unique on each workstation and should be unique throughout your entire site. A user ID number for an account is kept in the third field of the */etc/passwd* file.

After you close a user account, do not reuse that account's user ID number. It is possible that files somewhere on a system could still be owned by the ID number, or files may be placed on the system from an old backup tape. These files would be compromised by associating a new user with an old ID number. In general, the rule is that the ID number is the permanent property of the user to whom it is assigned. For more information on user ID numbers, see the passwd(4) reference page.

Group ID Numbers

Each user account belongs to a group of users on the system. Users with similar interests or jobs can belong to the same group. For example, members of the publications department might belong to group *pub*. The benefit to this arrangement is that it allows groups of related users to share files and resources without sharing those files or resources with the entire system community.

Each group has a group ID number. These numbers are unique on each system and should be unique throughout the entire site. As with user IDs, you should not reuse group IDs.

When you create a file, it is assigned your group ID. You can change the group ID of a file with the chgrp(1) command. By manipulating the permissions field of the file, the owner (or someone with the effective user ID of the owner) can grant read, write, or execute privileges to other group members.

Information about groups is kept in the */etc/group* file. A sample entry from this file is shown and explained below:

```
raccoons::101:norton,ralph
```

Each entry is one line; each line has the following fields:

group name — The group name can be any length, though some commands truncate the name to eight characters. The first character must be alphabetic.

password — The password field may contain an encrypted password. An empty field, as in the above example, indicates that no password is required. The passwd(1M) command cannot be used to create or modify a group password. To place a password on a group, you must use the *passwd* command to encrypt a password. Use a test user account created specifically for this purpose and then delete the test account. Then, copy that encrypted password verbatim from the */etc/passwd* file into the */etc/group* entry you want to protect with the password. Users specifically listed as group members in the */etc/group* file entry are not required to give the password, but other users are so required when they attempt to change groups to the protected group with the *newgrp* command. Password protection, though, is rarely used on user groups.

group ID	The group ID is a number from 0 to 60,000. The number must not include a comma. Numbers below 100 are reserved for system accounts.
login names	The login names of group members are in a comma-separated list.

For complete information on user groups, see the group(4) reference page.

Adding User Accounts Using Shell Commands

Occasionally, you may have to add a user account manually; in other words, without using the automated tools such as the System Manager. All administrators should understand the process in case a problem develops with some part of the automated tools or if you want to design your own scripts and programs for administering user accounts at your site. Be sure to check your work with the *pwck* command.

The procedure for manually adding user accounts is

1. Edit the */etc/passwd* file.
2. Edit the */etc/group* file.
3. Create the user's home directory and startup files.
4. Verify the new account.

These steps are described in the following four procedures.

Editing /etc/passwd

To edit the */etc/passwd* file:

1. Log in as **root**.
2. Edit the file */etc/passwd* with your preferred text editor.

   The file */etc/passwd* has one line for each account on the system. Each line contains seven fields, and each field is separated by a colon. The lines look similar to this:

   ```
   ralph:+:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

3. Copy one of the lines (for example, the last line in the file) and add it after the last account entry in the file.
4. Change the first field (*ralph* in this example) to the name of the new account; for example, *alice*.

5. Remove any characters between the first colon after the account name and the second colon. Deleting these characters removes the password from an account. Either you or the new user can add a password later.
6. The next field (in this case “103”) is the user ID of the new account. Change it to a number 1 greater than the current highest user ID on your system. You should not use user ID numbers between 0 and 100, as these are reserved for system use.
7. The next field (in this case “101”) is the group ID number of the new account. Check the file */etc/group* and pick a suitable group ID for the new user account. The */etc/group* file lists all the groups on the system by group ID, followed by a list of the current users who belong to that group.
8. Change the next field (in this case *Ralph Cramden*) to the name of the new user, in this case *Alice Cramden*. If you want, you can add an “office” and “phone number” to this field. After the user’s name, add a comma, then the office location, another comma, and the phone number. For example:

   ```
   :Alice Cramden, Brooklyn, (212) 555-1212:
   ```

   Actually, you can put any information you want in these fields. The fields are interpreted by the finger(1) program as “user name, office, phone number.”
9. The next field (in this case */usr/people/ralph*) is the location of the user’s home directory. Change this field to reflect the name of the new user’s account. In this example, you would change */usr/people/ralph* to */usr/people/alice*.
10. The last field (in this example */bin/csh*) is the user’s login shell. For most users, the C shell (*/bin/csh*), Korn Shell (*/bin/sh*), or Bourne shell (*/bin/bsh*) is appropriate. Leave this field unchanged, unless you want to use a different or special shell. Special shells are discussed in “Configuring Special Login Shells” on page 112. Once you have selected a shell, you are finished editing */etc/passwd*.
11. Write the changes you made and exit the file.

Editing /etc/group

This procedure, which is optional, adds the new user to the file */etc/group*. However, users can be a member of a group without being listed in the */etc/group* file. If you want to maintain a list pf groups to which users belong, edit this file.

1. Open the */etc/group* file with your preferred text editor. You should see some lines similar to this:

   ```
   sys::0:root,bin,sys,adm
   root::0:root
   daemon::1:root,daemon
   bin::2:root,bin,daemon
   adm::3:root,adm,daemon
   mail::4:root
   uucp::5:uucp
   rje::8:rje,shqer
   lp:*:9:
   nuucp::10:nuucp
   bowling:*:101:ralph
   other:*:102:
   ```

2. Place the name of the new account (in this example *alice*) after any of the groups. Separate the account name from any other account names with a comma, but not with blank spaces. For example:

   ```
   bowling:*:101:ralph,alice
   ```

   Although adding account names to the */etc/group* file is optional, it is a good way to keep track of who belongs to the various system groups.

   Also, you can assign an account to more than one group by placing the account name after the names of the various groups in */etc/group*. The user can change group affiliations with the *newgrp* and *multgrps* commands.

3. Write your changes and exit the file.

Setting Up a Home Directory

To create the new user's home directory and copy shell startup files over to that directory, follow this procedure:

1. Use the mkdir(1) command to create the user's home directory. For example, to create a home directory for the user "alice":

   ```
   mkdir /usr/people/alice
   ```

   Make the directory owned by user *alice*, who is in group *bowling*:

   ```
   chown alice /usr/people/alice
   ```

   ```
   chgrp bowling /usr/people/alice
   ```

   Make sure the new home directory has the appropriate access permissions for your site. For a site with relaxed security:

   ```
   chmod 755 /usr/people/alice
   ```

   For more information, see the reference pages for chown(1), chgrp(1), and chmod(1).

2. Copy the shell startup files to the new user's home directory.

   If the new account uses the C shell:

   ```
   cp /etc/stdcshrc /usr/people/alice/.cshrc
   ```

   ```
   cp /etc/stdlogin /usr/people/alice/.login
   ```

   If the new account uses the Korn or Bourne shell:

   ```
   cp /etc/stdprofile /usr/people/alice/.profile
   ```

3. You can make these shell startup files owned by the user, or leave them owned by *root*. Neither approach affects how the user logs in to the system, although if the files are owned by root, the user is less likely to alter them accidentally and thereby be unable to log in.

   To give a user complete access to his or her shell startup files, use the *chmod* command. For C shell:

   ```
   chmod 755 /usr/people/alice/.cshrc /usr/people/alice/.login
   ```

   For Korn or Bourne shell:

   ```
   chmod 755 /usr/people/alice/.profile
   ```

   Remember to check for any other user files that may be owned by root in the user's directory and change those too.

4. It is a good idea to immediately create a password for the new user. Enter

   ```
   passwd alice
   ```

   and follow the prompts to create a password. Let the user know their assigned password and advise them to change it to a password of their own choosing. Refer to *IRIX Admin: Backup, Security, and Accounting* for advice to give users on choosing passwords.

Verify the New Account

Issue the *pwck* command to check your work. This command performs a simple check of the */etc/passwd* file and makes sure that no user ID numbers have been reused and that all fields have reasonable entries. If your work has been done correctly, you should see output similar to the following:

```
sysadm:*:0:0:System V Administration:/usr/admin:/bin/sh
           Login directory not found
auditor::11:0:Audit Activity Owner:/auditor:/bin/sh
        Login directory not found
dbadmin::12:0:Security Database Owner:/dbadmin:/bin/sh
        Login directory not found
tour::995:997:IRIS Space Tour:/usr/people/tour:/bin/csh
        Login directory not found
4Dgifts::999:998:4Dgifts Acct:/usr/people/4Dgifts:/bin/csh
        First char in logname not lower case alpha
        1 Bad character(s) in logname
        Login directory not found
nobody:*:-2:-2::/dev/null:/dev/null
        Invalid UID
           Invalid GID
```

These messages are normal and expected from *pwck*. All errors generated by *pwck* are described in detail in the pwck(1M) reference page.

Adding User Groups Using Shell Commands

Follow these steps to add a group to the system manually:

1. Log in as root.
2. Edit the file */etc/group*. The file contains a list of groups on the system, one group per line. Each line contains the name of the group, an optional password, the group ID number, and the user accounts that belong to that group.

   For example, to create a group called *raccoons*, with a group ID of 103, place this line at the end of the file:

   ```
   raccoons:*:103:
   ```

3. If there are users who should belong to the group, add their names in the last field. Each name should be separated by a comma, for example:

   ```
   raccoons:*:103:ralph,norton
   ```

4. Write and exit the file. Make sure the group IDs in the file */etc/passwd* file match those in the */etc/group* file.

For more information on user groups, see the group(4) reference page.

Changing a User's Group

To change a user's group affiliation, perform these steps:

1. Log in as root.
2. Edit the file */etc/group*. Place the user's account name on the line corresponding to the desired group. If the account name appears as a member of another group, remove that reference unless you want the account to be a member of both groups.
3. Write and exit the file */etc/group*.
4. Edit the file */etc/passwd*.
5. Find the user's entry in the file.

6. Change the old group ID on that line to the new group ID. The group ID is the fourth field (after the account name, password, and user ID).
7. Write and exit the file.

The user's group affiliation is now changed. Remind the user to change the group ownership on his or her files. If you prefer, you can perform this task yourself as **root** using the *find* and *chgrp* commands. See "Using find" on page 24 for more information.

Deleting a User From the System

This procedure deletes the user's home directory and all the files in and below that directory. If you want only to close or disable a user account but preserve the user's files and other information, see "Locking a User Account" on page 96.

To delete a user's account completely, follow these steps:

1. Log in as root.
2. If you think you might need a copy of the user's files later on, make a backup copy of the directory (for example, on cartridge tape using tar(1) or cpio(1)).
3. Edit the */etc/passwd* file and replace the encrypted password (or "+" sign if you are using shadow passwords) with the following string:

   ```
   *ACCOUNT CLOSED*
   ```

   It is imperative that the asterisks shown in this example be used as shown. An asterisk in the encrypted password field disallows all logins on that account. Alternately, you can lock an account by using fewer than 13 characters in the password field, but it is better to use the asterisks and an identifiable lock message.
4. Use find(1) to locate all files on the system that are owned by the user and remove them or change their ownership. Information on the use of *find* is provided in "Using find" on page 24 and in the find(1) reference page.

Deleting a Group From the System

To delete a group from the system, follow these steps:

1. Edit the */etc/group* file and change the desired entry to a new but unused name, for example, you might change the group *bigproject* to *bigproject.closed*.
2. Edit the */etc/passwd* file and remove the group from the user entries wherever it exists.
3. Use *find* to find all files and directories with the old group affiliation and change the affiliation to a group that is still in use with the *chgrp* command.

Locking a User Account

If you want, you can close a user's account so that nobody can log in to it or *su* to that user's ID number.

If you expect that the user will again require access to the system in the near future, close an account in the manner described below rather than removing it from the system completely (as described in "Deleting a User From the System" on page 95).

To close an account, follow these steps:

1. Log in as root.
2. Edit the file */etc/passwd*. Find the user's account entry.
3. Make the entry a comment by placing a number sign at the beginning of the line. For example:

   ```
   # ralph:+:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

4. As an added measure of security, you can replace the encrypted password (the second field in the entry) with a string that cannot be interpreted as a valid password. For example:

   ```
   # ralph:*:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

   Using the asterisk has the added benefit of reminding you that you deliberately closed the account.

5. If necessary, you can also close off the user's home directory with the following commands:

```
chown root /usr/people/ralph
chgrp bin /usr/people/ralph
chmod 700 /usr/people/ralph
```

The user's account is now locked, and only *root* has access to the user's home account.

Temporarily Changing User Groups

Normally users are members of only one group at a time. However, users can change groups using the *newgrp* command. Changing groups is sometimes useful for performing administrative tasks.

The superuser can belong to any group listed in the */etc/groups* file. Other users must be listed as members of a group in order to temporarily change groups with *newgrp*. Refer to the newgrp(1) reference page for more information.

You can belong to multiple groups simultaneously by invoking the *multgrps* command. In this case, files you create have their group IDs set to the group you were in before you issued the *multgrps* command. You have group access permissions to any file whose group ID matches any of the groups you are in. Refer to the multgrps(1) reference page for more information.

You can change groups only to a group you are affiliated with in the */etc/groups* file. To determine which groups you belong to, use the id(1) command.

Changing User Information

This section covers the following procedures:

This section tells you how to change the values for an individual user's login information. You cannot use these commands for a login you installed as an NIS-type entry. If the login account is an NIS type, you must change the master password file on the network server. See the *NIS Administration Guide* for more information about NIS.

Changing a User's Login Name

To change a user's login name, perform the following steps:

1. Edit the */etc/passwd* file and change the entry for the user's login to reflect the new login name. For example, to change the login name *ralph* to *cramden*, find the line:

   ```
   ralph:x:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

   Change the name field and the default directory field as follows:

   ```
   cramden:x:103:101:Ralph Cramden:/usr/people/cramden:/bin/csh
   ```

   For consistency's sake, the home directory should always have the same name as the user account. If your system has shadow passwords enabled, you see the letter **x** in place of the encoded password in the user's entry. For more information on shadow passwords, see the *IRIX Admin: Backup, Security, and Accounting* guide.

   When you save and exit the file, you may see an error message that the file is "read-only" or that write permission is denied. This is a protection that IRIX puts on the */etc/passwd* file. Use the command:

   ```
   :w!
   ```

   in the *vi* editor to override this protection. If you are using *jot*, the file can be saved with no difficulty. For complete information, see the vi(1) reference page or the appropriate reference page for the editor that you use.

2. If your system has shadow passwords enabled, edit the */etc/shadow* file next. Look for the line that begins with the user name you want to change. In this example, the line looks like this:

   ```
   ralph:XmlGDVKQYet5c:::::::
   ```

   Change the name in the entry to "cramden" as follows:

   ```
   cramden:XmlGDVKQYet5c:::::::
   ```

   When you have made the change, save and exit the file. As with */etc/passwd*, if you are using vi(1), you may encounter an error message.

3. Go to the directory that contains the user's home directory and change the name of the home directory to match the user's new login name. Use the command:

   ```
   mv ralph cramden
   ```

4. Since IRIX identifies the files owned by the user by the user ID number rather than by the login name, there should be no need to change the ownership.

Changing a User's Password

Occasionally, a user forgets his or her password. To solve the problem, you must assign that user a temporary password, then have the user change the temporary password to something else. This is because there is no easy way to guess a forgotten password.

To assign a new password, perform these steps:

1. Log in as root.
2. Use the *passwd* command to change the password for the user's account.

   For example, if the user ralph forgets his password, enter:

   ```
   passwd ralph
   ```

3. Follow the screen prompts:

   ```
   New password: 2themoon
   Re-enter new password: 2themoon
   ```

   Note: Although a password appears in the example for clarity, it is not actually displayed on the screen.

   Because you are logged in as the superuser (root), you are not prompted for an old password.

The user's password is now changed to "2themoon." The user should immediately change the password to something else.

Changing a User's Login ID Number

It is not recommended to change user login ID numbers. These numbers are crucial in maintaining ownership information and responsibility for files and processes. However, if for some reason you must change a user's login ID number, perform the following steps:

1. Make a complete backup tape of the user's home directory and any working directories the user may have on the system.
2. Lock the user's account by placing a number sign (#) at the beginning of the line, and an asterisk (*) in the password field of the */etc/passwd* file. Do not delete the entry, as you want to keep it as a record that the old user ID number was used and should not be reused. When you are finished, the entry should look like this:

   ```
   # ralph:*:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

3. Completely remove the user's home directory, all subdirectories, and any working directories the user may have.
4. Use the following command from your system's root directory to find any other files the user may own on the system and display the filenames on the console:

   `find / -user` *name* **`-print`**

   Archive and remove any files that are found.

5. Create a new user account using the instructions provided in this chapter. It may have the same name as the old account, but it is better to change names at the same time, to avoid confusion. Use the new user ID number.
6. Restore the home directory, working directories, and any other files you located from the backup you made. If necessary, use the *chown* and *chgrp* commands to set the new user ID correctly.

Changing a User's Default Group

A user can be a member of many different groups on your system, but only one group is the default group. This is the group that the user begins with at login time. To change the default group at login time, simply edit the */etc/passwd* file and find the appropriate line. For example:

```
cramden:+:103:101:Ralph Cramden:/usr/people/cramden:/bin/csh
```

To change the default group from 101 to 105, simply change the field in the passwd file entry as follows:

```
cramden:+:103:105:Ralph Cramden:/usr/people/cramden:/bin/csh
```

Be certain before you make any change, however, that group 105 is a valid group in your */etc/groups* file and that the user is a member of the group. For more information on creating groups, see "Adding User Groups Using Shell Commands" on page 94.

Changing a User's Comments Field

The fifth field in each entry in */etc/passwd* is for comments about the user account. This field typically contains the user's name and possibly his or her telephone number or desk location. To change this information, simply edit the */etc/passwd* file and change the information. (Note only that you cannot use a colon (:) within the comments, since IRIX interprets these as ending the comments field.) For example, consider this entry:

```
cramden:x:103:101:Ralph Crumdin:/usr/people/cramden:/bin/csh
```

It would not be long before Ralph came to the administrator and requested to have the misspelling of his name corrected. In this case, change the line to read:

```
cramden:x:103:101:Ralph Cramden:/usr/people/cramden:/bin/csh
```

Changing a User's Default Home Directory

The sixth field in an */etc/passwd* entry specifies the user's home directory. This is the directory that the user is placed in at login time, and the directory that is entered in the shell variable *$HOME*. For complete information on shell variables, see the reference pages for the shell you are using (typically *csh*, *bsh*, *tcsh*, or *ksh*). Home directories are typically placed in */usr/people*, but there is no reason why you cannot select another directory. Some administrators select a different directory to preserve filesystem space on the */usr* filesystem, or simply because the users have a strong preference for another directory name. In any case, the procedure for changing the home directory of a user is quite simple. Follow these steps:

1. Log in as root.
2. Edit the */etc/passwd* file and look for the user entry you want to change. For example:

   ```
   cramden:x:103:101:Ralph Cramden:/usr/people/cramden:/bin/csh
   ```

   In this example, the home directory is */usr/people/cramden*. To change the home directory to a recently added filesystem called *disk2*, change the entry to read:

   ```
   cramden:x:103:101:Ralph Cramden:/disk2/cramden:/bin/csh
   ```

   When you have made your changes, write and exit the file.
3. Create the directory in the new filesystem and move all of the files and subdirectories to their new locations. When this is done, remove the old home directory and the process is finished.
4. Be sure that you notify your users well in advance if you plan to change their home directories. Most users have personal aliases and programs that may depend on the location of their home directories. As with all major changes to your system's layout, changing home directories should not be done for trivial reasons, as it seriously inconveniences users.

Changing a User's Default Shell

To change the default shell, follow these steps:

1. Log in as root.
2. Edit the */etc/passwd* file and change the field that names the user's default shell. For example, in the *passwd* entry:

   ```
   ralph:x:103:101:Ralph Cramden:/usr/people/ralph:/bin/csh
   ```

   The default shell is */bin/csh*. To change Ralph's shell to */bin/ksh*, edit the line to look like this:

   ```
   ralph:x:103:101:Ralph Cramden:/usr/bin/ralph:/bin/ksh
   ```

3. Save and exit the */etc/passwd* file. When the user next logs in, the new default shell will be used.
4. Note that you can use any executable program as the default shell. IRIX simply executes the given program when a user logs in. Note also that using a program other than a command shell such as *csh* or *sh* can cause problems for the user. When the program identified as the default shell in the *passwd* file exits, the user is logged out. For example, if you use */bin/mail* as the default shell, when the user exits *mail*, he or she is logged out and cannot perform any other work.

Configuring The User's Environment

A user's environment is determined by certain shell startup files. For C shell users, these are the files */etc/cshrc* and, in their home directories, *.cshrc* and *.login*. For Korn and Bourne shell users, these are the */etc/profile* file and the *.profile* file in their home directories.

Shell startup files configure a user's login environment and control aspects of subshells created during a login session.

Available Login Shells

The following login shells are provided with IRIX:

/bin/csh The C shell provides a history mechanism (that is, it remembers commands you enter); job control (you can stop processes, place them in background, and return them to foreground); and the ability to use wildcard characters to specify filenames. Users can construct sophisticated commands and scripts using a C programming language-like syntax. For a complete description of this shell, see the csh(1) reference page.

/bin/sh, */bin/ksh* The former */bin/sh* shell is now a symbolic link to the Korn shell, */sbin/sh*. The Korn shell is an expansion of the best features of the Bourne shell and the C shell, and allows for command line editing, job control, programming from the shell prompt in the shell language, and other features. For a complete description of this shell, see the sh(1) reference page. In particular, refer to the section "Compatibility Issues" for information on Bourne and Korn shell compatibility. Refer to the discussion on */bin/bsh* below for information on the Bourne shell.

/bin/bsh The Bourne is a simpler shell than *csh*. The Bourne shell does not contain any kind of history mechanism and uses a different syntax from *csh*. It does make use of wildcard characters and is smaller and faster to invoke than *csh*. For a complete description of this shell, see the bsh(1) reference page.

/bin/rsh This is a restricted shell, which limits the commands a user can type. The *rsh* command syntax is identical to *bsh*, except that users cannot:

- change directories
- use the ls(1) command
- set the shell search path ($PATH)
- specify path or command names containing /
- redirect output (> and >>)

The restrictions of */bin/rsh* are enforced after *.profile* has been executed.

For complete information about these shells, see the ksh(1), csh(1), and bsh(1) reference pages. The *rsh* restricted shell is described on the ksh(1) reference page.

Note: Two shells called *rsh* are shipped with IRIX. */usr/lib/rsh* is the restricted shell. The other shell, in */usr/bsd/rsh*, is the Berkeley remote shell. Be careful not to confuse the two.

The various startup files that configure these shells are described in the next sections.

C Shell Configuration Files

When a C shell user logs in to the system, three startup files are executed in the following order:

1. The */etc/cshrc* file.

   This is an ASCII text file that contains commands and shell procedures, and sets environment variables that are appropriate for all users on the system. This file is executed by the *login* process.

   A sample */etc/cshrc* is shown below:

   ```
   # default settings for all users
   # loaded <<before>> $HOME/.cshrc
   umask 022
   if ($?prompt) cat /etc/motd
   set mail=$MAIL
   if ( { /bin/mail -e } ) then
    echo 'You have mail.'
   endif
   ```

   In the example, several commands are executed:

   - the message of the day is displayed if a prompt exists.
   - the location of the user's mail file is set.
   - a message informs the user if he or she has mail.

2. The individual user's *.cshrc*.

   This file is similar to */etc/cshrc* but is kept in the user's home directory. The *.cshrc* file can contain additional commands and variables that further customize a user's environment. For example, use this file to set the shell prompt for the user. The *.cshrc* file is executed whenever a user spawns a subshell. A sample *.cshrc* is shown below:

   ```
   set prompt  = "Get back to work: "
   set filec
   set history = 20
   ```

   In this example, the user's prompt is set, automatic filename completion is turned on, and the length of the history of recently issued commands is set to 20.

3. The *.login* file.

   This is an executable command file that resides in the user's home directory. The *.login* also customizes the user's environment, but is only executed once, at login time. For this reason, use this file to set environment variables and to run shell script programs that need be done only once per login session. A sample *.login* is shown below:

   ```
   eval ‘tset -s -Q‘
   umask 022
   stty line 1 erase ’^H’ kill ’^U’ intr ’^C’ echoe
   setenv DISPLAY wheeler:0
   setenv SHELL csh
   setenv VISUAL /usr/bin/vi
   setenv EDITOR /usr/bin/emacs
   setenv ROOT /
   set path = (. ~/bin /usr/bsd /bin /usr/bin /usr/sbin \ /usr/bin/X11
   /usr/demos /usr/local/bin)
   ```

   In this example, the user's terminal is further initialized with *tset*, then the file creation mask is set to 022. Some useful key bindings are set, using the command *stty*. The user's default display is set to be on the console screen of the system called wheeler. Several important environment variables are set for commonly used utilities and the filesystem point of reference. Finally, the default path is expanded to include the user's own binary directory and other system directories.

For information on the shell programming commands used in these examples, see the csh(1) reference page.

Bourne and Korn Shell Configuration Files

When a Bourne or Korn shell user logs in to the system, two startup files are executed in the following order:

1. The */etc/profile* file.

   This is an ASCII text file that contains commands and shell procedures and sets environment variables that are appropriate for all users on the system. This file is executed by the *login* process.

   A sample */etc/profile* is shown below:

```
# Ignore keyboard interrupts.
trap "" 2 3
# Set the umask so that newly created files and directories will be
# readable by others, but writable only by the user.
umask 022
case "$0" in
*su )
# Special processing for ‘‘su -’’ could go here.
;;
-* )
# This is a first time login.
#
# Allow the user to break the Message-Of-The-Day only.
trap "trap ’’ 2" 2
cat -s /etc/motd
trap "" 2
# Check for mail.
if /bin/mail -e
then
echo "you have mail"
fi
;;
esac
trap 2 3
```

   In the example, several commands are executed:

   - Keyboard interrupts are trapped.
   - The user's *umask* is set to 022—full permission for the user, read and execute permission for members of the user's group and others on the system.
   - If the user is logging in for the first time, the message of the day (*/etc/motd*) is displayed, and the user is notified if he or she has mail.

2. The individual user's *.profile*.

   This file is similar to */etc/profile*, but is kept in the user's home directory. The *.profile* file can contain additional commands and variables that further customize a user's environment. It is executed whenever a user spawns a subshell.

   A sample *.profile* is shown below:

```
# Set the interrupt character to Ctrl+C and do clean backspacing.
stty intr '' echoe
# Set the TERM environment variable
eval 'tset -s -Q'
# List files in columns if standard out is a terminal.
ls() { if [ -t ]; then /bin/ls -C $*; else /bin/ls $*; fi }
PATH=:/bin:/usr/bin:/usr/sbin:/usr/bsd:$HOME/bin:.
EDITOR=/usr/bin/vi
PS1="IRIX> "
export EDITOR PATH PS1
```

   In this example:

   - The interrupt character is set to **Ctrl+C**.
   - The TERM environment variable is set with *tset*.
   - A function called *ls* is defined so that when the user enters *ls* to list files in a directory, and the command is issued from a terminal or window, the *ls* command is invoked with the **-C** option.
   - The environment variables PATH and EDITOR are set.
   - The user's prompt (PS1) is set to *IRIX*>.

For information on the shell programming commands used in these examples, see the ksh(1) and bsh(1) reference pages.

Configurable Shell Environment Variables

Every shell uses a series of variables that hold information about the shell and about the login account from which it originated. These variables provide information to other processes as well as to the shell itself.

Collectively, these environment variables make up what is called the shell's *environment*. The basic concepts of environment variables and an environment are the same for all types of IRIX shells, although the exact method of creating and manipulating the environment variables differs.

A basic set of environment variables includes where in the IRIX filesystem to search for commands (PATH), the location of the home directory of the user's account (HOME), the present working directory (PWD), the name of the *terminfo* description used to communicate with the user's display screen or terminal (TERM), and some other variables.

When a process (shell) begins, the *exec* system call passes it an array of strings, called the *environment*.

Since *login* is a process, the array of environment strings is made available to it. To look at your current shell environment, use the *printenv* command. A typical C shell environment might look something like this:

```
LOGNAME=trixie
PWD=/usr/people/trixie
HOME=/usr/people/trixie
PATH=.:/usr/people/trixie/bin:/usr/bsd:/bin:/etc:/usr/sbin:
/usr/bin: /usr/local/bin:
SHELL=/bin/csh
MAIL=/var/mail/trixie
TERM=iris-ansi
PAGER=more
TZ=EST5EDT
EDITOR=emacs
DISPLAY=myhost:0
VISUAL=vi
```

For C shell users, these variables are set in the */etc/cshrc*, *.cshrc*, or *.login* startup file. For Korn and Bourne shell users, these variables are set in either the */etc/profile* or *.profile* startup files.

The default environment variables that are assigned for C shell users, if no others are set in any of the startup files, are:

- HOME
- PATH
- LOGNAME
- SHELL
- MAIL
- TZ
- USER
- TERM

Other processes use this information. For example, user *trixie*'s terminal is defined as an *iris-ansi* (TERM=iris-ansi). When the user invokes the default visual editor *vi*, *vi* checks this environment variable, then looks up the characteristics of an *iris-ansi* terminal.

New variables can be defined and the values of existing variables can be changed at any time with the *setenv* command (C shell only). For example, to change the PAGER variable under C shell, enter:

```
setenv PAGER pg
```

This sets the value of the PAGER environment variable to the command *pg*. The PAGER variable is used by *mail*.

Bourne and Korn shell users set environment variables like this:

```
$ PAGER=pg ; export PAGER
```

Environment variables can be set on the command line, or in either of the shell startup files */etc/profile* or *$HOME/.profile*.

Configuring Default File Permissions With umask

A system default called *umask* controls the access permissions of any files or directories that you create. The system default for IRIX, without *umask* set, is 022, which sets the following permissions:

user	Full access: read, write, and, if applicable, execute permission. Directories can be executed; that is, you can "change directories" into any of your own directories and copy files from them.
group	Anyone in the same group can read and, if applicable, execute other group members' files. Execute permission is turned on for directories. Write permission is turned off.
other	All other users on the system have the same access permissions as group access.

The system default *umask* of 022 is the same as running *chmod 644* on files that you create and *chmod 755* on directories and executable files that you create. Setting your *umask* does not affect existing files and directories. To change the default permission, use the *umask* shell command. Like *chmod*, *umask* uses a three-digit argument to set file permissions. However, the argument to *umask* works the opposite as the argument to *chmod*. The argument to *umask* lowers the access permissions from a maximum of 666 (full access for files) and 777 (full access for directories).

The following command leaves permission unchanged for user, group, and other when you create files and directories:

```
umask 000
```

This command reduces access for other users by 1 (it removes execute permission):

```
umask 001
```

This command reduces access for group by 1 (no execute permission) and for others by 2 (no write permission, but execute is allowed):

```
umask 012
```

This command removes write and execute permission for group and removes all permissions for others:

```
umask 037
```

For more information, see the umask(1) reference page.

Configuring Special Login Shells

You may want to assign an account a login shell other than one of the system defaults. Reasons for doing this include:

- The need for special-use accounts that require restricted or very specific access to the system
- A user request for a special shell

You can specify any program as the login shell for an account. For example, you can use a third-party application program as the login shell. Users with this application as a shell log in to the system and are immediately placed in the application. All interaction with the system is through the application, and when the users quit the application, they are automatically logged out. To restrict access to the system, you can also use a custom shell that you create.

Another example is the *nuucp* account, which uses */usr/lib/uucp/uucico* as a login shell.

Many users have favorite shells, for example the *bash* shell, that they might want you to install. As with any other software, make sure it comes from a reputable source. (*bash* shell is public domain software.) You may want to back up the system completely before installing the shell, then monitor the system closely for a while to be sure there are no problems with the shell.

For security reasons, you should not blindly accept compiled binaries and install them as login shells on the system (or anywhere else on the system, for that matter). Start with the source code for the shell, make sure there are no security holes in the code, then compile it for your site.

Note that special shells should be located in a filesystem that is always mounted before users log in to the system. If the filesystem that contains a login shell is not mounted, people who use that shell cannot log in to their accounts.

Communicating with Users

There are several ways to communicate with users in the IRIX system, including electronic mail, the message of the day, the remote login message, *news*, *write*, and *wall*.

Electronic Mail

Users can send messages to one another using one of the electronic mail programs provided with IRIX. Command-line as well as GUI implementations of various mail applications are available. For a complete discussion of configuring electronic mail, see the *IRIX Admin: Networking and Mail* guide.

Message of the Day

You can communicate items of broad interest to all users with the */etc/motd* file. The contents of */etc/motd* are displayed on the user's terminal as part of the login process. The login process executes */etc/cshrc* (for the C shell), which commonly contains the command:

```
cat /etc/motd
```

Any text contained in */etc/motd* is displayed for each user every time the user logs in. For this information to have any impact on users, you must take pains to use it sparingly and to remove outdated announcements.

A typical use for the message of the day facility might be:

```
5/30: The system will be unavailable from 6-11 pm Thursday, 5/30,
while we install additional hardware
```

Be sure to remove the message when it is no longer important.

The file */etc/motd* contains the "message of the day." This message is displayed on a user's screen, either by */etc/profile* if the user runs Bourne shell, or by */etc/cshrc* if the user runs C shell, when the user first logs in to the system.

You can place announcements of system activity in the *motd* file. For example, you should warn users of scheduled maintenance, changes in billing rates, new hardware and software, and any changes in the system or site configuration that affect them.

Since users see this message every time they log in, change it frequently to keep it from becoming stale. If users see the same message repeatedly, they lose interest in reading the message of the day and can miss an important announcement.

Make sure you remove outdated announcements. If nothing new is happening on the system, trim the file to a short "welcome to the system" message.

A typical *motd* file looks something like this:

```
Upcoming Events: ---------------

26 November -- The system will be down from 8pm until Midnight for a
software upgrade. We are installing FareSaver+, Release 3.2.2d.

Watch this space for further details.

28 November through 31 November -- We will be operating with a minimal
staff during the holiday. Please be patient if you need computer
services. Use the admin beeper (767-3465) if there is a serious
problem.
```

The *motd* file is used more frequently on servers than on workstations, but can be handy for networked workstations with guest accounts. You can also send electronic mail to all people who use the system, but this method consumes more disk space, and users may accidentally skip over the mail in their mailboxes.

Remote Login Message

The */etc/issue* file is the equivalent of the */etc/motd* file for users who log in over a serial line or the network. If */etc/issue* does not exist, or is empty, no message is displayed.

The */etc/issue message* is displayed before the login prompt is given to someone attempting to log in to a system over a serial line or the network. If */etc/issue* does not exist, or is empty, no message is displayed. This is essentially different from */etc/motd* because it is displayed *before* the login prompt. This message is often used to notify potential users of rules about using the equipment; for example, a disclaimer that the workstation or server is reserved for employees of a particular corporation and that intruders will be prosecuted for unauthorized use.

News

You can set up a simple electronic bulletin board facility with the */usr/news* directory and the *news* command. With *news*, you can post messages of interest about the system. This is not the same system as the publicly distributed Usenet system. Place announcements of interest about the system in the directory */usr/news*. Use one file per announcement, and name each file something descriptive, such as *downtime* and *new-network*. Use the *news* command to display the items.

You can automatically invoke *news* from a shell startup file, for example from the */etc/cshrc* file. It is a good idea to check for new news items only from a shell startup file, since users may not be ready to read news immediately upon logging in. For example:

```
news -s
```

With the **-s** argument, *news* indicates how many articles there are since you last read news.

When you read news with the *news* command, you can do the following:

Read everything
: To read all news posted since the last time you read articles, enter the *news* command with no arguments:

  ```
  news
  ```

Select some items
: To read selected articles, enter the *news* command with the names of one or more items as arguments:

  ```
  news downtime new-network
  ```

Read and delete
: After you run the *news* command, you can stop any item from printing by pressing **Ctrl+C** or **Break**. Pressing **Ctrl+C** or **Break** twice stops the program.

Ignore everything
: If you are too busy to read announcements at the moment, you can read them later. Items remain in */usr/news* until the administrator (*root*) removes them. The list of news items is still displayed each time you log in.

Flush all items

There are two ways to catch up with all current news items:

`touch .news_time`

This updates the time-accessed and time-modified fields of the *.news_time* file and thus the *news* program no longer considers there are articles for you to read.

This command prints all current articles, but sends the output to */dev/null* so you do not see the articles:

`news > /dev/null`

This brings you up to date without reading any outstanding articles.

Write to a User

Use the *write* command to write messages to a user on the system. For example:

`write ralph`

User *ralph* sees this on his screen:

```
Message from root on brooklyn (console) [ Tue Feb 26 16:47:47 ] ...
```

You can wait for *ralph* to respond, or you can begin typing your message. If the other user responds, you see a similar message on your screen.

Type your message. As you press Enter, each line of your message is displayed on the other user's screen.

Usually a *write* session is a dialogue, where each user takes turns writing. It is considered good etiquette to finish your turn with a punctuation mark on a line by itself, for example:

```
I noticed that you are using over 50 meg of disk space. Is there
anything I can do to help you reduce that?
>
```

Entering the greater-than symbol indicates you are through with your paragraph and are waiting for user *ralph* to respond. The other user should choose a different punctuation character to indicate when he or she is through.

You can prevent other users from writing to you with *write* by making your terminal or window unwritable. Use the *mesg* command:

```
mesg n
```

The *n* argument makes your terminal or window unwritable, and the *y* argument makes it writable. The superuser can write to any terminal or window, even if the user has made his or her terminal unwritable with *mesg n*.

The *talk* utility is similar to *write*, and is preferred by some users. For more information, refer to the talk(1) and write(1) reference pages.

Write to All Users

The superuser can use the *wall* command to write to all the users who are logged in on the system. This useful when you need to announce that you are bringing the system down.

To use *wall*, enter:

```
wall
```

Enter your message. Press Ctrl+D when you are finished, and *wall* sends the message.

You can also compose the message in a file, for example *messagefile*, then send it using *wall*:

```
wall < messagefile
```

The *wall* command is not affected by a user's *mesg* setting. That is, a user cannot stop *wall* from displaying on his or her screen. On a graphics display with multiple windows, the message is displayed in all windows.

Chapter 6

Configuring Disk and Swap Space

Chapter 6 provides information on configuring your system disk space for maximum effectiveness, including allocating swap space for the operating system kernel. Topics described in this chapter include:

- Disk usage information commands
- Using disk quotas
- Using NFS and disk partitions to manage disk space
- Setting and increasing system swap space

Chapter 6

Configuring Disk and Swap Space

For a variety of reasons, users often accumulate files without realizing how much disk space they are using. This is not so much a problem for workstation users, but can be a big problem for servers, where multiple users must share system resources. IRIX provides a number of utilities to help you manage disk usage.

You also may need to allocate disk space for the system to use as swap space. Swap space is disk space allocated to be used as medium-term memory for the operating system kernel. Lack of swap space limits the number and size of applications that may run at once on your system, and can interfere with system performance.

This chapter provides you with some background information on disk usage and the tools and options available to you to manage it. For specifics on setting and maintaining disk quotas, see the *IRIX Admin: Disks and Filesystems* guide.

Disk Usage Commands

The commands in this section help you determine the current status of disk usage on your system.

du Command

The *du* command shows specific disk usage by file or directory anywhere on the system. The size of the files and directories can be shown in 512-byte blocks, or in 1K blocks if you use the **-k** flag. For more complete information, consult the du(1) reference page.

df Command

The *df* command shows the free space remaining on each filesystem on your workstation. Free space is shown for all filesystems, whether they are local or NFS-mounted. The amount of free space is displayed in 512-byte blocks, or in 1K blocks if you use the **-k** option. For more complete information, consult the df(1) reference page.

quot Command

The *quot* command displays the number of kilobytes of disk usage for each user in a specified filesystem. You can use the output of this command to mail your users, notifying them of their disk usage. For complete information, see the quot(1M) reference page.

diskusg Command

Part of the system accounting package is the *diskusg* command. Like *quot*, this utility reports the disk usage of each user on your system. The difference is that *diskusg* is typically used as part of the system accounting package with *dodisk* rather than as a standalone command. For complete information on using *diskusg*, see the diskusg(1) reference page.

Managing Disk Space

This section describes several commands you can use to help you in managing disk space. In particular, various techniques are discussed which allow you to maximize available disk space.

File Compression and Archiving

One way to minimize disk usage is to encourage your users to archive or compress their files. Compression works best for files that are rarely used but that should not be discarded. Users can achieve some disk savings by using the *compress* utility. Compressing a file allows you to leave it on the system, but can reduce the size of the file by as much as 50%. Compressed files have the suffix *.Z* and should not be renamed. Compression and archiving can be used together for maximum disk space savings.

If the files in question are used infrequently, consider archiving them to tape, floppy, or other archive media. This maintains protection if you need the files later, but regaining them is slightly more difficult than if they are compressed.

The quotas Subsystem

The *quotas* subsystem allows you to deal with severe disk usage problems. Using this subsystem, you can place a maximum disk usage quota on each user on your system. For complete information about this subsystem, see the quotas(4) reference page.

In general, it is your job as the site administrator to set disk use policies, establishing and enforcing quotas if necessary. You should publish clear guidelines for disk use, and notify users who regularly exceed their quotas. It is also a good idea to impose quotas on the use of temporary directories, such as */tmp* and on all anonymous "guest" accounts, such as *guest* and *uucp*. If your root filesystem reaches 100% capacity, your system may shut down and inconvenience your users.

Be as flexible as possible with disk quotas. Often, legitimate work forces users to temporarily exceed disk quotas. This is not a problem as long as it is not chronic.

Do not, under any circumstances, remove user files arbitrarily and without proper warning.

A typical scenario is when all the users on the system know they should try to limit disk use in their home accounts to about 20 MB (about 40,000 512-byte blocks). User *norton* consistently uses more than twice this limit. These are the steps you take to alleviate the problem:

1. Meet with the user and find out why he or she is using this much disk space. There may be legitimate reasons that require you to reconsider the disk use policy and perhaps increase the amount of available disk space.

   If the user is merely saving an inordinate number of outdated files, suggest that he or she back up the files onto tape and remove them from the system. For example, many users save electronic mail messages in enormous mailboxes for long after the messages are useful. Saving the files to tape keeps them handy, while saving disk space.

2. If you cannot meet with the person, or cannot discuss the matter in person, try sending electronic mail.

   If you use a script that automatically checks disk use (with *diskusg*) and sends mail to users who exceed their quotas, note that people get used to these messages after some time and start to ignore them. Send the particular user a personal message, stating that you need to discuss the situation.

3. Sometimes a user is not aware that data is available elsewhere on the system, or on other accessible workstations at the site. A user may have personal copies of site-specific tools and data files. Work with the user to reduce this kind of redundancy.

4. Make sure the user is still active on the system. Sometimes people leave an organization, and the site administrators are not immediately informed.

   Also, the user may not need the account on a particular workstation any longer and may not have cleaned up the files in that account. To see if this is the case, check the last time the user logged in to the system with the finger(1) command:

   ```
   finger norton
   ```

   Among other information, *finger* displays the date and time the user last logged in to the system. This information is read from */etc/wtmp*, if it exists.

5. If in an extreme case you must remove a user's files, back them up to tape before removing them. Do not take this step lightly. Removing user files unnecessarily can disrupt work and engender ill will from your coworkers. Make sure you give the user plenty of advance notice that you are going to copy the files to tape and remove them from the system.

   As an added precaution, you may want to make two copies of the tape and send one copy to the user whose files you remove. Make sure you verify that the tapes are readable before you remove the files from the system.

Managing Disk Space With NFS

If your system is running the optional Network File System (NFS) software, you can use this product to reduce disk consumption on your workstations by exporting commonly used directories. When a system exports a directory, it makes that directory available to all systems running the NFS software. For example, if you have 10 workstations on your network and each workstation is storing 5 MB of online reference pages and release notes, you can eliminate 45 MB of wasted disk space by designating one workstation to be the reference page server and exporting the */usr/man* and */usr/catman* directories. All other workstations can remove those files and mount them remotely from the server. Since NFS mounts take up no disk space on the client workstation, that disk space is available for other uses.

Another option is to mount free disk space from another system. This option works best when there is an uneven load across several systems. For example, if one workstation is using only 25% of its available space and other workstations are above 90%, it may be useful to mount a filesystem to even out the load.

Used wisely, your network can save a tremendous amount of disk space through this strategy. Be aware, though, that the drawback to this strategy is that if your server must be rebooted or serviced, no one can access the files and programs that are mounted from that server while it is offline.

Managing Disk Space With Disk Partitions

An extreme method of enforcing disk use quotas is to create a disk partition and filesystem for each user account and to mount the filesystem on an empty directory as the user's home directory. Then, when users run out of disk space, they will not be able to create or enlarge any files. They can, however, still write their files to */tmp* and */var/tmp*, unless those directories are also full. When users attempt to write or create a file that takes them over their limit, they receive an error message indicating that no disk space is left on the device.

This method of disk control is not generally recommended. It requires a great deal of preparation and maintenance on the part of the administrator, and is not easily modified once in place. Additionally, fragmenting your disk into many small partitions reduces the total amount of available disk space and produces a performance overhead on your system. In this case, the disk controller must write a user's files within only one small partition, instead of in the next convenient place on the disk.

Consider this method of disk space control only if your system is so overloaded and your users so obstinate that all other measures have failed. If your */usr* partition is chronically 100% full, the system is halting operations daily due to lack of disk space, and there is no way to increase your disk space, then you may want to consider this method.

Reducing Wasted Disk Space

Sometimes there is a great deal of wasted disk space on a system. When you are low on space, check to make sure that large files have not accumulated in the temporary directories or in the administrative directories.

The */var/adm* directory structure is notorious for accumulating large log files and other large files that are useful for debugging problems that use up a tremendous amount of space. The */var/adm/crash* directory may be storing several images of the IRIX kernel (from past system failures) and copies of the entire core memory (*vmcore*). These files can take up large amounts of space (many megabytes) and should be archived on tape and removed from your system.

If you have system auditing enabled, be aware that this facility generates very large audit trail record files, and these need to be archived to tape on a regular (perhaps daily) basis.

Also, check any UUCP or *ftp* directories you may have available, and generally look for *core* files, and any other large and unnecessary files that may exist on your system.

Swap Space

The IRIX operating system uses a portion of the disk as *swap space* for temporarily saving part or all of a user's program when there is not enough physical memory to contain all of the running programs. If you run many very large programs, you might run out of swap space. For a complete discussion of the dynamics of paging and swapping, see "Checking for Excessive Paging and Swapping" on page 197.

Use *sar -p*, *sar -w*, *sar -q*, *swap -s*, and *swap -l* to monitor paging and swap space use. If you find that you are running out of swap space, two solutions are available: you can add more memory, or you can add more swap space. Adding swap space does not improve the performance of large programs, but it permits them to run successfully.

Under sar(1), swapping of whole processes is reported with the **-w** flag. Performance problems associated with swapping come from the excess or slow I/O involved in paging.

IRIX allows programs occupying more space than the system limit to run, since each program is only partially loaded into memory at any given time. One of the effects of this policy is that IRIX has to preallocate swap space based on likely future usage, and sometimes this prediction is incorrect. When the swap space is actually needed, IRIX allocates the most convenient available space, not the specific space allocated. So the physical allocation is separate from the accounting allocation.

If your system preallocates all your swap space, but the space has not yet been used, it may appear that your system is running out of swap space when it is not. It is possible that your system has simply preallocated the rights to future swap space to existing processes, and no new processes can allocate space due to the strict swap space accounting in IRIX.

Strict swap space accounting is always in effect, but the ability to add both physical and virtual swap space through ordinary system files allows the administrator to add swap space or to effectively turn off strict swap space accounting, without having to either repartition the disk or reconfigure and reboot the system.

Adding Virtual Swap Space

If processes are being denied stack growth or new processes due to a stated lack of swap space, and you believe that there is adequate physical space, add the following entry to your */etc/fstab* file:

```
/usr/swap swap swap pri=4,vlength=204800 0 0
```

Then give the command:

```
mkfile -v 0b /usr/swap
```

The file (*/usr/swap*) will be zero-length, so you have added only virtual swap space and no real swap area. Your kernel should then allow more processes to execute. However, when an attempt is made to access more than the system limit, IRIX swaps the largest running program out of memory.

Listing Swap Space With the swap -l Command

To determine how much swap space is already configured in your workstation, use the swap(1M) command:

```
swap -l
```

If you are running applications that require the system to swap out programs frequently, you may also want to fine-tune the swap area of the disk used by the operating system. For more information on this process, see “Checking for Excessive Paging and Swapping” on page 197.

Checking Swap Activity With the swap -s Command

The *swap -s* command is a very useful tool for determining if you need to add swap space of some sort. The output of the *swap -s* command looks something like:

```
total: 0 allocated + 64248 reserved = 64248 blocks used, 17400 blocks
available
```

where the fields displayed are as follows (see the swap(1M) reference page for more details):

Allocated — The number of 512- bytes blocks allocated to private pages (for example, pages that contain data that is in use)

Reserved — The number of 512- byte blocks currently allocated but not yet marked as private pages (the space has been claimed, but is not yet being used)

Blocks used — The number of 512- byte blocks either allocated or reserved (the total number of allocated and reserved blocks)

Blocks available — The number of 512- byte blocks available for future reservation and allocation (the total swap shown by the *swap -l* command less the number of blocks used)

Given the following sample *swap -s* output:

```
total: 0 allocated + 34200 reserved = 34200 blocks used, 47448 blocks
available
```

You see that 0 swap blocks are in use, 34200 have been reserved but not used, which leaves 47448 blocks available for reservation. So, at this point, the system is not swapping, but the programs running on the system have requested approximately 17 megabytes of swap space, just in case they need to grow.

Note: 10000 blocks is equal to approximately 5 Megabytes

Many applications reserve what is known as virtual swap space. That is, they request more memory than they will ever need. The actual size of the application is the amount of physical system resources that the application is using. The virtual size of the application is the amount of system resources it is using plus the amount of extra resources requested but not in use. This is the case in the above example; space has been reserved, but is not in use.

Negative Swap Space

Look at another example of *swap -s* output:

```
total: 41920 allocated + 58736 reserved = 100656 blocks used, -19400
blocks available
```

It may seem worrisome that the swap space available is a negative number. What this means, though, is that some of the allocated / in use pages are located in main memory (RAM). The *swap -s* output does not take main memory into account. The data that is shown in the negative is actually data that is contained in system memory.

It appears that approximately 20 megabytes of physical swap space is in use, as shown by the amount of allocated space. Therefore, the system is not out of physical swap space. If there was no more physical swap space, the number of allocated blocks would be very close to the number of blocks reported by the *swap -l* command. Approximately 30 additional megabytes of swap space has been requested, shown by the requested field, giving a total of 50 megabytes requested and / or in use. This appears to leave an overrun of 10 megabytes.

Another way to think of that negative number is that it is the amount of physical swap space minus the number of blocks used (allocated + requested). So, as long as that negative number has an absolute value less than approximately the amount of physical memory (obtained from the *hinv* command) that you have, you have not overrun your system.

The following example shows *swap -s* output of a system that has most likely come to its swapping limit:

```
total: 76920 allocated + 23736 reserved = 100656 blocks used, -19400
blocks available
```

Notice that the total numbers are the same, but the number of allocated blocks is much higher. If the *swap -l* in this example were to report 81000 blocks of physical swap space on the system, it is easy to see that there are only 4000 physical blocks that are not in use.

If *swap -s* reports a negative number, increase virtual swap when your system is not near its physical limits. This allows your system to allocate space to those applications that grab more space than they actually need. To do this, you can turn on virtual swapping by entering the following commands:

```
su
chkconfig vswap on
/etc/init.d/swap start
```

This allocates more swap space, or space that can be reserved but not allocated. See the */etc/init.d/swap* file and the swap(1M) reference page for more information.

If virtual swapping is already on (use *chkconfig* to find out) or if the number of allocated blocks is approaching the number of blocks reported by the *swap -l* command, the only way to remedy the situation is to add more physical memory or swap space. See the swap(1M) reference page for more information regarding adding swap space (whether through another disk partition or a swap file).

Increasing Swap Space on a One-Disk System

Suppose you don’t have the luxury of a multiple-disk system. This section explains how to increase the size of the swap partition on a single disk. You can increase your available swap space by repartitioning your disk, as described earlier in this chapter, or you can add space with the *swap* command as discussed here.

The *swap* command allows you to designate a portion of any disk partition as additional swap space. You can add swap space at any time and delete the new swap space when you no longer need it. There are several options available with this command, and the command is described completely in the swap(1M) reference page, but the most convenient method to use is to specify a normal system file as additional swap space.

To specify a file as additional swap space, you first create an empty file of appropriate size with the mkfile(1M) command. For example, if you want to add 10 megabytes of swap space to your system, and you want that space to be taken from the */usr* filesystem, use the following *mkfile* command:

```
mkfile -v 10m /var/tmp/moreswap
```

In this command, the **-v** option directs *mkfile* to be verbose in its output to you, which means that you see the following message as a confirmation that the file has been created:

```
/var/tmp/moreswap 10485760 bytes
```

If you do not specify the **-v** option, *mkfile* does its work silently. The second field in the *mkfile* command is the size of the file. In this case, **10m** specifies a file that is 10 megabytes in size. You can use **b**, **k**, or **m** as a suffix to the **size** argument to indicate that the size number is in bytes, kilobytes, or megabytes, respectively. For example, the following commands all produce files of 10 megabytes:

```
mkfile -v 10485760b /var/tmp/moreswap
mkfile -v 10240k /var/tmp/moreswap
mkfile -v 10m /var/tmp/moreswap
```

Once your file is created, you can use the *swap* command to add it as swap space on the system. When you make your file, be certain that the file resides in the filesystem from which you want to take the space. The */var/tmp* directory is a good place to use as it typically has more available space than the *root* filesystem (/). Note, however, that you can also use filesystems mounted remotely via NFS. Complete information on using remote mounted filesystems for swap space is available in the swap(1M) reference page.

To begin using your new file as swap space, give the following command:

```
/sbin/swap -a /var/tmp/moreswap
```

The **-a** option indicates that the named file is to be added as swap space immediately. To check your new swap space, use the command:

```
swap -l
```

This command lists all current swap spaces and their status.

To make your new swap file permanent (automatically added at boot time), add the following line to your */etc/fstab* file:

```
/var/tmp/moreswap    swap    swap   pri=3  0  0
```

Note that if you create a swap file in the */tmp* directory of your root filesystem, the file is removed when the system is booted. The */var/tmp* directory of the */var* filesystem is not cleaned at boot time, and is therefore a better choice for the location of swap files. If you want to create your swap files in the root filesystem, first create a */swap* directory, and then create your swap files within that directory.

Increasing Swap Space on a Multidisk System

Adding more swap space to a multidisk system can be done just as if you were adding space on a single-disk system. You can always use the *mkfile* and *swap* commands to add a swap file to your system. However, if you want to add dedicated swap space in a new disk partition, follow the procedures in this example:

1. To double the default amount of swap space, you can use another disk drive as follows:

   ```
   Partition/slice
       0        Temporary space (mount as /tmp)
       1        Swap space
       6        usr2
   ```

   Note that the operating system continually writes onto the partition that is used as swap space, completely destroying any data that might exist there. Be sure that the swap partition does not overlap any user filesystem partitions. Verify the size of the swap partition in blocks.

2. Once you choose a partition, create the file */etc/init.d/addswap* to add this partition permanently as a swap partition. Place a line of the following form in the file:

   swap -a /dev/dsk/*devicename* **0** *length*

   The argument *devicename* is the device name where the swap partition is located (such as *ips0d1s1*), and *length* is in blocks.

3. Use the *chmod* command to enable execute permission on the file. The command is:

   chmod +x addswap

4. Create a symbolic link to the new file with the command:

   ln -s /etc/init.d/addswap /etc/rc2.d/S59addswap

   The */etc/rc2.d* directory controls the system activities that take place when the system boots into multiuser mode (run level 2). The *S* at the beginning of the symbolic link file that you created indicates that the commands in the file should be *started* when the system initiates this run level. Symbolic link files that begin with the letter *K* indicate that the commands described in the file should be *killed*. The number following the *S* or *K* at the beginning of the link filename indicates the sequence in which the commands are executed.

   You can also modify the file */etc/fstab* to document (in the form of a comment) that the chosen partition is being used as a swap partition.

Chapter 7

Managing User Processes

Chapter 7 describes the tasks you may perform to manage user processes. Topics described in this chapter include:

- Monitoring user processes
- Prioritizing processes
- Terminating processes

Chapter 7

Managing User Processes

Just as files can use up your available disk space, too many processes going at once can use up your available CPU time. When this happens, your system response time gets slower and slower until finally the system cannot execute any processes effectively. If you have not tuned your kernel to allow for more processes, the system refuses new processes long before it reaches a saturation point. However, due to normal variations in system usage, you may experience fluctuations in your system performance without reaching the maximum number of processes allowed by your system.

Monitoring User Processes

Not all processes require the same amount of system resources. Some processes, such as database applications working with large files, tend to be *disk intensive*, requiring a great deal of reading from and writing to the disk as well as a large amount of space on the disk. These activities take up CPU time. Time is also spent waiting for the hardware to perform the requested operations. Other jobs, such as compiling programs or processing large amounts of data, are *CPU intensive*, since they require a great number of CPU instructions to be performed. Some jobs are *memory intensive*, such as a process that reads a great deal of data and manipulates it in memory. Since the disk, CPU, and memory resources are limited, if you have more than a few intensive processes running at once on your system, you may see a performance degradation.

As the administrator, you should be on the lookout for general trends in system usage, so you can respond to them and keep the systems running as efficiently as possible. If a system shows signs of being overloaded, and yet the total number of processes is low, your system may still be at or above reasonable capacity. The following sections show four ways to monitor your system processes.

Monitoring Processes With top

The *top* and *gr_top* commands are the most convenient utilities provided with IRIX to monitor the top CPU-using processes on your system. These utilities display the top such processes dynamically, that is, if a listed process exits, it is removed from the table and the next-highest CPU-using process takes its place. *gr_top* graphically displays the same information as *top*. If you are using a non-graphics server, you cannot use *gr_top* locally, but you can use it if you set the display to another system on the network that does have graphics capability. For complete information on configuring and using *top* and *gr_top*, consult the top(1) and gr_top(1) reference pages. For information on resetting the display, see “Displaying Windows on Alternate Workstations” on page 20.

Monitoring Processes With osview

The *osview* and *gr_osview* commands display kernel execution statistics dynamically. If you have a graphics workstation, you can use the gr_osview(1) tool, which provides a real-time graphical display of system memory and CPU usage. *osview* provides the same information in ASCII format. You can configure *gr_osview* to display several different types of information about your system’s current status. In its default configuration, *gr_osview* provides information on the amount of CPU time spent on user process execution, system overhead tasks, interrupts, and idle time. For complete information on *osview* and *gr_osview*, see the osview(1) and gr_osview(1) reference pages.

Monitoring Processes With sar

The System Activity Reporter, *sar*, provides essentially the same information as *osview*, but it represents a “snapshot” of the system status, not a dynamic reflection. Because *sar* generates a single snapshot, it is easily saved and can be compared with a similar snapshot taken at another time. You can use *sar* automatically with *cron* to get a series of system snapshots over time to help you locate chronic system bottlenecks by establishing baselines of performance for your system at times of light and heavy loads and under loads of various kinds (CPU load, network load, disk load, and so on). For complete information on *sar*, see *IRIX Admin: Backup, Security, and Accounting* and the sar(1) reference page. For more information on using *sar* to monitor system activity, see “Using timex(1), sar(1), and par(1)” on page 188.

Monitoring Processes With ps

The *ps -ef* command allows you to look at all the processes currently running on your system. The output of *ps -ef* follows the format shown in Table 7-1:

Table 7-1 Output Format of the *ps -ef* Command

Name	PID	PPID	C	Time	TTY	CPU Time	Process
joe	23328	316	1	May 5	ttyq1	1:01	csh

In this table, the process shown is for the user joe. In a real situation, each user with processes running on the system is represented. Each field in the output contains useful information.

Name	The login name of the user who “owns” the process.
PID	The process identification number.
PPID	The process identification number of the parent process that spawned or forked the listed process.
C	Current execution priority. The higher this number, the lower the scheduling priority. This number is based on the recent scheduling of the process and is not a definitive indicator of its overall priority.
Time	The time when the process began executing. If it began more than 24 hours before the *ps* command was given, the date on which it began is displayed.
TTY	The TTY (Terminal or window) with which the process is associated.
CPU	The total amount of CPU time expended to date on this process. This field is useful in determining which processes are using the most CPU time. If a process uses a great deal in a brief period, it can cause a general system slowdown.

For even more information, including the general system priority of each process, use the **-l** flag to *ps*. For complete information on interpreting *ps* output, see the ps(1) reference page.

Prioritizing Processes With nice

IRIX provides methods for users to force their CPU-intensive processes to execute at a lower priority than general user processes. The nice(1) and npri(1M) commands allow the user to control the priority of their processes on the system. The *nice* command functions as follows:

nice [-*increment* **]** *command*

When you form your command line using */bin/nice*, you fill in the *increment* field with a number between 1 and 19. If you do not fill in a number, a default of 10 is assumed. The higher the number you use for the *increment*, the lower your process' priority will be (19 is the lowest possible priority; all numbers greater than 19 are interpreted as 19). The csh(1) shell has its own internal *nice* functions, which operate differently from the *nice* command, and are documented in the csh(1) reference page.

After entering the *nice* command and the increment on your command line, give the *command* as you would ordinarily enter it. For example, if the user joe wants to make his costly compile command happen at the lowest possible priority, he forms the command line as follows:

```
nice -19 cc -o prog prog.c
```

If a process is invoked using *nice*, the total amount of CPU time required to execute the program does not change, but the time is spread out, since the process executes less often.

The superuser (root) is the only user who can give *nice* a negative value and thereby *increase* the priority of a process. To give *nice* a negative value, use two minus signs before the increment. For example:

```
nice --19 cc -o prog prog.c
```

The above command endows that process with the highest priority a user process can have. The superuser should not use this feature frequently, as even a single process that has been upgraded in priority causes a significant system slowdown for all other users. Note that */bin/csh* has a built-in *nice* program that uses slightly different syntax from that described here. For complete information on *csh*, see the csh(1) reference page.

The *npri* command allows users to make their process' priority *nondegrading*. In the normal flow of operations, a process loses priority as it executes, so large jobs typically use fewer CPU cycles per minute as they grow older. (There is a minimum priority, too. This priority degradation simply serves to maintain performance for simple tasks.) By using *npri*, the user can set the *nice* value of a process, make that process nondegrading, and set the default time slice that the CPU allocates to that process. *npri* also allows you to change the priority of a currently running process. The following example of *npri* sets all the possible variables for a command:

```
npri -h 10 -n 10 -t 3 cc -o prog prog.c
```

In this example, the **-h** flag sets the nondegrading priority of the process, while the **-n** flag sets the absolute *nice* priority. The **-t** flag sets the time slice allocated to the process. IRIX uses a 10-millisecond time slice as the default, so the example above sets the time slice to 30 milliseconds. For complete information about *npri* and its flags and options, see the npri(1) reference page.

Changing the Priority of a Running Process

The superuser can change the priority of a running process with the renice(1M) or *npri* commands. Only the superuser can use these commands. *renice* is used as follows:

renice -n *increment pid* [**-u** *user*] [**-g** *pgrp*]

In the most commonly used form, *renice* is invoked on a specific process that is using system time at an overwhelming rate. However, you can also invoke it with the **-u** flag to lower the priority of all processes associated with a certain user, or with the **-g** flag to lower the priorities of all processes associated with a process group. More options exist and are documented in the renice(1M) reference page.

The *npri* command can also be used to change the parameters of a running process. This example changes the parameters of a running process with *npri*:

```
npri -h 10 -n 10 -t 3 -p 11962
```

The superuser can use *renice* or *npri* to increase the priority of a process or user, but this can have a severe impact on system performance.

Terminating Processes

From time to time a process may use so much memory, disk, or CPU time that your only alternative is to terminate it before it causes a system crash. Before you kill a process, make sure that the user who invoked the process does not try to invoke it again. You should, if at all possible, speak to the user before killing the process, and at a minimum notify the user that the process was prematurely terminated and give a reason for the termination. If you do this, the user can reinvoke the process at a lower priority or possibly use the system's job processing facilities (*at*, *batch*, and *cron*) to execute the process at another time.

To terminate a process, use the *kill* command. For most terminations, use the *kill -15* variation. The **-15** flag indicates that the process is to be allowed time to exit gracefully, closing any open files and descriptors. The **-9** flag to *kill* terminates the process immediately, with no provision for cleanup. If the process you are going to kill has any child processes executing, using the *kill -9* command may cause those child processes to continue to exist on the process table, though they will not be responsive to input. The wait(1) command, given with the process number of the child process, removes them. For complete information about the syntax and usage of the *kill* command, see the kill(1) reference page. You must always know the PID of the process you intend to kill with the *kill* command.

Killing Processes by Name with the killall Command

The *killall* command allows you to kill processes by their command name. For example, if you wish to kill the program *a.out* that you invoked, use the syntax:

```
killall a.out
```

This command allows you to kill processes without the time-consuming task of looking up the process ID number with the *ps* command.

Note: This command kills all instances of the named program running under your shell and if invoked with no arguments, kills all processes on the system that are killable by the user who invoked the command. For ordinary users, these are simply the processes invoked and forked by that user, but if invoked by root, all processes on the system are killed. For this reason, this command should be used carefully. For more information on *killall*, refer to the killall(1M) reference page.

Chapter 8

Troubleshooting the File Alteration Monitor

Chapter 8 describes the File Alteration Monitor. This software monitors specified files and directories for changes and reports the changes to application software such as WorkSpace and Mailbox. Topics described in this chapter include:

- Verifying that FAM is installed on your system
- Troubleshooting FAM

Chapter 8

Troubleshooting the File Alteration Monitor

The File Alteration Monitor (*fam*) is a daemon that monitors files and directories. Application writers can include certain function calls in their applications to let *fam* know that they want to be informed of changes to whichever files and/or directories they specify. WorkSpace and Mailbox are two applications that use *fam*; WorkSpace uses it to keep the directory views up to date, and Mailbox uses it to know when to indicate the arrival of new mail.

The *fam* daemon runs only when applications using it are running; it exits after all programs using it have stopped.

Sometimes, when attempting to start up an application that uses *fam*, an error message is displayed:

```
Cannot connect with File Alteration Monitor (fam)
```

There are several reasons why this message appears. This chapter describes some of the common ways to troubleshoot the problem.

Basic fam Troubleshooting

If you see this message on your screen:

```
Can't connect to fam
```

or

```
Cannot connect with File Alteration Monitor (fam)
```

Perform these steps:

1. Check to see if *fam* is running with the command:

   ps -ef | grep fam

2. If *fam* is not running, verify the following things:

   - Verify that */usr/etc/fam* exists and is executable with the following command:

     ls -l /usr/etc/fam

     If the file is not found, you must reinstall the *eoe.sw.unix* subsystem.

     If the file is found, the permissions should be:

     ```
     -rwxr-xr-x 1 root sys 156484 Jan 24 18:34 /usr/etc/fam
     ```

     The date and size may vary.

   - Verify that *fam* is listed in the */etc/inetd.conf* file. The *fam* daemon is invoked when the system starts up the network. Even if the system is not networked to other systems, the network software must be started. A line similar to the following should be found in */etc/inetd.conf*:

     ```
     sgi_fam/1 stream rpc/tcp wait root ?/usr/etc/fam famd -t 6
     ```

   - Verify that *inetd* is running with the command:

     ps -ef | grep inetd

     You should see a response similar to:

     ```
     root   214     1  0   Oct 24 ?       0:01 /usr/etc/inetd
     ```

     If the message

     ```
     portmapper failure
     ```

     is displayed, it is also a sign that the network is not active. Start the network according to the steps outlined in the *IRIX Admin: Networking and Mail* guide.

- Verify that *fam* is registered with *portmapper* with the command:

  rpcinfo -p | grep fam

  You see output similar to the following:

  ```
  391002    1   tcp   1033  sgi_fam
  ```

  If you are using a foreign NIS master system, see the section "If You Are Using a Sun NIS Master".

3. If *fam* is running, turn on debugging mode by adding a **-d** flag to the entry in */etc/inetd.conf*. The finished line should be similar to the following:

   ```
   sgi_fam/1 stream rpc/tcp wait root ?/usr/etc/fam famd -t 6 -d
   ```

   Reboot your system for the debugging to take effect. The debugging information is written in the file */var/adm/SYSLOG*. This can be conveniently viewed with the *sysmon* tool, described in "sysmon System Log Viewer" on page 38.

If You Are Using a Sun NIS Master

If you have the optional NIS (YP) software installed at your site, and you are using a Sun™ system as your NIS master, with no *rpc* entries for *sgi_toolkitbus* and *sgi_fam*, this section provides the information to correct the error message.

Depending on the operating system (the Sun 3.*x* or the Sun 4.0) on the Sun NIS (YP) server, one of the two following solutions applies.

- Sun 3.*x*

  If the Sun workstation is running version 3.*x* of Sun / OS, add two entries to the */etc/rpc* database on the Sun NIS server. They are:

  - `sgi_toolkitbus 391001`
  - `sgi_fam 391002`

  On the NIS server, enter the command:

  cd /usr/etc/yp; make rpc

  This may take as much as an hour before the NIS server pushes this information to its clients.

- Sun 4.0

  If the Sun workstation is running version 4.0 of Sun / OS or later, add two entries to the */etc/rpc* database on the Sun NIS server machine. They are:

  - `sgi_toolkitbus 391001`
  - `sgi_fam 391002`.

  On the NIS server, type:

  `cd /var/yp; make rpc`

  It may take as much as an hour before the NIS server pushes this information to its clients.

Note: If the NIS system is neither Silicon Graphics or Sun server, the same *rpc* entries must be added, but the syntax may be different.

Chapter 9

Using the Command (PROM) Monitor

Chapter 9 describes the Command Monitor, also known as the PROM Monitor. Both the old-style PROM monitor and the newer ARCS PROM monitor are described. Topics described in this chapter include:

- Entering the Command Monitor
- Summary of commands
- Getting help
- Running the Command Monitor
- The Command Monitor environment
- Booting a program or operating system from the Command Monitor

Chapter 9

Using the Command (PROM) Monitor

This chapter describes the Command (PROM) Monitor programs, which control the boot environment for all Silicon Graphics workstations and servers. With the Command Monitor, you can boot and operate the CPU under controlled conditions, run the CPU in Command Monitor mode, and load programs (for example, the operating system kernel, */unix* or special debugging and execution versions of the kernel).

Refer to the prom(1M) reference page for detailed information on the PROM monitor.

PROM stands for Programmable Read-Only Memory. Most PROM chips are placed in your computer at the factory with software programmed into them that allows the CPU to boot and allows you to perform system administration and software installations. The PROMs are not part of your disk or your operating system; they are the lowest level of access available for your system. You cannot erase them or bypass them.

Since PROMs are not normally changed after the manufacture of the system, some features may not be present on older systems. Some systems have PROM firmware that responds to new programming when the operating system is updated. See your hardware owner's guide and release notes for information specific to your system.

Newer systems use a PROM called the ARCS PROM. ARCS stands for Advanced Risc Computing Standard. This PROM provides a graphical interface and allows mouse control of booting and execution. ARCS systems also support the use of the keyboard, and the older key syntaxes have been retained for compatibility. Systems that use the ARCS prom include some models of Indigo®, Indy, Indigo²™, CHALLENGE, Onyx, some Crimson™ systems, as well as the Origin™ systems.

This chapter contains information on the following topics:

- Basic instruction on entering the Command Monitor. See "How to Enter the Command (PROM) Monitor" on page 152.
- A summary of the commands available through the general Command Monitor. See "Summary of Command Monitor Commands" on page 154.

- How to get help while using the Command Monitor. See “Getting Help in the Command Monitor” on page 156.
- Instructions for convenient use of the Command Monitor. See “Using Command Monitor Commands” on page 156 and “Running the Command Monitor” on page 160.
- Instructions for manipulating the Command Monitor Environment. See “The Command Monitor Environment” on page 161.
- Instructions for booting programs from the Command Monitor. See “Booting a Program From the Command Monitor” on page 169.

How to Enter the Command (PROM) Monitor

To get into the Command Monitor on most systems, follow these steps:

1. Reboot the system with the *reboot* command, or if the system is already off, turn it on.

   On server systems without graphics capability, you see the following prompt:

   ```
   Starting up the system....
   To perform system maintenance instead, press <Esc>
   ```

   On systems with graphics, you see similar messages, displayed on your screen as shown in Figure 9-1.

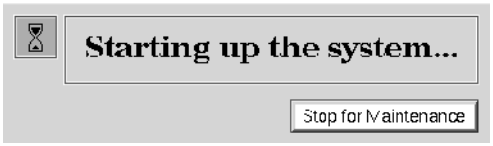

Figure 9-1 ARCS System Startup Message

   The procedures are substantially the same for graphical or text usage, except that you need not press the Escape key on graphics systems, instead you can use your mouse cursor to click a button labeled Stop for Maintenance.

2. Press **Esc** or click the button. You see the following menu, or a similar menu:

```
System Maintenance Menu
1   Start System
2   Install System Software
3   Run Diagnostics
4   Recover System
5   Enter Command Monitor
6   Select Keyboard Layout
```

The menu items have the following effects:

Start System — This option starts the default operating system.

Install System Software
: This option brings up the standalone version of inst(1M). See *IRIX Admin: Software Installation and Licensing* for further information on this option. If your system has the ARCS PROM, it allows you to interactively select the type of device you will use to perform the installation (for example, tape drive, network connection, or CD-ROM drive) and then select the specific device from those of the specified type.

Run Diagnostics
: This option runs a diagnostic program on your system hardware. See your system owner's guide for further information on this option.

Recover System
: This option allows you to read a previously made system backup onto the system disk. See *IRIX Admin: Backup, Security, and Accounting* for further information on this option. If your system has the ARCS PROM, it allows you to interactively select the type of device you will use to perform the recovery (for example, tape drive, network connection, or CD-ROM drive) and then select the specific device from those of the specified type.

Enter Command Monitor
: This option allows you to enter the Command Monitor program, described in this chapter.

Select Keyboard Layout
: This option allows you to select from several different keyboard layouts for common languages.

3. Enter the numeral 5 and press **Return** or click on the appropriate button. You see the Command Monitor prompt:

   >>

   You have entered the Command Monitor.

Summary of Command Monitor Commands

Table 9-1 summarizes the Command Monitor commands and gives each command's syntax. Note that not all commands work on all systems

Table 9-1 Command Monitor Command Summary

Command	Description	Syntax
auto	Boots default operating system (no arguments). This has the same effect as choosing Start System from the PROM Monitor initial menu.	**auto**
boot	Boots the named file with the given arguments.	**boot** [**-f**][**-n**] *pathname*
date	Displays or sets the date and time.	date [*mmddhhmm*[*ccyy* | *yy*] [*.ss*]]
eaddr	Prints the Ethernet address of the built-in Ethernet controller on this system.	**eaddr**
exit	Leaves Command Monitor and returns to the PROM menu.	**exit**
help	Prints a Command Monitor command summary.	**help** [*command*] **?** [*command*]
hinv	Prints an inventory of known hardware on the system. Some optional boards may not be known to the PROM monitor.	**hinv**

Table 9-1 (continued) Command Monitor Command Summary

Command	Description	Syntax
init	Partially restarts the Command Monitor, noting changed environment variables.	**init**
ls	List files on a specified device.	**ls** *devicename*
off	Turns off power to the system.	**off**
passwd	Sets PROM password.	**passwd**
pathname	Given a valid file pathname, the system attempts to find and execute any program found in that path.	*pathname*
printenv	Displays the current environment variables.	**printenv** [*env_var_list*]
resetenv	Resets all environment variables to default.	**resetenv**
resetpw	Resets the PROM password to null (no password required).	**resetpw**
setenv	Sets environment variables. Using the **-p** flag makes the variable setting persistent, that is, the setting remains through reboot cycles.	**setenv** [**-p**] *variable value*
single	Boots the system into single-user mode.	**single**
unsetenv	Unsets an environment variable.	**unsetenv** *variable*
version	Displays Command Monitor version.	**version**

Getting Help in the Command Monitor

The question mark (**?**) command displays a short description of a specified command. If you do not specify a command, the **?** command displays a summary of all Command Monitor commands. To get help, type either **help** or a question mark (**?**).

help [*command*]

? [*command*]

Using Command Monitor Commands

The following sections cover these subjects:

- The command syntax notation that this chapter uses
- The function of the commands listed in Table 9-1

Using the Command Line Editor in the Command Monitor

You can edit on the command line by using the commands shown in Table 9-2.

Table 9-2 Command Monitor Command Line Editor

Command	Description
Ctrl+h, Delete	Deletes previous character
Ctrl+u	Deletes entire line; question mark (**?**) prompts for corrected line
Ctrl+c	If a command is executing, kills current command
!!	Repeats the last command

Syntax of Command Monitor Commands

The Command Monitor command syntax is designed to resemble the syntax of commands used with the IRIX operating system. This chapter uses IRIX notation for command descriptions:

- **`Boldface`** words are literals. Type them as they are shown.
- Square brackets ([]) surrounding an argument means that the argument is optional.
- Vertical lines (|) separating arguments mean that you can specify only one optional argument within a set of brackets.
- *file* means that you must specify a filename. A filename includes a device specification as described in “Syntax of Command Monitor Filenames” on page 157.

Syntax of Command Monitor Filenames

When you specify filenames for Command Monitor commands, use this syntax:

device`([`*cntrlr*`,[`*unit*`[,`*partition*`]]])`*file*

- *device* specifies a device driver name known to the PROM.
- *cntrlr* specifies a controller number for devices that may have multiple controllers.
- *unit* specifies a unit number on the specified controller.
- *partition* specifies a partition number within a unit.
- *file* specifies a pathname for the file to be accessed.

If you do not specify *cntrlr*, *unit*, and *partition*, they default to zero. The notation shows that you can specify only a *cntrlr*, a *cntrlr* and *unit*, or all three variables. The commas are significant as place markers. For example, the root partition (partition 0) on a single SCSI disk system is shown as:

```
dksc(0,1,0)
```

where:

- dksc indicates the SCSI driver.
- The first 0 indicates SCSI controller 0.
- The 1 indicates drive number 1 on SCSI controller 0
- The final 0 indicates partition 0 (root partition) on drive 1 on SCSI controller 0.

The */usr* partition (partition 3) on the same disk would be written as:

```
dksc(0,1,3)
```

The Command Monitor defines the devices shown in Table 9-3.

Table 9-3 Device Names for Command Monitor Commands

Device Name	Description
dksc	SCSI disk controller (dks in IRIX)
tpsc	SCSI tape controller (tps in IRIX)
tty	CPU board duart
tty(0)	Local console
tty(1)	Remote console
gfx	Graphics console
console	Pseudo console, which may be one of gfx(0), tty(0), or tty(1).
bootp	Ethernet controller using bootp and TFTP protocols
tpqic	Quarter-inch QIC02 tape drive

The PROM device notation is different from IRIX device notation. Certain environment variables (such as root and swap) are passed to higher level programs, and often require IRIX notation for the */dev* device name. For example, in PROM notation, a SCSI disk partition most commonly used for swap is written:

```
dksc(0,0,1)
```

In IRIX notation, the same disk is:

```
dksc0d0s1
```

Syntax of ARCS PROM Filenames

Systems that use the ARCS prom (including Indy, Indigo^2, some models of Indigo, CHALLENGE, and Onyx) use a slightly different syntax for specifying pathnames and disk partitions.

ARCS pathnames use the same syntax as the hardware inventory. The pathnames are written as a series of “type(unit)” components that parallel the hardware inventory format.

Old-style pathnames are automatically converted to new-style pathnames, so the old names can still be used. The PROM matches the first device described by the pathname, so full pathnames are not always required. Some examples of common pathnames are shown in Table 9-4.

Table 9-4 ARCS Filenames

ARCS Naming Convention	Pathname or Device
scsi(0)disk(1)partition(1)	dksc(0,1,1)
disk(1)part(1)	dksc(0,1,1)
scsi(0)cdrom(5)partition(7)	dksc(0,5,7)
network(0)bootp()*host*:*file*	bootp()*host*:*file*
serial(0)	First serial port
keyboard()	Graphics keyboard
video()	Graphics display

Running the Command Monitor

This section describes the commands that you use to run the Command Monitor. The Command Monitor accepts the commands listed in Table 9-1 on page 154.

Reinitializing the Processor From the Command Monitor

The *init* command reinitializes the processor from PROM memory, and returns you to the monitor program.

Setting a PROM Password

Your system has a facility that allows you to require a password from users who attempt to gain access to the Command Monitor. To set the PROM password, perform the following steps:

1. Select option 5 from the System Maintenance menu to enter the Command Monitor. You see the Command Monitor prompt:

   ```
   Command Monitor. Type "exit" to return to the menu.
   >>
   ```

2. Enter the command:

   `help`

3. Issue the *passwd* command:

   `passwd`

   You see the prompt:

   ```
   Enter new password:
   ```

4. Enter the password you want for your system and press Enter. You see the prompt:

   ```
   Confirm new password:
   ```

   Enter the password again, exactly as you typed it before. If you typed the password the same as the first time, you next see the Command Monitor prompt again. If you made a mistake, the system prints an error message and you must begin again. If you see no error message, your password is now set. Whenever you access the Command Monitor, you will be required to enter this password.

It is very important that you choose and enter your password carefully, because if it is entered incorrectly or forgotten, you may have to remove a jumper on the CPU board of your system. This procedure is different for each system type, and is described in your owner's guide. Some systems, though, allow you to reset the PROM password from IRIX by logging in as root and issuing the following command:

```
nvram passwd_key ""
```

The quotation marks with no characters or space between them are essential to remove the PROM password. You must be root to perform this operation.

The *resetpw* command within the Command Monitor also resets the PROM password.

The Command Monitor Environment

The Command Monitor maintains an environment, which is a list of variable names and corresponding values (the values are actually text strings). These *environment variables* contain information that the Command Monitor either uses itself or passes to booted programs. The system stores some environment variables—those that are important and unlikely to change frequently—in nonvolatile RAM (nvram). If you turn off power to the machine or press the reset button, the system remembers these variables. When you change the setting of these variables using the *setenv* command, the PROM code automatically stores the new values in nonvolatile RAM.

You can also use the */etc/nvram* command to set or print the values of nonvolatile RAM variables on your system. For complete information on the *nvram* command, see the nvram(1) reference page.

Table 9-5 on page 162 shows a list of the environment variables that the system stores in nonvolatile RAM.

The ARCS PROM defines some variables not found in older PROMS, and so an additional list is provided in Table 9-7.

Several environment variables also exist that affect the operation of IRIX. These are not stored in non-volatile RAM, but they do affect the operation of the PROM and of IRIX. See Table 9-6.

Table 9-5 lists nonvolatile RAM variables:

Table 9-5 Variables Stored in Nonvolatile RAM

Variable	Description
netaddr	Specifies the local network address for booting across the Ethernet. See the *bootp* protocol.
dbaud	Specifies the diagnostics console baud rate. You can change it by setting this variable (acceptable rates include 75, 110, 134, 150, 300, 600, 1200, 2400, 4800, 9600, and 19200), or by pressing the Break key. IRIS® uses the *dbaud* rate for the diagnostics console during the entire system start-up. Pressing the Break key changes the baud rate only temporarily; the baud rate reverts to the value specified in *dbaud* or *rbaud* when you press the reset switch or issue an *init* command.
rbaud	Specifies the remote console baud rate. The list of acceptable baud rates is the same as for *dbaud*, above.
bootfile	Specifies the name of the file to use for autobooting, normally a standalone shell (sash). This variable is valid for pre-ARCS PROMs only. ARCS PROMs store this information in the *OSLoader* variable.

Table 9-5 (continued) Variables Stored in Nonvolatile RAM

Variable	Description
bootmode	Specifies the type of boot in pre-ARCS PROMs. ARCS PROMs store this information in the *AutoLoad* variable. The options have these meanings: c—performs a complete cold autoboot, using the file pointed to by the bootfile variable to boot the kernel; boots sash, then boots kernel; runs power-on diagnostics. m—(default) goes straight to the Command Monitor; clears memory; runs power-on diagnostics. d—go straight to the Command Monitor; does not clear memory; does not run power-on diagnostics.
boottune	Selects the boot music string. A value of *0* randomizes the selection each time. *1* is the default value. (Supported only on POWER Indigo^{2}™ systems)
autopower	Allows systems with software power control to automatically reset after a power failure if set to *y*.
console	Specifies which console to use. The options have these meanings: G—graphics console with the Silicon Graphics, Inc., logo in the upper left corner. g—(default) graphics console without the Silicon Graphics logo.

Table 9-5 (continued) Variables Stored in Nonvolatile RAM

Variable	Description
keybd	Specifies the type of keyboard used. The default is "df." Available settings depend on the exact PROM revision, but may include some or all of: USA, DEU, FRA, ITA, DNK, ESP, CHE-D, SWE, FIN, GBR, BEL, NOR, PRT, CHE-F. or US, DE, FR, IT, DK, ES, deCH, SE, FI, GB, BE, NO, PT, frCH on systems with the keyboard layout selector. On some systems, JP is also acceptable to specify a Japanese keyboard.
diskless	Specifies that the system is diskless and must be booted over the network. On ARCS systems, diskless system environment parameters should be set as follows: **`diskless=1`** **`SystemPartition=bootp()`***host:/path* **`OSLoader=`***kernelname*
monitor	Specifies the monitor resolution on Indy systems when an unrecognized brand of monitor is used. Set this variable to *h* or *H* to specify a high-resolution monitor, the default is a low-resolution monitor.
nogfxkeybd	Specifies that the keyboard is not required to be connected if set to *1*.
notape	Specifies that no tape drive is attached to the system. If a tape drive is attached to the system, this variable must be set to *1* (true) in order to access a tape drive on another system on the network.
volume	Specifies the system speaker volume numerically.

Table 9-5 (continued) Variables Stored in Nonvolatile RAM

Variable	Description
pagecolor	Specifies the background color of the textport using a set of 6 hexadecimal RGB values.
prompoweroff	On Indy systems only, this variable specifies that the system should return to the PROM monitor before powering off on shutdown if set to *y*.
rebound	Specifies that the system should automatically reboot after a kernel panic if set to *y*.
sgilogo	Specifies that the Silicon Graphics logo and related information is displayed on the PROM monitor graphical screen if set to *y*.
diagmode	Specifies the mode of power-on diagnostics. If set to *v*, then diagnostics are verbose and extensive.

Table 9-6 lists Command Monitor environment variables that directly affect the operating system. Note that these variables are not stored in non-volatile RAM and are discarded if the system is powered off.

Table 9-6 Environment Variables That Affect the IRIX Operating System

Variable	Description
showconfig	Prints extra information as IRIX boots. If set through *setenv*, its value must be *istrue*.
initstate	Passed to IRIX, where it overrides the initdefault line in */etc/inittab*. Permitted values are s and the numbers 0-6. See init(1M).

Table 9-6 (continued) Environment Variables That Affect the IRIX Operating System

Variable	Description
swap	Specifies in IRIX notation the swap partition to use. If not set, it defaults to the partition configured into the operating system, which is normally partition 1 on the drive specified by the root environment variable.
path	Specifies a list of device prefixes that tell the Command Monitor where to look for a file, if no device is specified.
verbose	Tells the system to display detailed error messages.

When you boot a program from the Command Monitor, it passes the current settings of all the environment variables to the booted program.

The environment variables specific to ARCS PROMs are described in Table 9-7.

Table 9-7 ARCS PROM Environment Variables

Variable	Description
ConsoleIn/ConsoleOut	These variables are set automatically at system startup.
OSLoadPartition	The disk partition where the operating system kernel is located. This is also used as the default root partition and is set automatically at system startup.
OSLoader	The operating system loading program. By default, this is SASH (the stand-alone shell). This is set automatically at system startup.
SystemPartition	The disk partition where the operating system loading program is found. This is set automatically at system startup.

Table 9-7 (continued) ARCS PROM Environment Variables

Variable	Description
OSLoadFilename	The filename of the operating system kernel. By default, this is */unix*. This variable is automatically set at system startup.
OSLoadOptions	This variable specifies options to the boot command used to load the operating system. For more information on boot options, see "Booting a Program From the Command Monitor" on page 169.
AutoLoad	This variable specifies whether the operating system will boot automatically after a reset or power cycle. This variable supersedes *bootmode* and can be set to *yes* or *no*.

Displaying the Current Environment Variables

The *printenv* command displays the Command Monitor's current environment variables.

printenv [*env_var_list*]

To change (reset) the variables, see the next section.

Changing Environment Variables

The *setenv* command changes the values of existing environment variables or creates new ones.

setenv *env_var string*

env_var is the variable you're setting, and *string* is the value you assign to that variable. To see the current monitor settings, use *printenv*.

When you use *setenv* to change the value of one of the stored environment variables in Table 9-5, the system automatically saves the new value in nonvolatile RAM. You do not need to reenter the change the next time the system is turned off and then on again.

Setting the Keyboard Variable

If the *keybd* variable is set to anything but the default *df*, the appropriate keyboard translation table is loaded from the volume header of the hard disk. If the table is missing or unable to load, then the default table stored in the PROMs is used. The *keybd* variable can be set to any value, but the keyboard translation table should be loaded from the volume header on the hard disk. This variable overrides the normal system mechanism for determining the kind of keyboard installed in the system. Do not change this variable unless you are performing keyboard diagnostics. Table 9-8 lists *keybd* variables suggested for international keyboards:

Table 9-8 *keybd* Variables for International Keyboards

Variable	Description
BEL or BE	Belgian
DNK or DK	Danish
DEU or DE	German
DF	The default
FRA or FR	French
FIN or FI	Finnish
ITA or IT	Italian
JP	Japanese
NOR or NO	Norwegian
PRT or PT	Portuguese
CHE-F or freCH	Swiss-French
CHE-D or deCH	Swiss-German
ESP or ES	Spanish
SE or SWE	Swedish
GB or GBR	United Kingdom (Great Britain)
US or USA	United States (available on all models)

Removing Environment Variables

The *unsetenv* command removes the definition of an environment variable.

unsetenv *env_var*

env_var is the variable whose definition you are removing (see *setenv*, above). Note that variables stored in nonvolatile RAM cannot be unset.

Booting a Program From the Command Monitor

This section describes each Command Monitor boot command and shows you how to use it. When you reboot or press the Reset button, you start up the Command Monitor. Do not press the Reset button under normal circumstances, that is, when the workstation is running IRIX.

Booting the Default File

The *auto* command reboots the operating system. It uses the default boot file as though you were powering on the CPU. At the Command Monitor prompt (>>), type:

auto

The PROM's environment variable *bootfile* specifies the default boot file. In addition, you must set the environment variable *root* to the disk partition that IRIX uses as its root filesystem. The *auto* command assumes that the desired image of IRIX resides on the partition specified by *root* of the drive specified in the environment variable *bootfile*.

The *bootfile* name can contain no more than 14 characters. To select a different boot file, see "Changing Environment Variables" on page 167.

Booting a Specific Program

The *boot* command starts the system when you want to use a specific boot program and give optional arguments to that program. The syntax of the *boot* command is:

boot[**-f** *program*][**-n**][*args*]

- **-f** specifies the program you want to boot. The program name must contain fewer than 20 characters. If you do not specify this option, the environment variable *bootfile* specifies the default program. *boot* normally loads *sash*.

  When you specify a program, you can include a device specification. If you don't, the Command Monitor uses the device specifications in the environment variable *path*. The Command Monitor tries in turn each device that you specify in *path*, until it finds the program you request, or until it has tried all the devices listed in *path*.

- **-n** means no go: it loads the specified program, but does not transfer control to it. Instead, **-n** returns you to the Command Monitor command environment.

- *args* are variables that the Command Monitor passes to the program you're booting. For an *arg* that starts with a hyphen (-), you must prepend an additional hyphen so that the Command Monitor doesn't think that the argument is intended for itself. The Command Monitor removes the extra hyphen before it passes the argument to the booted program. For more information, see "Booting the Standalone Shell."

For example, to boot the disk formatter / exerciser program (*fx*) from the cartridge tape drive, use this command:

```
boot -f SCSI(0)tape(7)partition(0)fx
```

Without any arguments, *boot* loads the program specified in *bootfile*.

Booting the Standalone Shell

The Command Monitor has been designed to keep it independent of operating systems and as small as possible. Therefore, the Command Monitor cannot directly boot files residing in IRIX or other operating system file trees. However, the Command Monitor provides a two-level boot mechanism that lets it load an intermediary program that understands file systems; this program can then find and load the desired boot file. The program is called the *standalone shell*, and is referred to as *sash*. *sash* is a reconfigured and expanded version of the Command Monitor program, and includes the modules needed to handle operating system file structures. It also has enhanced knowledge about devices.

After the system software is installed, a copy of *sash* is located in the volume header of the first disk. The header contains a very simple file structure that the Command Monitor understands. You can also boot *sash* from tape or across the network. To boot *sash* from your disk, shut down the system, and when you see the message:

```
Starting up the system...
To perform system maintenance instead, press Esc
```

Press the Esc key. You may have to enter your system's Command Monitor password, if your system has one. Next, you see a menu similar to the following:

```
System Maintenance Menu
      (1) Start System
      (2) Install System Software
      (3) Run Diagnostics
      (4) Recover System
      (5) Enter Command Monitor
```

Select option 5, Enter Command Monitor from the System Maintenance Menu. You see the following message and prompt:

```
Command Monitor. Type "exit" to return to the menu.
>>
```

To boot the standalone shell (*sash*), enter the command:

```
boot -f sash
```

sash operates in interactive command mode. You see the SASH prompt:

```
sash:
```

To use the multilevel boot feature, set the PROM environment variable *bootfile* to refer to a specific copy of *sash*. In normal configurations, setting *bootfile* to *dksc(0,0,8)sash* tells the Command Monitor to load *sash* from the SCSI disk controller 0, disk unit 0, partition 8 (the volume header). Use this syntax:

SCSI drives**—setenv bootfile "dksc(0)disk(1)partition(8)sash"**

Then issue a boot command, as in this example for an SCSI drive:

```
boot dksc()unix initstate=s
```

The following actions take place:

- *boot* loads *dksc(0)disk(0)partition(8)sash*, as specified by *bootfile*, since the boot command doesn't contain a **-f** argument. (A **-f** argument overrides the default specified by *bootfile*.)
- *sash* gets two arguments: **dksc()unix** and **initstate=s**, which brings the system up in single-user mode. (Note that the Command Monitor removes the leading hyphen [-] from any argument, so if you use the next layer of software, and need an argument with a leading hyphen, put two hyphens in front of it.)
- *sash* loads the file specified by the first argument (**dksc()unix**) and passes the next argument to that file.

Do not issue the *auto* command from *sash* with the *bootfile* set as shown above. If you do, the system tries to boot *sash* over itself and exits with an error.

To be able to use the *auto* command from *sash*, set *bootfile* to refer to the kernel, for example, *dksc()unix*. Even better, return to the PROM level to use the *auto* command.

Booting Across the Network

At the heart of the operation of diskless workstations is the *bootp* protocol. The *bootp* protocol is a DARPA standard protocol supported on all Silicon Graphics servers and workstations. One of the devices that the Command Monitor can use for booting is the network. Silicon Graphics provides a TCP/IP boot protocol that lets you boot files that reside on another host in the network, if the other host supports the booting protocol. The network booting protocol is the *bootp* protocol. It is a datagram protocol that uses the User Datagram Protocol (UDP) of TCP/IP to transfer files across the Ethernet network.

To boot across the network, you must first determine the Internet address of the machine you want to boot. The Internet address is a number assigned by the network administrator of the network to which the system is attached. The format of the number is four decimal numbers between 0 and 255, separated by periods; for example:

```
194.45.54.4
```

Use the *setenv* command to set the *netaddr* environment variable to this address; for example:

```
setenv netaddr 194.45.54.4
```

Booting Across the Network With bootp

Once you have set the *netaddr* environment variable, you can use *bootp* to refer to a remote file by using a filename of the form:

bootp()[*hostname*:] *path*

- *hostname* is the name of the host where the file resides. The specified host must run the *bootp* server daemon, *bootp*. If you omit *hostname*, *bootp* broadcasts to get the file from any of the hosts on the same network as the system making the request. The first host that answers fills the request. Only hosts that support *bootp* can respond to the request. It is safe to omit the hostname only when you know that the path is unique to a particular host, or when you know that all the copies of the file are interchangeable.

  hostname can be the name of a host on a different Ethernet network from the machine that you are booting, if a gateway on the local Ethernet network provides a route to the remote host. The gateway must be running a *bootp* server that you have configured to do cross-network forwarding.

  For more information about booting through gateways, see bootp(1M). For more information about the */etc/inetd.conf* configuration file, see inetd(1M).

- *path* is the pathname of a file on the remote host. For example, this command:

  ```
  boot -f bootp()wheeler:/usr/local/boot/unix
  ```

  boots the file */usr/local/boot/unix* from the remote host *wheeler*. The command:

  ```
  boot -f bootp()/usr/alice/help
  ```

  boots the file */usr/alice/help* from any host on the network responding to the *bootp* broadcast request that has a file of that name.

To configure the gateway to permit cross-network forwarding, follow these steps:

1. Log in as root or become the superuser by issuing the *su* command.
2. Edit the file */etc/inetd.conf* on the gateway system. This file configures the *bootp* server, which is started by the inetd(1M) daemon.
3. Change the *bootp* description so that *inetd* invokes *bootp* with the **-f** flag. Find this line:

   ```
   bootp  dgram  udp  wait  root  /usr/etc/bootp  bootp
   ```

   Add the **-f** flag to the final *bootp* on the line:

   ```
   bootp  dgram  udp  wait  root  /usr/etc/bootp  bootp  -f
   ```

4. Change the *tftp* configuration line in one of the following ways:

   Remove the **-s** flag from the argument list for *tftpd*:

   ```
   tftp   dgram  udp   wait  guest   /usr/etc/tftpd  tftpd -s
   ```

   This allows *tftpd* access to all publicly readable directories. If you are concerned about a possible security compromise, you can instead explicitly list the directories to which *tftpd* needs access. In this case, you need to add */usr/etc*:

   ```
   tftp dgram udp wait guest /usr/etc/tftpd tftpd -s /usr/etc
   ```

   See tftpd(1M) and tftp(1C) for more information.

5. Signal *inetd* to reread its configuration file.

   ```
   killall -1 inetd
   ```

Booting Across a Larger Network

If you have access to a larger network, and the bootable file you need is sufficiently remote on the network that the *tftp* and *bootp* timeouts and network delays are keeping you from booting successfully, it is possible to use an intermediary host as a *bootp* server.

As an example, consider the following situation. You have a host named *local_host* that needs to boot a kernel found on the remote system *far_host*. But the network is heavily used, resulting in *bootp* and *tftp* timing out before the boot operation can take place. However, a third host, *near_host*, has the optional NFS software and has automount(1M) running, allowing access to the files on *far_host*. To boot through this method, perform the following steps:

1. On *near_host*, the system acting as intermediary, log in as root and open the file */etc/inetd.conf*. This file configures the *bootp* server, which is started by the inetd(1M) daemon.
2. Change the *bootp* description in the */etc/inetd.conf* file so that *inetd* invokes *bootp* with the **-f** flag. Find this line:

   ```
   bootp  dgram  udp  wait  root  /usr/etc/bootp  bootp
   ```

   Add the **-f** flag to the final *bootp* on the line:

   ```
   bootp  dgram  udp  wait  root  /usr/etc/bootp  bootp  -f
   ```

   Change the *tftp* configuration line in the */etc/inetd.conf* file in one of the following two ways:

   Remove the *-s /usr/local/boot* string from the argument list for *tftpd*, so that the entry matches the following:

   ```
   tftp   dgram  udp   wait  guest   /usr/etc/tftpd  tftpd
   ```

   This allows *tftpd* access to all publicly readable directories.

   If you are concerned about a possible security compromise, you can instead explicitly list the directories to which *tftpd* needs access. In this case, you need to add */hosts*:

   ```
   tftp dgram udp wait guest /usr/etc/tftpd tftpd -s /hosts
   ```

   See tftpd(1M) and tftp(1C) for more information.
3. Signal *inetd* to reread its configuration file.

   ```
   killall -1 inetd
   ```

4. On *far_host*, the system on the distant subnetwork, use NFS to export the directory containing the needed bootable kernel (in this case, the file is */usr/local/boot/unix*). If you need help exporting a directory, see the export(1M) reference page.
5. On *local_host*, the system you are trying to boot, give the command:

   `boot -f bootp()near_host:/hosts/far_host/usr/local/boot/unix`

   If *bootp* times out, try the command again, as *automount* may require a bit of time to retrieve the files from the remote system.

Booting From a Disk or Other Device

To tell the Command Monitor to load standalone commands from various resources (such as a disk or CD-ROM device), set the *path* environment variable. (See “Changing Environment Variables” on page 167.) Set the *path* variable as follows:

`setenv path` "*device_name alternate_path*"

For example, issue the following command:

`setenv path "dksc(0)disk(0)partition(8)bootp()/altdir/altbootfile"`

This causes the Command Monitor to boot the file *dksc(0)disk(0)partition(8)/altdir/altbootfile*. If that file fails, the Command Monitor boots *bootp()/altdir/altbootfile*. If that file also fails, the Command Monitor prints the message `command not found`. Note that pathnames are separated with spaces. If the device specification is contained within a command or by *bootfile*, the Command Monitor ignores *path*. Only *bootp* or volume headers are understood by the PROM.

Chapter 10

System Performance Tuning

Chapter 10 describes the process by which you can improve your system performance. Your system is configured to run as fast as possible under most circumstances. However, if your use of the system is out of the ordinary, you may find that adjusting certain parameters and operating system values may improve your total performance, or you may wish to optimize your system for some feature, such as disk access, to better make use of the graphics features or your application software. Topics described in this chapter include:

- Measuring system performance.
- Improving general system performance.
- Tuning for specific hardware and software configurations.

Chapter 10

System Performance Tuning

This chapter describes the basics of tuning the IRIX operating system for the best possible performance for your particular needs. Information provided includes the following topics:

- General information on system tuning and kernel parameters. See “Theory of System Performance Tuning” on page 179.
- Tuning applications under development. See “Application Tuning” on page 181.
- Observing the operating system to determine if it should be tuned. See “Monitoring the Operating System” on page 187.
- Tuning and reconfiguring the operating system. See “Tuning the Operating System” on page 203.

Theory of System Performance Tuning

The standard IRIX system configuration is designed for a broad range of uses, and adjusts itself to operate efficiently under all but the most unusual and extreme conditions. The operating system controls the execution of programs in memory and the movement of programs from disk to memory and back to disk.

The basic method of system tuning is as follows:

1. Monitor system performance using various utilities.
2. Adjust specific values (for example, the maximum number of processes).
3. Reboot the system if necessary.
4. Test the performance of the new system to see if it is improved.

Note that performance tuning cannot expand the capabilities of a system beyond its hardware capacity. You may need to add hardware, in particular another disk or additional memory, to improve performance.

Files Used for Kernel Tuning

Table 10-1 lists the files / directories used for tuning and reconfiguring a system.

Table 10-1 Files and Directories Used for Tuning

File/Directory:	Purpose:
/var/sysgen/system / *	Directory containing files defining software modules
/var/sysgen/master.d	Directory containing files defining kernel switches and parameters
*/var/sysgen/mtune/**	Directory containing files defining more tunable parameters
/var/sysgen/stune	File defining default parameter values
*/var/sysgen/boot/**	Directory of object files
/unix	File containing kernel image

Typically you tune a parameter in one of the files located in the *mtune* directory (for example, the *kernel* file) by using the systune(1M) command.

Overview of Kernel Tunable Parameters

Tunable parameters control characteristics of processes, files, and system activity. They set various table sizes and system thresholds to handle the expected system load. If certain system structures are too large, they waste memory space that would be used for other processes and can increase system overhead due to lengthy table searches. If they are set too low, they can cause excessive I / O, process aborts, or even a system crash, depending on the particular parameter.

This section briefly introduces some of the tunable parameters and switches. Appendix A, “IRIX Kernel Tunable Parameters,” describes all parameters, gives default values, provides suggestions on when to change each parameter, and describes problems you may encounter.

Tunable parameters are specified in separate configuration files in the */var/sysgen/mtune* and the */var/sysgen/master.d* directories. See the mtune(4) reference page for *mtune* information and the master(4) reference page for information on *master.d*.

The default values for the tunable parameters are usually acceptable for most configurations for a single-user workstation environment. However, if you have a lot of memory or your environment has special needs, you may want to adjust the size of a parameter to meet those needs. A few of the parameters you may want to adjust are listed below.

nproc	Defines the maximum number of processes, systemwide. This parameter is typically auto-configured.
maxup	Defines the maximum number of processes per UID.
rlimit-core-cur	Maximum size of a core file.
rlimit-data-cur	Maximum amount of data space available to a process.
rlimit-fsize-cur	Maximum file size available to a process.
rlimit-nofile-cur	Maximum number of file descriptors available to a process.
rlimit-rss-cur	Maximum resident set size available to a process.
rlimit-vmem-cur	Maximum amount of mapped memory for a process.
sshmseg	Maximum number of attached shared memory segments per process.

Application Tuning

You can often increase system performance by tuning your applications to more closely follow your system's resource limits. If you are concerned about a decrease in your system's performance, first check your application software to see if it is making the best use of the operating system. If you are using an application of your own manufacture, you can take steps to improve performance. Even if a commercially purchased application is degrading system performance, you can identify the problem and use that information to make decisions about system tuning or new hardware, or even simply when and how to use the application. The following sections explain how to examine and tune applications. The rest of this chapter assumes that your applications have been tuned as much as possible according to these suggestions.

Checking Application Performance

If your system seems slow, for example, an application runs slowly, first check the application. Poorly designed applications can perpetuate poor system performance. Conversely, an efficiently written application means reduced code size and execution time.

A good utility to use to try to determine the source of the problem is the timex(1) utility. *timex* reports how a particular application is using its CPU processing time. The format is:

`timex -s` *program*

which shows *program*'s real (actual elapsed time), user (time process took executing its own code), and sys (time of kernel services for system calls) time. For example:

```
timex -s ps -el
```

The above command executes the *ps -el* command and then displays that program's time spent as:

```
real 0.95
user 0.08
sys 0.41
```

Tuning an Application

There are many reasons why an application spends a majority of its time in either user or sys space. For purposes of example, suspect excessive system calls or poor locality of code.

Typically, you can only tune applications that you are developing. Applications purchased for your system cannot be tuned in this manner, although there is usually a facility to correspond with the application vendor to report poor performance.

If the application is primarily spending its time in user space, the first approach to take is to tune the application to reduce its user time by using the pixie(1) and prof(1) commands. See the respective reference pages for more information about these commands. To reduce high *user* time, make sure that the program does the following:

- Makes only the necessary number of system calls. Use *timex -s* to find out the number of system calls / second the program is making. The key is to try to keep **scall/s** at a minimum. System calls are those like read(2) and exec(2); they are listed in Section 2 of the reference pages.
- Uses buffers of at least 4K for read(2) and write(2) system calls. Or use the standard I / O library routines fread(3) and fwrite(3), which buffer user data.
- Uses shared memory rather than record locking where possible. Record locking checks for a record lock for every read and write to a file. To improve performance, use shared memory and semaphores to control access to common data (see shmop(2), semop(2), and usinit(3P)).
- Defines efficient search paths ($PATH variable). Specify the most used directory paths first, and use only the required entries, so that infrequently used directories aren't searched every time.
- Eliminates polling loops (see select(2)).
- Eliminates busy wait (use sginap(0)).
- Eliminates system errors. Look at */var/adm/SYSLOG*, the system error log, to check for errors that the program generated, and try to eliminate them.

Run *timex* again. If the application still shows a majority of either user or sys time, suspect excessive paging due to poor "locality" of text and data. An application that has locality of code executes instructions in a localized portion of text space by using program loops and subroutines. In this case, try to reduce high user / sys time by making sure that the program does the following:

- Groups its subroutines together. If often-used subroutines in a loaded program are mixed with seldom-used routines, the program could require more of the system's memory resources than if the routines were loaded in the order of likely use. This is because the seldom-used routines might be brought into memory as part of a page.
- Has a working set that fits within physical memory. This minimizes the amount of paging and swapping the system must perform.
- Has correctly ported FORTRAN-to-C code. FORTRAN arrays are structured differently from C arrays; FORTRAN is column major while C is row major. If you don't port the program correctly, the application will have poor data locality.

After you tune your program, run *timex* again. If sys time is still high, tuning the operating system may help reduce this time.

You can do a few other things to improve the application's I/O throughput. If you are on a single-user workstation, make sure that:

- The application gains I/O bandwidth by using more than one drive (if applicable). If an application needs to concurrently do I/O on more than one file, try to set things up so that the files are in different filesystems, preferably on different drives and ideally on different controllers.
- The application obtains unfragmented layout of a file. Try to arrange an application so that there is only one file currently being written to the filesystem where it resides. That is, if you have several files you need to write to a filesystem, and you have the choice of writing them either one after another or concurrently, you actually get better space allocation (and consequently better I/O throughput) by writing these files singly, one after another.

If you are on a multiuser server, however, it's hard to control how other applications access the system. Use a large size I/O—16K or more. You may also be able to set up separate filesystems for different users. With high sys time output from *timex*, you need to monitor the operating system to determine why this time is high.

Looking At/Reordering an Application

Many applications have routines that are executed over and over. You can optimize program performance by modifying these heavily used routines in the source code. The following paragraphs describe the tools that can help tune your programs.

Analyzing Program Behavior With prof

Profiling allows you to monitor program behavior during execution and determine the amount of time spent in each of the routines in the program. Profiling is of two types:

- program counter (PC) sampling
- basic block counting

PC sampling is a statistical method that interrupts the program frequently and records the value of the program counter at each interrupt. Basic block counting, on the other hand, is done by using the *pixie*(1) utility to modify the program module by inserting code at the beginning of each basic block (a sequence of instructions containing no branch instructions) that counts the number of times that each block is entered. Both types of profiling are useful. The primary difference is that basic block counting is deterministic and PC sampling is statistical. To do PC sampling, compile the program with the **-p** option. When the resulting program is executed, it will generate output files with the PC sampling information that can then be analyzed using the prof(1) utility. *prof* and *pixie* are not shipped with the basic IRIX distribution, but are found in the optional IRIS Development Option software distribution.

To do basic block counting, compile the program and then execute *pixie* on it to produce a new binary file that contains the extra instructions to do the counting. When the resulting program is executed, it produces output files that are then used with *prof* to generate reports of the number of cycles consumed by each basic block. You can then use the output of *prof* to analyze the behavior of the program and optimize the algorithms that consume the majority of the program's time. Refer to the cc(1), f77(1), pixie(1), and prof(1) reference pages for more information about the mechanics of profiling.

Reordering a Program With pixie

User program text is demand-loaded a page at a time (currently 4K). Thus, when a reference is made to an instruction that is not currently in memory and mapped to the user's address space, the encompassing page of instructions is read into memory and then mapped into the user's address space. If often-used subroutines in a loaded program are mixed with seldom-used routines, the program can require more of the system's memory resources than if the routines are loaded in the order of likely use. This is because the seldom-used routines might be brought into memory as part of a page of instructions from another routine.

Tools are available to analyze the execution history of a program and rearrange the program so that the routines are loaded in most-used order (according to the recorded execution history). These tools include *pixie*, *prof*, and *cc*. By using these tools, you can maximize the cache hit ratio (checked by running *sar -b*) or minimize paging (checked by running *sar -p*), and effectively reduce a program's execution time. The following steps illustrate how to reorganize a program named *fetch*.

1. Execute the *pixie* command, which adds profiling code to *fetch*:

   ```
   pixie fetch
   ```

   This creates an output file, *fetch.pixie*, and a file that contains basic block addresses, *fetch.Addrs*.

2. Run *fetch.pixie* (created in the previous step) on a normal set or sets of data. This creates the file named *fetch.Counts*, which contains the basic block counts.

3. Create a feedback file that the compiler passes to the loader. Do this by executing *prof*:

   ```
   prof -pixie -feedback fbfile fetch fetch.Addrs fetch.Counts
   ```

   This produces a feedback file named *fbfile*.

4. Compile the program with the original flags and options, and add the following two options:

   ```
   -feedback fbfile
   ```

For more information, see the prof(1) and pixie(1) reference pages.

Commercial Applications

You cannot usually tune commercially available applications to any great degree. If your monitoring has told you that a commercially purchased application is causing your system to run at unacceptably slow levels, you have a few options:

- You can look for other areas to reduce system overhead and increase speed, such as reducing the system load in other areas to compensate for your application. Options such as batch processing of files and programs when system load levels permit often show a noticeable increase in performance. See “Automating Tasks With at, batch, and cron” on page 27.
- You can use the *nice*, *renice*, *npri*, and *runon* utilities to change the priority of other processes to give your application a greater share of CPU time. See “Prioritizing Processes With nice” on page 140 and “Changing the Priority of a Running Process” on page 141.
- You can undertake a general program of system performance enhancement, which can include maximizing operating system I/O through disk striping and increased swap space. See the *IRIX Admin: Disks and Filesystems* guide.

- You can add memory, disk space, or even upgrade to a faster CPU.
- You can find another application that performs the same function but that is less intensive on your system. (This is the least preferable option, of course.)

Monitoring the Operating System

Before you make any changes to your kernel parameters, learn which parameters should be changed and why. Monitoring the functions of the operating system will help you determine if changing parameters will help your performance, or if new hardware is necessary.

Receiving Kernel Messages and Adjusting Table Sizes

In rare instances, a table overflows because it isn't large enough to meet the needs of the system. In this case, an error message appears on the console and in */var/adm/SYSLOG*. If the console window is closed or stored, check *SYSLOG* periodically.

Some system calls return an error message that can indicate a number of conditions, one of which is that you need to increase the size of a parameter. Table 10-2 lists the error messages and parameters that may need adjustment. These parameters are in */var/sysgen/master.d/kernel*.

Table 10-2 System Call Errors and Related Parameters

Message	System Call	Parameter
`EAGAIN` `No more processes`	fork(2)	Increase *nproc* or swap space
`ELIBMAX` `linked more shared libraries than limit`	exec(2)	Increase *shlbmax*
`E2BIG` `Arg list too long`	shell(1), make(1), exec(2)	Increase *ncargs*

Be aware that there can be other reasons for the errors in the previous table. For example, EAGAIN may appear because of insufficient virtual memory. In this case, you may need to add more swap space. For other conditions that can cause these messages, see the owner's guide appendix titled "Error Messages."

Other system calls fail and return error messages that may indicate IPC (interprocess communication) structures need adjustment. These messages and the parameters to adjust are listed in Appendix A, "IRIX Kernel Tunable Parameters."

Using timex(1), sar(1), and par(1)

Three utilities you can use to monitor system performance are *timex*, *sar*, and *par*. They provide very useful information about what's happening in the system.

The operating system has a number of counters that measure internal system activity. Each time an operation is performed, an associated counter is incremented. You can monitor internal system activity by reading the values of these counters.

The *timex* and *sar* utilities monitor the value of the operating system counters, and thus sample system performance. Both utilities use *sadc*, the *sar* data collector, which collects data from the operating system counters and puts it in a file in binary format. The difference is that *timex* takes a sample over a single span of time, while *sar* takes a sample at specified time intervals. The *sar* program also has options that allow sampling of a specific function such as CPU usage (**-u** option) or paging (**-p** option). In addition, the utilities display the data differently.

The *par* utility has the ability to trace system call and scheduling activity. It can be used to trace the activity of a single process, a related group of processes, or the system as a whole.

When would you use one utility over the other? If you are running a single application or a couple of programs, use *timex*. If you have a multiuser / multiprocessor system and / or are running many programs, use *sar* or *par*.

As in all performance tuning, be sure to run these utilities at the same time you are running an application or a benchmark, and be concerned only when figures are outside the acceptable limits over a period of time.

Using timex

The *timex* utility is a useful troubleshooting tool when you are running a single application. For example:

timex -s *application*

The **-s** option reports total system activity (not just that due to the application) that occurred during the execution interval of *application*. To redirect *timex* output to a file, (assuming you use the Bourne shell, (sh(1)) enter:

timex -s *application* **2> file**

The same command, entered using the C shell, looks like this:

timex -s *application* **> file**

Using sar

The *sar* utility is a useful troubleshooting tool when you're running many programs and processes and / or have a multiuser system such as a server. You can take a sample of the operating system counters over a period of time (for a day, a few days, or a week).

Depending on your needs, you can choose the way in which you examine system activity. You can monitor the system:

- during daily operation
- consecutively with an interval
- before and after an activity under your control
- during the execution of a command

You can set up the system so that *sar* automatically collects system activity data and puts it into files for you. Use the *chkconfig* command to turn on *sar*'s automatic reporting feature, which generates a *sar -A* listing. A *crontab* entry instructs the system to sample the system counters every 20 minutes during working hours and every hour at other times for the current day (data is kept for the last 7 days). To enable this feature, type:

/etc/chkconfig sar on

The collected data is put in */var/adm/sa* in the form *sann* and *sarnn*, where *nn* is the date of the report (*sarnn* is in ASCII format). You can use the sar(1M) command to output the results of system activity.

Using sar Consecutively With a Time Interval

You can use *sar* to generate consecutive reports about the current state of the system. On the command line, specify a time interval and a count. For example:

```
sar -u 5 8
```

This prints information about CPU use eight times at five-second intervals.

Using sar Before and After a User-Controlled Activity

You may find it useful to take a snapshot of the system activity counters before and after running an application (or after running several applications concurrently). To take a snapshot of system activity, instruct *sadc* (the data collector) to dump its output into a file. Then run the application(s) either under normal system load or restricted load, and when you are ready to stop recording, take another snapshot of system activity. Then compare results to see what happened.

Following is an example of commands that samples the system counters before and after the application:

```
/usr/lib/sa/sadc 1 1 file
```

Run the application(s) or perform any work you want to monitor, then type:

```
/usr/lib/sa/sadc 1 1 file
sar -f file
```

If *file* does not exist, *sadc* creates it. If it does exist, *sadc* appends data to it.

Using sar and timex During the Execution of a Command

Often you want to examine system activity during the execution of a command or set of commands. For example, to examine all system activity while running nroff(1), type:

```
/usr/lib/sa/sadc 1 1 sa.out
nroff -mm file.mm > file.out
/usr/lib/sa/sadc 1 1 sa.out
sar -A -f sa.out
```

By using *timex*, you can do the same thing with one line of code:

```
timex -s nroff -mm file.mm > file.out
```

Note that the *timex* also includes the real, user, and system time spent executing the *nroff* request.

There are two minor differences between *timex* and *sar*. The *sar* program can limit its output (such as, the **-u** option reports only CPU activity), while *timex* always prints the **-A** listing. Also, *sar* works in a variety of ways, but *timex* only works by executing a command—however, the command can be a shell file.

If you are interested in system activity during the execution of two or more commands running concurrently, put the commands into a shell file and run *timex -s* on the file. For example, suppose the file *nroff.sh* contained the following lines:

```
nroff -mm file1.mm > file1.out &
nroff -mm file2.mm > file2.out &
wait
```

To get a report of all system activity after both of the *nroff* requests (running concurrently) finish, invoke *timex* as follows:

```
timex -s nroff.sh
```

Using par

You can use *par* in much as you use *sar*:

- during daily operation
- consecutively with an interval
- before and after an activity under your control
- during the execution of a command

See the par(1) reference page for specifics on usage.

Use *par* instead of *sar* when you want a finer look at a suspect or problem process. Instead of simply telling you how much total time was used while your process was executing, like *timex*, *par* breaks down the information so you can get a better idea of what parts of the process are consuming time. In particular, use the following command options:

-isSSdu Check the time used by each system call and the intervening time lag.

-rQQ Check process scheduling, to see if it should be run more or less frequently.

When tracing system calls, *par* prints a report showing all system calls made by the subject processes complete with arguments and return values. In this mode, *par* also reports all signals delivered to the subject processes. In schedule tracing mode, *par* prints a report showing all scheduling events taking place in the system during the measurement period. The report shows each time a process is put on the run queue, started on a processor, and unscheduled from a processor, including the reason that the process was unscheduled. The events include timestamps. You can set up the system so *par* automatically collects system activity data and puts it into files for you.

The *par* utility works by processing the output of padc(1). This can be done in two ways: *padc* can be run separately and the output saved in a file to be fed to *par* as a separate operation, or *padc* can be invoked by *par* to perform the data collection and reporting in one step.

The *par* utility can provide different types of reports from a given set of *padc* data depending on the reporting options that are specified. This is a reason why it is sometimes desirable to run the data collection as a separate step.

Summary of sar, par, and timex

Now that you have learned when and how to use *par*, *sar*, and *timex*, you can choose one of these utilities to monitor the operating system. Then examine the output and try to determine what's causing performance degradation. Look for numbers that show large fluctuation or change over a sustained period; don't be too concerned if numbers occasionally go beyond the maximum.

The first thing to check is how the system is handling the disk I/O process. After that, check for excessive paging/swapping. Finally look at CPU use and memory allocation.

The following sections assume that the system you are tuning is active (with applications/benchmark executing).

Checking Disk I/O

The system uses disks to store data, and transfers data between the disk and memory. This input/output (I/O) process consumes a lot of system resources, so you want the operating system to be as efficient as possible when it performs I/O.

If you are going to run a large application or have a heavy system load, the system benefits from disk I/O tuning. Run *sar -A* or *timex -s* and look at the %busy, %rcache, %wcache, and %wio fields. To see if your disk subsystem needs tuning, check your output of *sar -A* against the figures in Table 10-3. (Note that in the table, the right column lists the *sar* option that prints only selected output, for example, output for disk usage (*sar -d*) or CPU activity (*sar -u*).)

Table 10-3 lists *sar* results that indicate an I/O-bound system.

Table 10-3 Indications of an I/O-Bound System

Field	Value	sar Option
%busy (% time disk is busy)	>85%	*sar -d*
%rcache (reads in buffer cache)	low, <85	*sar -b*
%wcache (writes in buffer cache)	low, <60%	*sar -b*
%wio (idle CPU waiting for disk I/O)	dev. system >30 fileserver >80	*sar -u*

Notice that for the %wio figures (indicates the percentage of time the CPU is idle while waiting for disk I/O), there are examples of two types of systems:

- A development system that has users who are running programs such as *make*. In this case, if %wio > 30, check the breakdown of %wio (*sar -u*). By looking at the %wfs (waiting for filesystem) and %wswp (waiting for swap), you can pinpoint exactly what the system is waiting for.
- An NFS system that is serving NFS clients and is running as a file server. In this case, if %wio > 80, %wfs > 90, the system is disk I/O bound.

There are many other factors to consider when you tune for maximum I/O performance. You may also be able to increase performance by:

- using logical volumes
- using partitions on different disks
- adding hardware (a disk, controller, memory)

Using Logical Volumes to Improve Disk I/O

By using logical volumes, you can improve disk I/O:

- You can increase the size of an existing filesystem without having to disturb the existing filesystem contents.
- You can stripe filesystems across multiple disks. You may be able to obtain up to 50% improvement in your I/O throughput by creating striped volumes on disks.

Striping works best on disks that are on different controllers. Logical volumes give you more space without remaking the first filesystem. Disk striping gives you more space with increased performance potential, but you run the risk that if you lose one of the disks with striped data, you lose all the data on the filesystem, since the data is interspersed across all the disks.

Contiguous logical volumes fill up one disk, and then write to the next. Striped logical volumes write to both disks equally, spreading each file across all disks in the volume, so it is impossible to recover from a bad disk if the data is striped, but it is possible if the data is in a contiguous logical volume. For information on creating a striped disk volume, see the *IRIX Admin: Disks and Filesystems* guide.

Using Partitions and Additional Disks to Improve Disk I/O

There are obvious ways to increase your system's throughput, such as limiting the number of programs that can run at peak times, shifting processes to non-peak hours (run batch jobs at night), and shifting processes to another system. You can also set up partitions on separate disks to redistribute the disk load or add disks.

Before continuing with the discussion about partitions, let's look at how a program uses a disk as it executes. Table 10-4 shows various reasons why an application may need to access the disk.

Table 10-4 An Application's Disk Access

Application	Disk Access
Execute object code	Text and data
Use swap space for data, stack	*/dev/swap*
Write temporary files	*/tmp* and */var/tmp*
Reads/Writes data files	Data files

You can maximize I/O performance by using separate partitions on different disks for some of the disk access areas. In effect, you are spreading out the application's disk access routines, which speeds up I/O.

By default, disks are partitioned to allow access in two ways, either:

- three partitions: partitions 0, 1 and 6, or
- one large partition, partition 7 (encompasses the three smaller partitions)

On the system disk, partition 0 is for root, 1 is for swap, and 6 is for */usr*.

For each additional disk, decide if you want a number of partitions or one large one and the filesystems (or swap) you want on each disk and partition. It is best to distribute filesystems in the disk partitions so that different disks are being accessed concurrently.

The configuration depends on how you use the system, so it helps to look at a few examples.

- Consider a system that typically runs a single graphics application that often reads from a data file. The application is so large that its pages are often swapped out to the swap partition.

  In this case, it might make sense to have the application's data file on a disk separate from the swap area.

- If after configuring the system this way, you find that it doesn't have enough swap space, consider either obtaining more memory, or backing up everything on the second hard disk and creating partitions to contain both a swap area and a data area.

- Changing the size of a partition containing an existing filesystem may make any data in that filesystem inaccessible. Always do a complete and current backup (with verification) and document partition information before making a change. If you change the wrong partition, you can change it back, providing you do not run *mkfs* on it or overwrite it. It is recommended that you print a copy of the *prtvtoc* command output after you have customized your disks, so that they may be more easily restored in the event of severe disk damage.

If you have a very large application and have three disks, consider using partitions on the second and third disks for the application's executables (*/bin* and */usr/bin*) and for data files, respectively. Next, consider a system that mostly runs as a "compile-engine."

In this case, it might be best to place the */tmp* directory on a disk separate from the source code being compiled. Make sure that you check and mount the filesystem before creating any files on it. (If this is not feasible, you can instruct the compiler to use a directory on another disk for temporary files. Just set the TMPDIR environment variable to the new directory for temporary files.) Now, look at a system that mainly runs many programs at the same time and does a lot of swapping.

In this case, it might be best to distribute the swap area in several partitions on different disks.

Adding Disk Hardware to Improve Disk I/O

If improved I/O performance still does not occur after you have tuned your system, you may want to consider adding more hardware: disks, controllers, or memory.

If you are going to add more hardware to your system, how do you know which disk/controller to add? You can compare hardware specifications for currently supported disks and controllers by looking up the system specifications in your hardware owner's guide. By using this information, you can choose the right disk/controller to suit your particular needs.

By balancing the most active filesystems across controllers/disks, you can speed up disk access.

Another way to reduce the number of reads and writes that go out to the disk is to add more memory. This reduces swapping and paging.

Checking for Excessive Paging and Swapping

The CPU can only reference data and execute code if the data or code are in the main memory (RAM). Because the CPU executes multiple processes, there may not be enough memory for all the processes. If you have very large programs, they may require more memory than is physically present in the system. So, processes are brought into memory in pages; if there's not enough memory, the operating system frees memory by writing pages temporarily to a secondary memory area, the swap area, on a disk.

IRIX overcommits real memory, loading and starting many more processes than can fit at one time into the available memory. Each process is given its own virtual section of memory, called its address space, which is theoretically large enough to contain the entire process. However, only those pages of the address space that are currently in use are actually kept in memory. These pages are called the working set. As the process needs new pages of data or code to continue running, the needed pages are read into main memory (called "faulting in" pages or "page faults"). If a page has not been used in the recent past, the operating system moves the page out of main memory and into the swap space to make room for new pages being faulted in. Pages written out can be faulted back in later. This process is called "paging" and it should not be confused with the action of "swapping."

Swapping is when all the pages of an inactive process are removed from memory to make room for pages belonging to active processes. The entire process is written out to the swap area on the disk and its execution effectively stops. When an inactive process becomes active again, its pages must be recovered from disk into memory before it can execute. This is called “swapping in” the process. On a personal workstation, swapping in is the familiar delay for disk activity, after you click on the icon of an inactive application and before its window appears.

When IRIX is multiprocessing a large number of processes, the amount of this swapping and paging activity can dominate the performance of the system. You can use the *sar* command to detect this condition and other tools to deal with it.

Determining whether your system is overloaded with paging and swapping requires some knowledge of a baseline. You need to use *sar* under various conditions to determine a baseline for your specific implementation. For example, you can boot your system and run some baseline tests with a limited number of processes running, and then again during a period of light use, a period of heavy networking activity, and then especially when the load is high and you are experiencing poor performance. Recording the results in your system log book can help you in making these baseline measurements.

Table 10-5 shows indicators of excessive paging and swapping on a smaller system.

Table 10-5 Indicators of Excessive Swapping / Paging

Important Field	sar Option
vflt / s - page faults (valid page not in memory)	*sar -p*
bswot / s (transfers from memory to disk swap area)	*sar -w*
bswin / s (transfers to memory)	*sar -w*
%swpocc (time swap queue is occupied)	*sar -q*
rflt / s (page reference fault)	*sar -t*
freemem (average pages for user processes)	*sar -r*

You can use the following *sar* options to determine if poor system performance is related to swap I/O or to other factors:

-u %wswp	Percent of total I/O wait time owed to swap input. This measures the percentage of time during which active processes were blocked waiting for a page to be read or written. This number is not particularly meaningful unless the *wio* value is also high.
-p vflt/s	Frequency with which a process accessed a page that was not in memory. Compare this number between times of good and bad performance. If the onset of poor performance is associated with a sharp increase of *vflt/s*, swap I/O may be a problem even if *%vswp* is low or 0.
-r freemem	Unused memory pages. The paging daemon (*vhand*) recovers what it thinks are unused pages and returns them to this pool. When a process needs a fresh page, the page comes from this pool. If the pool is low or empty, IRIX often has to get a page for one process by taking a page from another process, encouraging further page faults.
-p pgswp/s	Number of read/write data pages retrieved from the swap disk space per second.
-p pgfil/s	Number of read-only code pages retrieved from the disk per second.

If the *%vswp* number is 0 or very low, and *vflt/s* does not increase with the onset of poor performance, the performance problem is not primarily due to swap I/O.

However, when swap I/O may be the cause, there are several possible actions you can take:

- Provide more real memory. This is especially effective in personal workstations, where it is relatively economical to double the available real memory.
- Reduce the demand for memory by running fewer processes. This can be effective when the system load is not interactive, but composed of batch programs or long-running commands. Schedule commands for low-demand hours, using *cron* and *at*. Experiment to find out whether the total execution time of a set of programs is less when they are run sequentially with low swap I/O, or concurrently with high swap I/O.

- Make the swap input of read-only pages more effective. For example, if pages of dynamic shared objects are loaded from NFS-mounted drives over a slow network, you can make page input faster by moving all or a selection of dynamic shared objects to a local disk.
- Make swap I/O of writable pages more effective. For example, use swap(1M) to spread swap activity across several disks or partitions. For more information on swapping to files and creating new swap areas, see “Swap Space” on page 126.
- If you have changed process or CPU-related kernel parameters (for example, *nproc*), consider restoring them to their former values.
- Reduce page faults. Construct programs with “locality” in mind (see “Tuning an Application” on page 182).
- Consider using shared libraries when constructing applications.
- Reduce resident set size limits with *systune*. See “System Limits Parameters” on page 225 for the names and characteristics of the appropriate parameters.

Refer to “Multiple Page Sizes” on page 209 for information on dynamic tuning of page size.

Checking CPU Activity and Memory Allocation

After looking at disk I/O and paging for performance problems, check CPU activity and memory allocation.

Checking the CPU

A CPU can execute only one process at any given instant. If the CPU becomes overloaded, processes have to wait instead of executing. You can't change the speed of the CPU (although you may be able to upgrade to a faster CPU or add CPU boards to your system if your hardware allows it), but you can monitor CPU load and try to distribute it. Table 10-6 shows the fields to check for indications that a system is CPU bound.

Table 10-6 Indications of a CPU-Bound System

Field	Value	sar Option
%idle (% of time CPU has no work to do)	<5	*sar -u*
runq-sz (processes in memory waiting for CPU)	>2	*sar -q*
%runocc (% run queue occupied and processes not executing)	>90	*sar -q*

You can also use the top(1) or gr_top(1) commands to display processes having the highest CPU usage. For each process, the output lists the user, process state flags, process ID and group ID, CPU cycles used, processor currently executing the process, process priority, process size (in pages), resident set size (in pages), amount of time used by the process, and the process name. For more information, see the top(1) or gr_top(1) reference pages.

To increase CPU performance, make the following modifications:

- Off-load jobs to non-peak times or to another system, set efficient paths, and tune applications.
- Eliminate polling loops (see select(2)).
- Increase the *slice-size* parameter (the length of a process time slice). For example, change *slice-size* from Hz / 30 to Hz / 10. However, be aware that this may slow interactive response time.
- Upgrade to a faster CPU or add another CPU.

Checking Available Memory

"Checking for Excessive Paging and Swapping" on page 197 described what happens when you don't have enough physical (main) memory for processes. This section discusses a different problem—what happens when you don't have enough available memory (sometimes called virtual memory), which includes both physical memory and logical swap space.

The IRIX virtual memory subsystem allows programs that are larger than physical memory to execute successfully. It also allows several programs to run even if the combined memory needs of the programs exceed physical memory. It does this by storing the excess data on the swap device(s).

The allocation of swap space is done after program execution has begun. This allows programs with large a virtual address to run as long as the actual amount of virtual memory allocated does not exceed the memory and swap resources of the machine.

Usually it's evident when you run out of memory, because a message is sent to the console that begins:

```
Out of logical swap space...
```

If you see this message these are the possible causes:

- The process has exceeded ENOMEM or UMEM.
- There is not enough physical memory for the kernel to hold the required non-pageable data structures.
- There is not enough logical swap space.

You can add virtual swap space to your system at any time. See "Swap Space" on page 126 to add more swap space. You need to add physical swap space, though, if you see the message:

```
Process killed due to insufficient memory
```

The following system calls return EAGAIN if there is insufficient available memory: *exec*, *fork*, *brk*, *sbrk* (called by *malloc*), *mpin*, and *plock*. Applications should check the return status and exit gracefully with a useful message.

To check the size (in pages) of a process that is running, execute *ps -el* (you can also use *top*(1)). The SZ:RSS field shows very large processes.

By checking this field, you can determine the amount of memory the process is using. A good strategy is to run very large processes at less busy times.

Determining the Amount of System Memory

To see the amount of main memory, use the *hinv*(1) command. It displays data about your system's configuration. For example:

```
Main memory size: 64 Mb
```

Maximizing Memory

To increase the amount of virtual memory, increase the amount of real memory and / or swap space. Note that most of the paging / swapping solutions are also ways to conserve available memory. These include:

- limiting the number of programs
- using shared libraries
- adding more memory
- decreasing the size of system tables

However, the most dramatic way to increase the amount of virtual memory is to add more swap space. See "Swap Space" on page 126.

Tuning the Operating System

The process of tuning the operating system is not difficult, but it should be approached carefully. Make complete notes of your actions in case you need to reverse your changes later on. Understand what you are going to do before you do it, and do not expect miraculous results; IRIX has been engineered to provide the best possible performance under all but the most extreme conditions. Software that provides a great deal of graphics manipulation or data manipulation also carries a great deal of overhead for the system, and can seriously affect the speed of an otherwise robust system. No amount of tuning can change these situations.

Operating System Tuning Steps

To tune a system, you first monitor its performance with various system utilities as described in “Monitoring the Operating System” on page 187. This section describes the steps to take when you are tuning a system.

1. Determine the general area that needs tuning (for example, disk I/O or the CPU) and monitor system performance using utilities such as *sar* and *osview*. If you have not already done so, see “Monitoring the Operating System” on page 187.
2. Pinpoint a specific area and monitor performance over a period of time. Look for numbers that show large fluctuation or change over a sustained period; don’t be too concerned if numbers occasionally go beyond the maximum.
3. Modify one value/characteristic at a time (for example, change a parameter, add a controller) to determine its effect. It’s good practice to document any changes in a system notebook.
4. Use the systune(1M) command to change parameter values or make the change in the *master.d* directory structure if the variable is not tunable through *systune*. Remake the kernel and reboot if necessary.
5. Remeasure performance and compare the before and after results. Then evaluate the results (is system performance better?) and determine if further change is needed.

Keep in mind that the tuning procedure is more an *art* than a science; you may need to repeat the above steps as necessary to fine tune your system. You may find that you’ll need to do more extensive monitoring and testing to thoroughly fine-tune your system.

Finding Parameter Values

Before you can tune your system, you need to know the current values of the tunable parameters. To find the current value of your kernel parameters, use the systune(1M) command. This command, entered with no arguments, prints the current values of all tunable parameters on your system. For complete information on this command, see the systune(1M) reference page.

Changing Parameters and Reconfiguring the System

After determining the parameter or parameters to adjust, you must change the parameters and you may need to reconfigure the system for the changes to take effect. The systune(1M) utility tells you when you make parameter changes if you must reboot to activate those changes. There are several steps to the reconfiguration procedure:

1. Back up the system.
2. Copy your existing kernel to *unix.save.*
3. Make your changes.
4. Reboot your system, if necessary.

Backing Up the System

Before you reconfigure the system by changing kernel parameters, it's a good idea to have a current and complete backup of the system. See the *IRIX Admin: Backup, Security, and Accounting* guide.

Caution: Always back up the entire system before tuning.

Copying the Kernel

After determining the parameter you need to change (for example, you need to increase *nproc* because you have a large number of users), you must first back up the system and the kernel. Give the command:

```
cp /unix /unix.save
```

This command creates a safe copy of your kernel. Through the rest of this example, this is called your old saved kernel. If you make this copy, you can always go back to your old saved kernel if you are not satisfied with the results of your tuning.

Changing a Parameter

Once your backups are complete, you can execute the systune(1M) command. Note that you can present new values to *systune* in either hexadecimal or decimal notation. Both values are printed by *systune*.

An invocation of systune(1M) to increase *nproc* looks something like this:

```
systune -i
Updates will be made to running system and /unix.install
systune-> nproc
        nproc = 400 (0x190)
systune-> nproc = 500
        nproc = 400 (0x190)
        Do you really want to change nproc to 500 (0x1f4)? (y/n) y
In order for the change in parameter nproc to become effective
/unix.install must be moved to /unix and the system rebooted
systune-> quit
```

Then reboot your system. Also, be sure to document the parameter change you made in your system log book.

Caution: When you issue the *reboot* command, the system overwrites the current kernel (*/unix*) with the kernel you have just created (*/unix.install*). This is why you should always copy the current kernel to a safe place before rebooting.

Creating and Booting a New Kernel With autoconfig

The *systune* command creates a new kernel automatically. However, if you changed parameters without using *systune*, or if you have added new system hardware (such as a new CPU board on a multiprocessor system), you must use *autoconfig* to generate a new kernel.

The *autoconfig* command uses some environment variables. These variables are described in detail in the autoconfig(1M) reference page. If you have any of the following variables set, you may need to unset them before running *autoconfig*:

- UNIX
- SYSGEN
- BOOTAREA
- SYSTEM
- MASTERD
- STUNEFILE
- MTUNEDIR
- WORKDIR

To build a new kernel after reconfiguring the system, follow these steps:

1. Become the superuser by giving the command:

   ```
   su
   ```

2. Make a copy of your current kernel with the command:

   ```
   cp /unix /unix.save
   ```

3. Give the command:

   ```
   /etc/autoconfig -f
   ```

   This command creates a new kernel and places it in the file */unix.install*.

4. Reboot your system with the command:

   ```
   reboot
   ```

Caution: When you issue the *reboot* command, the system overwrites the current kernel (*/unix*) with the kernel you have just created (*/unix.install*). This is why you should always copy the current kernel to a safe place before rebooting.

An autoconfiguration script, found in */etc/rc2.d/S95autoconfig*, runs during system startup. This script asks you if you would like to build a new kernel under the following conditions:

- A new board has been installed for which no driver exists in the current kernel.
- There have been changes to object files in */var/sysgen/mtune*, master files in */var/sysgen/master.d*, or the system files in */var/sysgen/system*. This is determined by the modification dates on these files and the kernel.

If any of these conditions is true, the system prompts you during startup to reconfigure the operating system:

```
Automatically reconfigure the operating system? y
```

If you answer **y** to the prompt, the script runs *lboot* and generates */unix.install* with the new image.You can disable the autoconfiguration script by renaming */etc/rc2.d/S95autoconfig* to something else that does not begin with the letter *S*, for example, */etc/rc2.d/wasS95autoconfig*.

Recovering From an Unbootable Kernel

The following procedure explains how to recover from an unbootable */unix*, and describes how to get a viable version of the software running after an unsuccessful reconfiguration attempt. If you use the systune(1M) utility, you should never have to use this information, since *systune* does not allow you to set your parameters to unworkable values.

1. If the system fails to reboot, try to reboot it again. If it still fails, interrupt the boot process and direct the boot PROM to boot from your old saved kernel (*unix.save*).
2. Press the Reset button.You see the System Maintenance Menu:

   ```
   System Maintenance Menu
   1) Start System.
   2) Install System Software.
   3) Run Diagnostics.
   4) Recover System.
   5) Enter Command Monitor.
   ```

3. Choose option 5 to enter the Command Monitor. You see:

   ```
   Command Monitor. Type "exit" to return to the menu.
   >>
   ```

4. Now at the >> prompt, tell the PROM to boot your old saved kernel. The command is:

   ```
   boot unix.save
   ```

   The system boots the old saved kernel.

5. Once the system is running, use the following command to move your old saved kernel to the default */unix* name. This method also keeps a copy of your old saved kernel in *unix.save*:

   ```
   cp /unix.save /unix
   ```

Then you can normally boot the system while you investigate the problem with the new kernel. Try to figure out what went wrong. What was changed that stopped the kernel from booting? Review the changes that you made.

- Did you increase / decrease a parameter by a large amount? If so, make the change less drastic.
- Did you change more than one parameter? If so, make a change to only one parameter at a time.

Multiple Page Sizes

The operating system supports multiple page sizes, which can be tuned as described in this section.

Recommended Page Sizes

The page sizes supported depend on the base page size of the system. The base page size can be obtained by using the *getpagesize()* system call. Currently IRIX supports two base page sizes, 16K and 4K. On systems with 16K base page size the following tunable page sizes are supported, 16K, 64K, 256K, 1M, 4M, 16M. On systems with 4K base page size, the following tunable page sizes are supported, 4K, 16K, 256K, 1M, 4M, 16M. In general for most applications 4K, 16K, and 64K page sizes are sufficient to eliminate tlbmiss overhead.

Tunable Parameters for Coalescing

The IRIX kernel tries to keep a percentage of total free memory in the system at a certain page size. It periodically tries to coalesce a group of adjacent pages to form a large page. The following tunable parameters specify the upper limit for the number of free pages at a particular page size. Systems that do not need large pages can set these parameters to zero. The tunable parameters are:

- percent_totalmem_16k_pages
- percent_totalmem_64k_pages
- percent_totalmem_256k_pages
- percent_totalmem_1m_pages
- percent_totalmem_4m_pages
- percent_totalmem_16m_pages

The parameters specify the percentage of total memory that can be used as an upper limit for the number of pages in a specific page size. Thus setting percent_totalmem_64k_pages to 20 implies that the coalescing mechanism tries to limit the number of free 64K pages to 20% of total memory in the system. These parameters can be tuned dynamically at run time. Note that very large pages (>= 1 MB) are harder to coalesce dynamically during run time on a busy system. It is recommended these tunables be set during boot time in such cases. Setting these tunables to a high value can result in high coalescing activity. If the system runs low on memory, the large pages can be split into smaller pages as needed.

Reserving Large Pages

It is hard to coalesce very large pages (>= 1 MB) at run time due to fragmentation of physical memory. Applications that need such pages can set tunable parameters to reserve large pages during boot time. They are specified as the number of pages. The tunable parameters are:

- nlpages_64k
- nlpages_256k
- nlpages_1m
- nlpages_4m
- nlpages_16m

Thus setting nlpages_4m to 4 results in the system reserving four 4 MB pages during boot time. If the system runs low on memory, the reserved pages can be split into smaller pages for use by other applications. The command *osview* can be used to view the number of free pages available at a particular page size (see osview(1)). The default value for all these parameters is zero. Refer to “nlpages_64k” on page 244 for additional information.

Appendices

The following appendices are provided:

- Appendix A: **IRIX Kernel Tunable Parameters**
- Appendix B: **Troubleshooting System Configuration with System Error Messages**
- Appendix C: **IRIX Directories and Files**
- Appendix D: **Encapsulated PostScript File v.3.0 vs. PostScript File Format**
- Appendix E: **Bibliography and Suggested Reading**

Appendix A

IRIX Kernel Tunable Parameters

This appendix describes the tunable parameters that define kernel structures. These structures keep track of processes, files, and system activity. Many of the parameter values are specified in the files found in */var/sysgen/mtune* and */var/sysgen/master.d*.

If the system does not respond favorably to your tuning changes, you may want to return to your original configuration or continue making changes to related parameters. An unfavorable response to your tuning changes can be as minor as the system not gaining the hoped-for speed or capacity, or as major as the system becoming unable to boot or run. This generally occurs when parameters are changed to a great degree. Simply maximizing a particular parameter without regard for related parameters can upset the balance of the system to the point of inoperability. For complete information on the proper procedure for tuning your operating system, read Chapter 10, “System Performance Tuning.”

Format of This Appendix

The rest of this appendix describes the more important tunable parameters according to function. Related parameters are grouped into sections. These sections include:

- General tunable parameters. See “General Parameters” on page 217.
- System limits tunable parameters. See “System Limits Parameters” on page 225.
- Resource limits tunable parameters. See “Resource Limits Parameters” on page 227.
- Paging tunable parameters. See “Paging Parameters” on page 236.
- IPC tunable parameters–including interprocess communication messages, semaphores, and shared memory. See “IPC Parameters” on page 244, “IPC Messages Parameters” on page 246, “IPC Semaphores Parameters” on page 250, and “IPC Shared Memory Parameters” on page 253.
- Streams tunable parameters. See “Streams Parameters” on page 255.
- Signal parameters. See “Signal Parameters” on page 258.

- Dispatch parameters. See “Dispatch Parameters” on page 258.
- Extent File System (EFS) parameters. See “EFS Parameters” on page 262.
- Loadable driver parameters. See “Loadable Drivers Parameters” on page 263.
- CPU actions parameters. See “CPU Actions Parameters” on page 265.
- Switch parameters. See “Switch Parameters” on page 266.
- Timer parameters. See “Timer parameters” on page 273.
- Network File System (NFS) parameters. See “NFS Parameters” on page 275.
- Socket parameters. See “Socket Parameters” on page 278.
- Indy Video parameters. See “VINO Parameters” on page 285.
- Extended Accounting parameters. See “Extended Accounting Parameters” on page 285.

Each section begins with a short description of the activities controlled by the parameters in that section, and each listed parameter has a description that may include:

- Name—the name of the parameter.
- Description—a description of the parameter, including the file in which the parameter is specified, and the formula, if applicable.
- Value—the default setting and, if applicable, a range. Note that the value given for each parameter is usually appropriate for a single-user graphics workstation. Values may be presented in either hex or decimal notation.
- When to Change—the conditions under which it is appropriate to change the parameter.
- Notes—other pertinent information, such as error messages.

Note that the tunable parameters are subject to change with each release of the system.

General Parameters

The following group of tunable parameters specifies the size of various system structures. These are the parameters you will most likely change when you tune a system.

- *cachefs_readahead*—specifies the number of readahead blocks for the filesystem.
- *cachefs_max_threads*—specifies the maximum number of asynchronous I/O daemons per cachefs mount.
- *nbuf*—specifies the number of buffer headers in the file system buffer cache.
- *callout_himark*—specifies the high water mark for callouts
- *ncallout*—specifies the initial number of callouts
- *reserve_ncallout*—specifies the number of reserved callouts
- *ncsize*—specifies the name cache size.
- *ndquot*—used by the disk quota system.
- *nproc*—specifies the number of user processes allowed at any given time.
- *maxpmem*—specifies the maximum physical memory address.
- *syssegsz*—specifies the maximum number of pages of dynamic system memory.
- *maxdmasz*—specifies the maximum DMA transfer in pages.
- *nm_clusters*—specifies the maximum number of one-page clusters used in network buffers.
- *ecc_recover_enable*—specifies the system response to multibit errors.
- *vnode_free_ratio*—specifies the ratio of free vnodes to in-use vnodes.

cachefs_readahead

Description This parameter specifies the number of blocks to read ahead of the current read block in the filesystem. The blocks are read asynchronously.

Value Default: 1 (0x1)

Range: 0 - 10

cachefs_max_threads

Description This parameter specifies the maximum number of asynchronous I/O daemons that can be run per cachefs mount.

Value Default: 5 (0x5)

Range: 1 - 10

nbuf

Description The *nbuf* parameter specifies the number of buffer headers in the file system buffer cache. The actual memory associated with each buffer header is dynamically allocated as needed and can be of varying size, currently 1 to 128 blocks (512 to 64KB).

The system uses the file system buffer cache to optimize file system I/O requests. The buffer memory caches blocks from the disk, and the blocks that are used frequently stay in the cache. This helps avoid excess disk activity.

Buffers are used only as transaction headers. When the input or output operation has finished, the buffer is detached from the memory it mapped and the buffer header becomes available for other uses. Because of this, a small number of buffer headers is sufficient for most systems. If *nbuf* is set to 0, the system automatically configures *nbuf* for average systems. There is little overhead in making it larger for non-average systems.

The *nbuf* parameter is defined in */var/sysgen/mtune*.

Value
Default: 0 (Automatically configured if set to 0)

Formula: 100 + (*total number of pages of memory* / 40)

32-bit Range: up to 6000

64-bit Range: up to 250000

When To Change
The automatic configuration is adequate for average systems. If you see dropping “cache hit” rates in *sar* and *osview* output, increase this parameter. Also, if you have directories with a great number of files (over 1000), you may wish to raise this parameter.

callout_himark

Description
The *callout_himark* parameter specifies the maximum number of callout table entries system-wide. The callout table is used by device drivers to provide a timeout to make sure that the system does not hang when a device does not respond to commands.

This parameter is defined in */var/sysgen/mtune* and has the following formula:

nproc + 32

where:

nproc is the maximum number of processes, system-wide.

Value
Default: 0 (Automatically configured if set to 0)

Formula: *nproc* + 32

Range: 42 - 1100

When to Change
Increase this parameter if you see console error messages indicating that no more callouts are available.

ncallout

Description The *ncallout* parameter specifies the number of callout table entries at boot time. The system will automatically allocate one new callout entry if it runs out of entries in the callout table. However, the maximum number of entries in the callout table is defined by the *callout_himark* parameter.

Value Default: 40

Range: 20–1000

When to Change

Change *ncallout* if you are running an unusually high number of device drivers on your system. Note that the system automatically allocates additional entries when needed, and releases them when they are no longer needed.

reserve_ncallout

Description The *reserve_ncallout* parameter specifies the number of reserved callout table entries. These reserved table entries exist for kernel interrupt routines when the system has run out of the normal callout table entries and cannot allocate additional entries.

Value Default: 5

Range: 0-30

ncsize

Description This parameter controls the size of the name cache. The name cache is used to allow the system to bypass reading directory names out of the main buffer cache. A name cache entry contains a directory name, a pointer to the directory's in-core inode and version numbers, and a similar pointer to the directory's parent directory in-core inode and version number.

Value Default: 0 (Automatically configured if set to 0)

Range: 268-6200

ndquot

Description The *ndquot* parameter controls disk quotas.

Value Default: 0 (Automatically configured if set to 0)

Range: 268-6200

nproc

Description The *nproc* parameter specifies the number of entries in the system process (*proc*) table. Each running process requires an in-core *proc* structure. Thus *nproc* is the maximum number of processes that can exist in the system at any given time.

The default value of *nproc* is based on the amount of memory on your system. To find the currently auto-configured value of *nproc*, use the systune(1M) command.

The *nproc* parameter is defined in */var/sysgen/mtune*.

Value Default: 0 (Automatically configured if set to 0)

Range: 30–10000

When to Change

Increase this parameter if you see an overflow in the *sar -v* output for the *proc -sz ov* column or you receive the operating system message:

```
no more processes
```

This means that the total number of processes in the system has reached the current setting. If processes are prevented from forking (being created), increase this parameter. A related parameter is *maxup*.

Notes

If a process can't fork, make sure that this is system-wide, and not just a user ID problem (see the *maxup* parameter).

If *nproc* is too small, processes that try to fork receive the operating system error:

```
EAGAIN: No more processes
```

The shell also returns a message:

```
fork failed: too many processes
```

If a system daemon such as *sched*, *vhand*, *init*, or *bdflush* can't allocate a process table entry, the system halts and displays:

```
No process slots
```

maxpmem

Description

The *maxpmem* parameter specifies the amount of physical memory (in pages) that the system can recognize. The page size is 4 Kilobytes for 32 bit IRIX version 5 or 6 kernels and 16 Kilobytes for 64 bit IRIX version 6 kernels. If set to zero (0), the system will use all available pages in memory. A value other than zero defines the physical memory size (in pages) that the system will recognize.

This parameter is defined in */var/sysgen/mtune*.

Value

Default: 0 (Automatically configured if set to 0)

Range: 1024 pages—total amount of memory

When to Change

You don't need to change this parameter, except when benchmarks require a specific system memory size less than the physical memory size of the system. This is primarily useful to kernel developers. You can also boot the system with the command:

maxpmem = *memory_size*

added on the boot command line to achieve the same effect.

syssegsz

Description This is the maximum number of pages of dynamic system memory.

Value Default: 0 (Autoconfigured if set to 0)

32-bit Range: 0x2000 - 0x20000

64-bit Range: 0x2000 - 0x10000000

When to Change

Increase this parameter correspondingly when *maxdmasz* is increased, or when you install a kernel driver that performs a lot of dynamic memory allocation.

maxdmasz

Description

The maximum DMA transfer expressed in pages of memory. This amount must be less than the value of *syssegsz* and *maxpmem*.

Value Default: 1024 pages

32-bit Range: 1 - *syssegsz* (maximum 0x20000)

64-bit Range: 1 - *syssegsz* (maximum 0x10000000)

When to Change

Change this parameter when you need to be able to use very large read or write system calls, or other system calls that perform large scale DMA. This situation typically arises when using optical scanners, film recorders or some printers.

nm_clusters

Description The maximum number of single page clusters that can be allocated to network buffers. This limits the total memory that network buffers (mbufs) can consume.

Value Default: 1/8 of physical memory

Range: Default - *Total System Memory (in pages)*

When to Change

For most workstations and small servers the default is sufficient. For very large systems larger values are appropriate. A 0 value tells the kernel to set the value (1/8 of physical memory) based on the amount of physical memory configured in the hardware.

ecc_recover_enable

Description This parameter, when set to 0, directs the system not to attempt to recover from multibit errors. If set greater than 0, the parameter value is taken as a number of seconds. The system is directed to attempt recovery, but not in the event of more than 32 errors in each number of seconds specified by this parameter.

Value Default: 60 seconds (0x3c)

vnode_free_ratio

Description The ratio of free vnodes to vnodes in use that is to be maintained by the kernel.

Value Default: 2:1

Range: 1:1 to 16:1, or 0 to auto-configure

When to Change

For most workstations and servers the default, auto-configured value is sufficient. Increase this parameter if you have an application that opens and closes many files frequently. When a program is opening and closing and reopening many files, the system may overflow the file buffer cache, even though the file contents are still in memory. Then the files will be read in again, wasting disk activity and time. Increasing this parameter increases the number of files that can be “remembered” by IRIX.

System Limits Parameters

IRIX has configurable parameters for certain system limits. For example, you can set maximum values for each process (its core or file size), the number of groups per user, the number of resident pages, and so forth. These parameters are listed below. All parameters are set and defined in */var/sysgen/mtune*.

- *maxup*—the number of processes per user
- *ngroups_max*—the number of groups to which a user may belong
- *maxwatchpoints*—the maximum number of “watchpoints’’ per process.
- *nprofile*—amount of disjoint text space to be profiled
- *maxsymlinks*—specifies the maximum number of symlinks expanded in a pathname.

maxup

Description The *maxup* parameter defines the number of processes allowed per user login. This number should always be at least 5 processes smaller than *nproc*.

Value Default: 150 processes

Range: 15–10000 (but never larger than *nproc* - 5)

When to Change

Increase this parameter to allow more processes per user. In a heavily loaded time-sharing environment, you may want to decrease the value to reduce the number of processes per user.

ngroups_max

Description The *ngroups_max* parameter specifies the maximum number of multiple groups to which a user may simultaneously belong.

The constants NGROUPS_UMIN <= *ngroups_max* <= NGROUPS_UMAX are defined in *</usr/include/sys/param.h>*. NGROUPS_UMIN is the minimum number of multiple groups that can be selected at *lboot* time. NGROUPS_UMAX is the maximum number of multiple groups that can be selected at *lboot* time and is the number of group-id slots for which space is set aside at compile time. NGROUPS, which is present for compatibility with networking code (defined in *</usr/include/sys/param.h>*), must not be larger than *ngroups_max*.

Value Default: 16

Range: 0-32

When to Change

The default value is adequate for most systems. Increase this parameter if your system has users who need simultaneous access to more than 16 groups.

maxwatchpoints

Description *maxwatchpoints* sets the maximum number of watchpoints per process. Watchpoints are set and used via the *proc*(4) file system. This parameter specifies the maximum number of virtual address segments to be watched in the traced process. This is typically used by debuggers.

Value Default: 100

Range: 1-1000

When to Change

Raise *maxwatchpoints* if your debugger is running out of watchpoints.

nprofile

Description *nprofile* is the maximum number of disjoint text spaces that can be profiled using the sprofil(2) system call. This is useful if you need to profile programs using shared libraries or profile an address space using different granularities for different sections of text.

Value Default: 100

Range: 100-200

When to Change
Change *nprofile* if you need to profile more text spaces than are currently configured.

maxsymlinks

Description This parameter defines the maximum number of symbolic links that will be followed during filename lookups (for example, during the open(2) or stat(2) system calls) before ceasing the lookup. This limit is required to prevent loops where a chain of symbolic links points back to the original filename.

Value Default: 30

Range: 0-50

When to Change
Change this parameter if you have pathnames with more than 30 symbolic links.

Resource Limits Parameters

You can set numerous limits on a per-process basis by using getrlimit(2), setrlimit(2), and *limit*, the shell built-in command. These limits are inherited, and the original values are set in */var/sysgen/mtune*. These limits are different from the system limits listed above in that they apply only to the current process and any child processes that may be spawned. To achieve similar effects, you can also use the *limit* command within the Bourne, C, and Korn shells (*/bin/sh*, */bin/csh*, and */bin/ksh*).

Each limit has a default and a maximum. Only the superuser can change the maximum. Each resource can have a value that turns off any checking RLIM_INFINITY. The default values are adequate for most systems.

The following parameters are associated with system resource limits:

- *ncargs*—the number of bytes of arguments that may be passed during an exec(2) call.
- *rlimit-core-cur*—the maximum size of a core file.
- *rlimit-core-max*—the maximum value *rlimit-core-cur* may hold.
- *rlimit-cpu-cur*—the limit for maximum cpu time available to a process.
- *rlimit-cpu-max*—the maximum value *rlimit-cpu-current* may hold.
- *rlimit-data-cur*—the maximum amount of data space available to a process.
- *rlimit-data-max*—the maximum value *rlimit-data-cur* may hold.
- *rlimit-fsize-cur*—the maximum file size available to a process.
- *rlimit-fsize-max*—the maximum value *rlimit-fsize-cur* may hold.
- *rlimit-nofile-cur*—the maximum number of file descriptors available to a process.
- *rlimit-nofile-max*—the maximum value *rlimit-nofile-cur* may hold.
- *rlimit-rss-cur*—the maximum resident set size available to a process.
- *rlimit-rss-max*—the maximum value *rlimit-rss-cur* may hold.
- *rlimit-stack-cur*—the maximum stack size for a process.
- *rlimit-stack-max*—the maximum value *rlimit-stack-cur* may hold.
- *rlimit-vmem-cur*—the maximum amount of virtual memory for a process.
- *rlimit-vmem-max*—the maximum value *rlimit-vmem-cur* may hold.
- *rsshogfrac*—the percentage of memory allotted for resident pages.
- *rsshogslop*—the number of pages above the resident set maximum that a process may use.
- *shlbmax*—the maximum number of shared libraries with which a process can link.

ncargs

Description — The *ncargs* parameter specifies the maximum size of arguments in bytes that may be passed during an *exec*(2) system call.

This parameter is specified in */var/sysgen/mtune*.

Value — Default: 20480

Range: 5120–262144

When to Change — The default value is adequate for most systems. Increase this parameter if you get the following message from *exec*(2), *shell*(1), or *make*(1):

```
E2BIG arg list too long
```

Notes — Setting this parameter too large wastes memory (although this memory is pageable) and may cause some programs to function incorrectly. Also note that some shells may have independent limits smaller than *ncargs*.

rlimit_core_cur

Description — The current limit to the size of core image files for the given process.

Value — Default: 0x7fffffffffffffff (9223372036854775807 minutes)

Range: 0–0x7fffffffffffffff

When to change — Change this parameter when you want to place a cap on core file size.

rlimit_core_max

Description — The maximum limit to the size of core image files.

Value — Default: 0x7fffffffffffffff (9223372036854775807 minutes)

Range: 0–0x7fffffffffffffff

When to change — Change this parameter when you want to place a maximum restriction on core file size. *rlimit_core_cur* cannot be larger than this value.

rlimit_cpu_cur

Description The current limit to the amount of cpu time in minutes that may be used in executing the process.

Value Default: 0x7fffffffffffffff (9223372036854775807 minutes)

Range: 0–0x7fffffffffffffff

When to change
Change this parameter when you want to place a cap on cpu usage.

rlimit_cpu_max

Description The maximum limit to the amount of cpu time that may be used in executing a process.

Value Default: 0x7fffffffffffffff (9223372036854775807 minutes)

Range: 0–0x7fffffffffffffff

When to change
Change this parameter when you want to place a maximum restriction on general cpu usage.

rlimit_data_cur

Description The current limit to the data size of the process.

Value Default: 0 (auto-configured to *rlimit_vmem_cur* * NBPP (0x20000000))

Range: 0–0x7fffffffffffffff

When to change
Change this parameter when you want to place a cap on data segment size.

rlimit_data_max

Description The maximum limit to the size of data that may be used in executing a process.

Value Default: 0 (auto-configured to *rlimit_vmem_cur* * NBPP (0x20000000))

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a maximum restriction on the size of the data segment of any process.

rlimit_fsize_cur

Description The current limit to file size on the system for the process.

Value Default: 0x7fffffffffffffff (9223372036854775807 bytes)

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a limit on file size.

rlimit_fsize_max

Description The maximum limit to file size on the system.

Value Default: 0x7fffffffffffffff (9223372036854775807 bytes)

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a maximum size on all files.

rlimit_nofile_cur

Description The current limit to the number of open file descriptors that may be used in executing the process.

Value Default: 200

Range: 40–0x7fffffffffffffff

When to change

Change this parameter when you want to place a cap on the number of open file descriptors.

rlimit_nofile_max

Description The maximum limit to the number of open file descriptors that may be used in executing a process.

Value Default: 2500

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a maximum restriction on the number of open file descriptors.

rlimit_rss_cur

Description The current limit to the resident set size (the number of pages of memory in use at any given time) that may be used in executing the process. This limit is the larger of the results of the following two formulae:

physical_memory_size - 4 MB

or

physical_memory_size ∗ 9 / 10

Value Default: 0 (Automatically configured if set to 0)

Range: 0–(*rlimit_vmem_cur* ∗ NBPP) (0x7fffffffffffffff)

When to change

Change this parameter when you want to place a cap on the resident set size of a process.

rlimit_rss_max

Description The maximum limit to the resident set size that may be used in executing a process.

Value Default: (*rlimit_vmem_cur* ∗ NBPP) (0x20000000)

Range: 0–(*rlimit_vmem_cur* ∗ NBPP) (0x7fffffffffffffff)

When to change

Change this parameter when you want to place a maximum restriction on resident set size.

rlimit_stack_cur

Description The current limit to the amount of stack space that may be used in executing the process.

Value Default: 64 MB (0x04000000)

Range: 0–0x7fffffffffffffff)

When to change

Change this parameter when you want to place a limit on stack space usage.

rlimit_stack_max

Description The maximum limit to the amount of stack space that may be used in executing a process.

Value Default: *rlimit_vmem_cur* * NBPP (0x20000000)

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a maximum restriction on stack space usage.

rlimit_vmem_cur

Description The current limit to the amount of virtual memory that may be used in executing the process.

Value Default: 0 (auto-configured to *rlimit_vmem_cur* * NBPP (0x20000000))

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a cap on virtual memory usage.

rlimit_vmem_max

Description The maximum limit to the amount of virtual memory that may be used in executing a process.

Value Default: 0 (aut-configured to *rlimit_vmem_cur* * NBPP (0x20000000))

Range: 0–0x7fffffffffffffff

When to change

Change this parameter when you want to place a maximum restriction on virtual memory usage.

rsshogfrac

Description The number of physical memory pages occupied by a process at any given time is called its resident set size (RSS). The limit to the RSS of a process is determined by its allowable memory-use resource limit. *rsshogfrac* is designed to guarantee that even if one or more processes are exceeding their RSS limit, some percentage of memory is always kept free so that good interactive response is maintained.

Processes are permitted to exceed their RSS limit until either:

- one or more processes exceed their default RSS limit (thereby becoming an “RSS hog”) and the amount of free memory drops below *rsshogfrac* of the total amount of physical memory; or
- the amount of free memory drops below GPGSHI

In either of these cases, the paging daemon runs and trims pages from all RSS processes exceeding the RSS limit.

The parameter RSSHOGFRAC is expressed as a fraction of the total physical memory of the system. The default value is 75 percent.

This parameter is specified in */var/sysgen/mtune*. For more information, see the *gpgshi*, *gpgslo*, and *rsshogslop* resource limits.

Value Default: 75% of total memory

Range: 0–100% of total memory

When to Change

The default value is adequate for most systems.

rsshogslop

Description To avoid thrashing (a condition where the computer devotes 100% of its CPU cycles to swapping and paging), a process can use up to *rsshogslop* more pages than its resident set maximum (see “Resource Limits Parameters” on page 227).

This parameter is specified in */var/sysgen/mtune*. For more information, see the *rsshogfrac* resource limit.

Value Default: 20

When to Change

The default value is adequate for most systems.

shlbmax

Description The *shlbmax* parameter specifies the maximum number of shared libraries with which a process can link.

This parameter is specified in */var/sysgen/mtune*.

Value Default: 8

Range: 3–32

When to Change

The default value is adequate for most systems. Increase this parameter if you see the following message from *exec*(2):

```
ELIBMAX cannot link
```

Paging Parameters

The paging daemon, *vhand*, frees up memory as the need arises. This daemon uses a "least recently used" algorithm to approximate process working sets and writes those pages out to disks that have not been touched during a specified period of time. The page size is 4K for 32 bit kernels and 16K for 64 bit kernels. When memory gets exceptionally tight, *vhand* may swap out entire processes.

The *vhand* program reclaims memory by:

- stealing memory from processes that have exceeded their permissible resident set size maximum, forcing delayed write data buffers out to disk (with *bdflush*) so that the underlying pages can be reused
- calling down to system resource allocators to trim back dynamically sized data structures
- stealing pages from processes in order of lowest-priority process first, and the least-recently-used page first within that process
- swapping out the entire process

The following tunable parameters determine how often *vhand* runs and under what conditions. Note that the default values should be adequate for most applications.

The following parameters are included:

- *bdflushr*—specifies how many buffers will be written to disk at a time; *bdflush* performs flushes of dirty file system buffers once per second.
- *gpgsmsk*—specifies the mask used to determine if a given page may be swapped.
- *gpgshi*—the number of free pages above which *vhand* stops stealing pages.
- *gpgslo*—the number of free pages below which *vhand* starts stealing pages
- *maxlkmem*—The *maxlkmem* parameter specifies the maximum number of physical pages that can be locked in memory (by mpin(2) or plock(2)) by a non-superuser process.
- *maxsc*—the maximum number of pages that may be swapped by the *vhand* daemon in a single operation.
- *maxfc*—the maximum number of pages that will be freed at once.
- *maxdc*—the maximum number of pages that will be written to disk at once.

- *minarmem*—the minimum available resident pages of memory.
- *minasmem*—the minimum available swappable pages of memory.
- *tlbdrop*—number of clock ticks before a process' wired entries are flushed.
- *vfs_syncr*—The rate at which *vfs_syncr* is run, in seconds.
- *maxpglst*—The maximum number of pages that can be held in each pageout queue.

The following parameters determine page sizes as discussed in this section:

- percent_totalmem_16k_pages
- percent_totalmem_64k_pages
- percent_totalmem_256k_pages
- percent_totalmem_1m_pages
- percent_totalmem_4m_pages
- percent_totalmem_16m_pages
- nlpages_64k
- nlpages_256k
- nlpages_1m
- nlpages_4m
- nlpages_16m

bdflushr

Description
: The *bdflushr* parameter specifies how many buffers will be examined each time *bdflush* runs; *bdflush* performs periodic flushes of dirty file system buffers. It is parallel and similar to *vfs_syncr*. The *bdflush* daemon runs once per second.

  This parameter is specified in */var/sysgen/mtune*. For more information, see the *autoup* kernel parameter.

Value
: Default: 5

  Range: 1–31536000

When to Change
: The default value is adequate for most systems.

gpgsmsk

Description

The *gpgsmsk* parameter specifies the mask used to determine if a given page may be swapped. Whenever the pager (*vhand*) is run, it decrements software reference bits for every active page. When a process subsequently references a page, the counter is reset to the limit (NDREF, as defined in */usr/include/sys/immu.h*). When the pager is looking for pages to steal back (if memory is in short supply), it takes only pages whose reference counter has fallen to *gpgsmsk* or below.

This parameter is specified in */var/sysgen/mtune*.

Also see */usr/include/sys/immu.h* and */usr/include/sys/tuneable.h* and the *gpgshi* and *gpgslo* kernel parameters for more information.

Value

Default: 2

Range: 0–7

When to Change

This value is adequate for most systems.

Notes

If the value is greater than 4, pages are written to the swap area earlier than they would be with the default value of *gpgsmsk*. Thus swapping / paging may occur before it should, unnecessarily using system resources.

gpgshi

Description — When the *vhand* daemon (page handler) is stealing pages, it stops stealing when the amount of free pages is greater than *gpgshi*.

In other words, *vhand* starts stealing pages when there are fewer than *gpgslo* free pages in the system. Once *vhand* starts stealing pages, it continues until there are *gpgshi* pages.

If, at boot time, *gpgslo* and *gpgshi* are 0, the system sets *gpgshi* to 8% of the number of pages of memory in the system, and sets *gpgslo* to one half of *gpgshi*.

This parameter is specified in */var/sysgen/mtune*. For more information, see the kernel parameters *gpgsmsk* and *gpgslo*.

Value — Default: 0 (automatically configured to 8% of memory if set to 0)

Range: 30 pages – 1/2 of memory

When to Change — This value is adequate for most systems.

Notes — If this parameter is too small, *vhand* cannot supply enough free memory for system-wide demand.

gpgslo

Description — When the *vhand* daemon (page handler) executes, it won't start stealing back pages unless there are fewer than *gpgslo* free pages in the system. Once *vhand* starts stealing pages, it continues until there are *gpgshi* pages.

This parameter is specified in */var/sysgen/mtune*. For more information, see the *gpgshi* and *gpgsmsk* kernel parameters.

Value — Default: 0 (automatically configured to half of *gpgshi* if set to 0)

Range: 10 pages – 1/2 of memory

When to Change — This value is adequate for most systems.

Notes — If this parameter is too small, *vhand* does not start swapping pages; thus entire processes must be swapped. If this parameter is too large, *vhand* swaps pages unnecessarily.

maxlkmem

Description The *maxlkmem* parameter specifies the maximum number of physical pages that can be locked in memory (by mpin(2) or plock(2)) per non-superuser process.

This parameter is specified in */var/sysgen/mtune*.

Value Default: 2000

Range: 0 pages – 3/4 of physical memory

When to Change
Increase this parameter only if a particular application has a real need to lock more pages in memory.

On multi-user servers, you may want to decrease this parameter and also decrease *rlimit_vmem_cur*.

Notes When pages are locked in memory, the system can't reclaim those pages, and therefore can't maintain the most efficient paging.

maxfc

Description The *maxfc* parameter specifies the maximum number of pages that may be freed by the *vhand* daemon in a single operation. When the paging daemon (*vhand*) starts stealing pages, it collects pages that can be freed to the general page pool. It collects, at most, *maxfc* pages at a time before freeing them. Do not confuse this parameter with *gpgshi*, which sets the total number of pages that must be free before *vhand* stops stealing pages.

This parameter is specified in */var/sysgen/mtune*.

Value Default: 100

Range: 50–100

When to Change
This value is adequate for most systems.

maxsc

Description
The *maxsc* parameter specifies the maximum number of pages that may be swapped by the *vhand* daemon in a single operation. When the paging daemon starts tossing pages, it collects pages that must be written out to swap space before they are actually swapped and then freed into the general page pool. It collects at most *maxsc* pages at a time before swapping them out.

This parameter is specified in */var/sysgen/mtune*.

Value
Default: 100

Range: 8–100

When to Change
You may want to decrease this parameter on systems that are swapping over NFS (Network File System). This is always the case for diskless systems to increase performance.

maxdc

Description
maxdc is the maximum number of pages which can be saved up and written to the disk at one time.

Value
Default: 100 pages

Range: 1-100

When to Change
If the system is low on memory and consistently paging out user memory to remote swap space (for example, mounted via NFS), decrease this parameter by not more than 10 pages at a time. However, this parameter's setting does not usually make any measurable difference in system performance.

minarmem

Description This parameter represents the minimum available resident memory that must be maintained in order to avoid deadlock.

Value Default: 0 (Autoconfigured if set to 0)

When to Change
The automatically configured value of this parameter should always be correct for each system. You should not have to change this parameter.

minasmem

Description This parameter represents the minimum available swappable memory that must be maintained in order to avoid deadlock.

Value Default: 0 (Autoconfigured if set to 0)

When to Change
The automatically configured value of this parameter should always be correct for each system. You should not have to change this parameter.

tlbdrop

Description This parameter specifies the number of clock ticks before a process' wired entries are flushed.

Value Default: 100

When to Change
If *sar* indicates a great deal of transaction lookaside buffer (*utlbmiss*) overhead in a very large application, you may need to increase this parameter. In general, the more the application changes the memory frame of reference in which it is executing, the more likely increasing *tlbdrop* will help performance. You may have to experiment somewhat to find the optimum value for your specific application.

vfs_syncr

Description This parameter specifies the number of seconds between runs of the *vfs_syncr* process.

Value Default: 30

Range: 1 - 31536000 (1 year)

When to Change
Under normal circumstances it is not necessary to change this parameter.

maxpglst

Description This parameter specifies that can be held in each of the pager's pageout queues.

Value Default: 0 (Autoconfigured)

Range: 50 - 1000

percent_totalmem_64k_pages

Description This parameter specifies the percentage of total memory that can be used as an upper limit for the number of 64 KB pages.

Value Default: 0

Range: 0-100 (%)

When to Change
Set dynamically to get 64 KB pages.

Note: Other possible values are discussed in "Multiple Page Sizes" on page 209.

nlpages_64k

Description Use this parameter to reserve 64 KB pages at boot time. This increases the probability of getting large pages in a low memory system.

Value Default: 0

Range: 0-*memory_size*/64*1024, where *memory_size* is the total amount of memory in the system.

When to Change
Not recommended unless absolutely necessary.

Note: Other possible values are discussed in “Multiple Page Sizes” on page 209.

IPC Parameters

The IPC tunable parameters set interprocess communication (IPC) structures. These structures include IPC messages, specified in */var/sysgen/mtune/msg*; IPC semaphores, specified in */var/sysgen/mtune/sem*; and IPC shared memory, specified in */var/sysgen/mtune/shm*.

If IPC (interprocess communication) structures are incorrectly set, certain system calls will fail and return errors.

Before increasing the size of an IPC parameter, investigate the problem by using *ipcs*(1) to see if the IPC resources are being removed when no longer needed. For example, *shmget* returns the error ENOSPC if applications do not remove semaphores, memory segments, or message queues.

Note that IPC objects differ from most IRIX objects in that they are not automatically freed when all active references to them are gone. In particular, they are not deallocated when the program that created them exits.

Table A-1 lists error messages, system calls that cause the error, and parameters to adjust. Subsequent paragraphs explain the details you need to know before you increase the parameters listed in this table.

Table A-1 System Call Errors and IPC Parameters to Adjust

Message	System Call	Parameter
EAGAIN	*msgsnd*()	see below
EINVAL	*msgsnd*() *shmget*()	msgmax shmmax
EMFILE	*shmat*()	sshmseg
ENOSPC	*semget*() *shmget*()	msgmni semmni, semmns, shmmni

EAGAIN If IPC_NOWAIT is set, *msgsnd* can return EAGAIN for a number of reasons:

- The total number of bytes on the message queue exceeds *msgmnb*.
- The total number of bytes used by messages in the system exceeds *msgseg* * *msgsz*.
- The total number of system-wide message headers exceeds *msgmax*.

EINVAL *shmget* (which gets a new shared memory segment identifier) will fail with EINVAL if the given size is not within *shmmin* and *shmmax*. Since *shmmin* is set to the lowest possible value (1), and *shmmax* is very large, it should not be necessary to change these values.

EMFILE *shmat* will return EMFILE if it attaches more than *sshmseg* shared memory segments. *sshmseg* is the total number of system-shared memory segments per process.

ENOSPC *shmget* will return ENOSPC if:

- *shmmni* (the system-wide number of shared memory segments) is too small. However, applications may be creating shared memory segments and forgetting to remove them. So, before making a parameter change, use *ipcs*(1) to get a listing of currently active shared memory segments.

semget will return ENOSPC if:

- *semmni* is too small, indicating that the total number of semaphore identifiers is exceeded.
- *semmns* (the system-wide number of semaphores) is exceeded. Use *ipcs* to see if semaphores are being removed as they should be.

msgget will return ENOSPC if:

- *msgmni* is too small. Use *ipcs* to see if message queues are being removed as they should be.

IPC Messages Parameters

If no one on the system uses or plans to use IPC messages, you may want to consider excluding this module. The following tunable parameters are associated with interprocess communication messages (see the msgctl(2) reference page):

- *msgmax*—specifies the maximum size of a message.
- *msgmnb*—specifies the maximum length of a message queue.
- *msgmni*—specifies the maximum number of message queues system-wide.
- *msgseg*—specifies the maximum number of message segments system-wide.
- *msgssz*—specifies the size, in bytes, of a message segment.
- *msgtql*—specifies the maximum number of message headers system-wide.

msgmax

Description The *msgmax* parameter specifies the maximum size of a message.

This parameter is specified in */var/sysgen/mtune/msg*.

Value Default: 16 * 1024 (0x4000)

Range: 512-0x8000

When to Change

Increase this parameter if the maximum size of a message needs to be larger. Decrease the value to limit the size of messages.

msgmnb

Description The *msgmnb* parameter specifies the maximum length of a message queue.

This parameter is specified in */var/sysgen/mtune/msg*.

Value Default: 32 * 1024 (0x8000)

Range: *msgmax*–1 / 2 of physical memory

When to Change

Increase this parameter if the maximum number of bytes on a message queue needs to be longer. Decrease the value to limit the number of bytes per message queue.

msgmni

Description The *msgmni* parameter specifies the maximum number of message queues system-wide.

This parameter is specified in */var/sysgen/mtune/msg*.

Value Default: 50

Range: 10–1000

When to Change

Increase this parameter if you want more message queues on the system. Decrease the value to limit the message queues.

Notes — If there are not enough message queues, a msgget(2) system call that attempts to create a new message queue returns the error:

```
ENOSPC: No space left on device
```

msgseg

Description — The *msgseg* parameter specifies the maximum number of message segments system-wide. A message on a message queue consists of one or more of these segments. The size of each segment is set by the *msgssz* parameter.

This parameter is specified in */var/sysgen/mtune/msg*.

Value — Default: 1536

When to Change — Modify this parameter to reserve the appropriate amount of memory for messages. Increase this parameter if you need more memory for message segments on the system. Decrease the value to limit the amount of memory used for message segments.

Notes — If this parameter is too large, memory may be wasted (saved for messages but never used). If this parameter is too small, some messages that are sent will not fit into the reserved message buffer space. In this case, a msgsnd(2) system call waits until space becomes available.

msgssz

Description — The *msgssz* parameter specifies the size, in bytes, of a message segment. Messages consist of a contiguous set of message segments large enough to accommodate the text of the message. Using segments helps to eliminate fragmentation and speed the allocation of the message buffers.

This parameter is specified in */var/sysgen/mtune/msg*.

Value — Default: 8

When to Change

This parameter is set to minimize wasted message buffer space. Change this parameter only if most messages do not fit into one segment with a minimum of wasted space.

If you modify this parameter, you may also need to change the *msgseg* parameter.

Notes

If this parameter is too large, message buffer space may be wasted by fragmentation, which in turn may cause processes that are sending messages to sleep while waiting for message buffer space.

msgtql

Description

The *msgtql* parameter specifies the maximum number of message headers system-wide, and thus the number of outstanding (unread) messages. One header is required for each outstanding message.

This parameter is specified in */var/sysgen/mtune/msg*.

Value

Default: 40

Range: 10–4000

When to Change

Increase this parameter if you require more outstanding messages. Decrease the value to limit the number of outstanding messages.

Notes

If this parameter is too small, a msgsnd(2) system call attempting to send a message that would put *msgtql* over the limit waits until messages are received (read) from the queues.

IPC Semaphores Parameters

If no one on the system uses or plans to use IPC semaphores, you may want to consider excluding this module.

The following tunable parameters are associated with interprocess communication semaphores (see the semctl(2) reference page):

- *semmni*—specifies the maximum number of semaphore identifiers in the kernel.
- *semmns*—specifies the number of ipc semaphores system-wide.
- *semmnu*—specifies the number of “undo” structures system-wide.
- *semmsl*—specifies the maximum number of semaphores per semaphore identifier.
- *semopm*—specifies the maximum number of semaphore operations that can be executed per *semop*(2) system call.
- *semume*—specifies the maximum number of “undo” entries per undo structure.
- *semvmx*—specifies the maximum value that a semaphore can have.
- *semaem*—specifies the adjustment on exit for maximum value.

semmni

Description The *semmni* parameter specifies the maximum number of semaphore identifiers in the kernel. This is the number of unique semaphore sets that can be active at any given time. Semaphores are created in sets; there may be more than one semaphore per set.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 10

When to Change

Increase this parameter if processes require more semaphore sets. Increasing this parameter to a large value requires more memory to keep track of semaphore sets. If you modify this parameter, you may need to modify other related parameters.

semmns

Description The *semmns* parameter specifies the number of ipc semaphores system-wide. This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 60

When to Change
Increase this parameter if processes require more than the default number of semaphores.

Notes If you set this parameter to a large value, more memory is required to keep track of semaphores.

semmnu

Description The *semmnu* parameter specifies the number of "undo" structures system-wide. An undo structure, which is set up on a per-process basis, keeps track of process operations on semaphores so that the operations may be "undone" if the structure terminates abnormally. This helps to ensure that an abnormally terminated process does not cause other processes to wait indefinitely for a change to a semaphore.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 30

When to Change
Change this parameter when you want to increase / decrease the number of undo structures permitted on the system. *semmnu* limits the number of processes that can specify the UNDO flag in the *semop*(2) system call to undo their operations on termination.

semmsl

Description The *semmsl* parameter specifies the maximum number of semaphores per semaphore identifier.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 25

When to Change
Increase this parameter if processes require more semaphores per semaphore identifier.

semopm

Description The *semopm* parameter specifies the maximum number of semaphore operations that can be executed per *semop*() system call. This parameter permits the system to check or modify the value of more than one semaphore in a set with each *semop*() system call.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 10

When to Change

Change this parameter to increase / decrease the number of operations permitted per *semop*() system call. You may need to increase this parameter if you increase *semmsl* (the number of semaphore sets), so that a process can check / modify all the semaphores in a set with one system call.

semume

Description The *semume* parameter specifies the maximum number of "undo" entries per undo structure. An undo structure, which is set up on a per-process basis, keeps track of process operations on semaphores so that the operations may be "undone" if it terminates abnormally. Each undo entry represents a semaphore that has been modified with the UNDO flag specified in the *semop*(2) system call.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 10

When to Change

Change this parameter to increase / decrease the number of undo entries per structure. This parameter is related to the *semopm* parameter (the number of operations per *semop*(2) system call).

semvmx

Description The *semvmx* parameter specifies the maximum value that a semaphore can have.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 32767 (maximum value)

When to Change
Decrease this parameter if you want to limit the maximum value for a semaphore.

semaem

Description The *semaem* parameter specifies the adjustment on exit for maximum value, alias *semadj*. This value is used when a semaphore value becomes greater than or equal to the absolute value of *semop*(2), unless the program has set its own value.

This parameter is specified in */var/sysgen/mtune/sem*.

Value Default: 16384 (maximum value)

When to Change
Change this parameter to decrease the maximum value for the adjustment on exit value.

IPC Shared Memory Parameters

The following tunable parameters are associated with interprocess communication shared memory:

- *shmmax*—specifies the maximum size of an individual shared memory segment.
- *shmmin*—specifies the minimum shared memory segment size.
- *shmmni*—specifies the maximum number of shared memory identifiers system-wide.
- *sshmseg*—specifies the maximum number of attached shared memory segments per process.

shmmax

Description The *shmmax* parameter specifies the maximum size of an individual shared memory segment.

This parameter is specified in */var/sysgen/mtune/shm*.

Value Default: (*rlimit_vmem_cur* * NBPP) (0x20000000)

32-bit Range: 0x1000 - 0x7fffffff

64-bit Range: 0x1000 - 0x7fffffffffffffff

When to Change

Keep this parameter small if it is necessary that a single shared memory segment not use too much memory.

shmmin

Description The *shmmin* parameter specifies the minimum shared memory segment size.

This parameter is specified in */var/sysgen/mtune/shm*.

Value Default: 1 byte

When to Change

Increase this parameter if you want an error message to be generated when a process requests a shared memory segment that is too small.

shmmni

Description The *shmmni* parameter specifies the maximum number of shared memory identifiers system-wide.

This parameter is specified in */var/sysgen/mtune/shm*.

Value 32-bit Default: 100

64-bit Default: 400

Range: 10–1000

When to Change

Increase this parameter by one (1) for each additional shared memory segment that is required, and also if processes that use many shared memory segments reach the *shmmni* limit.

Decrease this parameter if you need to reduce the maximum number of shared memory segments of the system at any one time. Also decrease it to reduce the amount of kernel space taken for shared memory segments.

sshmseg

Description — The *sshmseg* parameter specifies the maximum number of attached shared memory segments per process. A process must attach a shared memory segment before the data can be accessed.

This parameter is specified in */var/sysgen/mtune/shm*.

Value — Default: 100

Range: 1–SHMMNI

When to Change

Keep this parameter as small as possible to limit the amount of memory required to track the attached segments.

Increase this parameter if processes need to attach more than the default number of shared memory segments at one time.

Streams Parameters

The following parameters are associated with STREAMS processing:

- *nstrpush*—maximum number of modules that can be pushed on a stream.
- *nstrintr*—maximum number.
- *strctlsz*—maximum size of the *ctl* part of message.
- *strmsgsz*—maximum stream message size.
- *strholdtime*—maximum stream hold time.
- *strpmonmax*—maximum private monitors.

nstrpush

Description *nstrpush* defines the maximum number of STREAMS modules that can be pushed on a single stream.

Value Default: 9 (0x9)

Range: 9-10

When to Change
Change *nstrpush* from 9 to 10 modules when you need an extra module.

nstrintr

Description This parameter defines the streams buffers used at interrupt time.

Value Default: 1024 (0x400)

Range: 32-4096

strctlsz

Description *strctlsz* is the maximum size of the *ctl* buffer of a STREAMS message. See the getmsg(2) or putmsg(2) reference pages for a discussion of the *ctl* and *data* parts of a STREAMS message.

Value Default: 1024 (0x400)

When to Change
Change *strctlsz* when you need a larger buffer for the *ctl* portion of a STREAMS message.

strmsgsz

Description *strmsgsz* defines the maximum STREAMS message size. This is the maximum allowable size of the *ctl* part plus the *data* part of a message. Use this parameter in conjunction with the *strctlsz* parameter described above to set the size of the *data* buffer of a STREAMS message. See the getmsg(2) or putmsg(2) reference pages for a discussion of the *ctl* and *data* parts of a STREAMS message.

Value Default: 0x8000

When to Change
Change this parameter in conjunction with the *strctlsz* parameter to adjust the sizes of the STREAMS message as a whole and the *data* portion of the message.

strholdtime

Description *strholdtime* defines the STRHOLDTIME macro in <*strsubr.h*>. The purpose of this macro is to cut down on overhead on streams drivers. This happens at a cost to system latency.

Value Default: 50 (0x32)

Range: 0-1000

strpmonmax

Description *strpmonmax* defines the maximum number of private streams monitors.

Value Default: 4 (0x4)

Range: 0-1024

Signal Parameters

The following signal parameters control the operation of interprocess signals within the kernel:

- *maxsigq*—specifies the maximum number of signals that can be queued.

maxsigq

Description The maximum number of signals that can be queued. Normally, multiple instances of the same signal result in only one signal being delivered. With the use of the SA_SIGINFO flag, outstanding signals of the same type are queued instead of being dropped.

Value Default: 64

Range: 32-32767

When to Change

Raise *maxsigq* when a process expects to receive a great number of signals and 64 queue places may be insufficient to avoid losing signals before they can be processed. Change *maxsigq* to a value appropriate to your needs.

Dispatch Parameters

One of the most important functions of the kernel is “dispatching” processes. When a user issues a command and a process is created, the kernel endows the process with certain characteristics. For example, the kernel gives the process a priority for receiving CPU time. This priority can be changed by the user who requested the process or by the Superuser. Also, the length of time (*slice-size*) that a process receives in the CPU is adjustable by a dispatch parameter. The Periodic Deadline Scheduler (PDS) is also part of the dispatch group. The deadline scheduler is invoked via the schedctl(2) system call in a user program and requires the inclusion of <*sys/schedctl.h*>. The following parameters are included in the dispatch group:

- *ndpri_hilim*—sets the highest non-degrading priority a user process may have.
- *ndpri_lolim*—sets the lowest non-degrading priority a user process may have.
- *runq_dl_refframe*—sets a limit on the amount of the reference frame that can be allocated.

- *runq_dl_nonpriv*—controls the amount of the reference frame that can be allocated by non-privileged user processes.
- *runq_dl_use*—specifies the longest interval that a deadline process may request.
- *slice_size*—specifies the amount of time a process receives at the CPU.

ndpri_hilim

Description The *ndpri_hilim* parameter sets the highest non-degrading priority a user process may have.

Note that the higher the numeric value of *ndpri_hilim*, the lower the priority of the process.

Value Default: 128

Range: 30-255

When to Change
Change this parameter when you want to limit user process priority in a busy system with many users or when you want to enable a high priority user process, for example, a real-time graphics application.

ndpri_lolim

Description *ndpri-lolim* sets the lowest possible non-degrading priority for a user process. Note that lower priority values give a process higher scheduling priority.

Value Default: 39

Range: 30-255

When to Change
The default value is adequate for most systems.

runq_dl_maxuse

Description This parameter sets an absolute limit on the amount of the reference frame (set by the *runq_dl_refframe* parameter) that can be allocated under any circumstances.

Value Default: 700

Range: 0-100000

When to Change
If your deadline-scheduled processes require more scheduled CPU time, increase the value of *runq_dl_maxuse* and *runq_dl_nonpriv*.

runq_dl_nonpriv

Description This parameter controls the amount of the reference frame (set by the *runq_dl_refframe* parameter) that can be allocated by non-privileged user processes.

Value Default: 200

Range: 0-100000

When to change
If your non-privileged deadline processes require more CPU time, increase this value.

runq_dl_refframe

Description This parameter specifies the longest interval that a deadline process may request.

Value Default: 1000

Range: 0-100000

When to Change
If you change the values of *runq_dl_nonpriv* and *runq_dl_use*, you may need to change this parameter as well, to expand the reference frame in which *runq_dl_nonpriv* and *runq_dl_use* act.

slice_size

Description

slice_size is the default process time slice, expressed as a number of ticks of the system clock. The frequency of the system clock is expressed by the constant Hz, which has a value of 100. Thus each unit of *slice_size* corresponds to 10 milliseconds. When a process is given control of the CPU, the kernel lets it run for *slice_size* ticks. When the time slice expires or when the process voluntarily gives up the CPU (for example, by calling *pause*(2) or by doing some other system call that causes the process to wait), the kernel examines the run queue and selects the process with the highest priority that is eligible to run on that CPU.

The *slice_size* parameter is defined in */var/sysgen/mtune/disp* and has the following formula:

`#define` *slice_size* `Hz / 30 int` *slice_size* `=` *slice_size*

Since *slice_size* is an integer, the resulting value is 3. This means that the default process time slice is 30 milliseconds.

Value

Default: 3

Range: 1–100

When to Change

If you use the system primarily for compute-intensive jobs and interactive response is not an important consideration, you can increase *slice_size*. For example, setting *slice_size* to 10 gives greater efficiency to the compute jobs, since each time they get control of the CPU, they are able to run for 100 milliseconds before getting switched out.

In situations where the system runs both compute jobs and interactive jobs, interactive response time will suffer as you increase the value of *slice_size*.

EFS Parameters

The IRIX Extent File System works closely with the operating system kernel, and the following parameters adjust the kernel's interface with the file system.

The following parameters are defined in the *efs* group:

- *efs_inline*—Whether to store symbolic link information in the inode or not.

The following parameters are set in the *kernel* parameter group, and are used for file system tuning. They determine how many pages of memory are clustered together into a single disk write operation. Adjusting these parameters can greatly increase file system performance. Available parameters include:

- *dwcluster*—number of delayed-write pages to cluster in each push.
- *autoup*—specifies the age, in seconds, that a buffer marked for delayed write must be before the *bdflush* daemon writes it to disk.

efs_inline

Description If this parameter is set to any value other than 0, any symbolic link data is stored within a file's inode, rather than out-of-line.

Value Default: 0

Range: 0-1

When to Change
It should not be necessary to change this variable. Increasing the value improves the lookup speed of symbolic links to some degree, however filesystems thus treated cannot be transferred to systems running releases of IRIX prior to version 5.3.

dwcluster

Description This parameter sets the maximum number of delayed-write pages to cluster in each push.

Value Default: 64

When to Change
It should not be necessary to change this parameter. The automatically configured value is sufficient.

autoup

Description The *autoup* parameter specifies the age, in seconds, that a buffer marked for delayed write must be before the *bdflush* daemon writes it to disk. This parameter is specified in */var/sysgen/mtune*. For more information, see the entry for the *bdflushr* kernel parameter.

Value Default: 10

Range: 1–30

When to Change
This value is adequate for most systems.

Loadable Drivers Parameters

IRIX allows you to load and run device drivers while the system remains up and running. Occasionally, you may have to make adjustments to the running kernel to allow for the extra resources these loadable drivers require. The following parameters allow you to make the necessary adjustments:

- *bdevsw_extra*—specifies an extra number of entries in the block device switch.
- *cdevsw_extra*—specifies an extra number of entries in the character device switch.
- *fmodsw_extra*—specifies an extra number of entries in the streams module switch.
- *vfssw_extra*—specifies an extra number of entries in the virtual file system module switch.
- *munlddelay*—specifies the timeout for auto-unloading loadable modules.

bdevsw_extra

Description This parameter specifies an extra number of entries in the block device switch. This parameter is for use by loadable drivers only. If you configured a block device into the system at lboot(1M) time, you will not need to add extra entries to *bdevsw*.

Value Default: 21

Range: 1-254

When to Change

Change this parameter when you have more than 21 block devices to load into dynamically the system. IRIX provides 21 spaces in the *bdevsw* by default.

cdevsw_extra

Description This parameter specifies an extra number of entries in the character device switch. This parameter is for use by loadable drivers only. If you configured a character device into the system at lboot(1M) time, you will not need to add extra entries to *cdevsw*.

Value Default: 23

Range: 3-254

When to Change

Change this parameter when you have more than 23 character devices to load dynamically into the system. IRIX provides 23 spaces in the *cdevsw* by default.

fmodsw_extra

Description This parameter specifies an extra number of entries in the streams module switch. This parameter is for use by loadable drivers only. If you configured a streams module into the system at lboot(1M) time, you will not need to add extra entries to *fmodsw*.

Value Default: 20

Range: 0-254

When to Change

Change this parameter when you have more than 20 streams modules to load dynamically into the system. IRIX provides 20 spaces in the *fmodsw* by default.

vfssw_extra

Description This parameter specifies an extra number of entries in the *vnode* file system module switch. This parameter is for use by loadable drivers only. If you configured a *vfs* module into the system at *lboot* time, you will not need to add extra entries to *vfssw*.

Value Default: 5

Range: 0-254

When to Change

Change this parameter when you have more than 5 virtual file system modules to load dynamically into the system. IRIX provides 5 spaces in the *vfssw* by default.

munlddelay

Description This parameter specifies the timeout in minutes after which to auto-unload loadable modules.

Value Default: 5 (0x5) minutes

CPU Actions Parameters

CPU actions parameters are used in multi-processor systems to allow the user to select the processor or processors that will be used to perform a given task.

The following parameters are defined:

- *nactions*—specifies the number of action blocks.

nactions

Description — The *nactions* parameter controls the number of action blocks. An action block lets you queue a process to be run on a specific CPU. The value of the *nactions* parameter is found by the formula:

maxcpu + 60

Value — Default: 0 (Auto-configured if set to 0)

Range: 60-200

When to Change — Increase the value of *nactions* if you see the kernel error message:

```
PANIC: Ran out of action blocks
```

Switch Parameters

The following parameters are simple on / off switches within the kernel that allow or disallow certain features, such as whether shells that set the user ID to the superuser are allowed:

- *dump_all_pages*—controls page dumping during kernel panics.
- *panic_on_sbe*—controls special factory debugging mode.
- *sbe_log_errors*—controls system logging of single bit errors.
- *sbe_mfr_override*—overrides default action of disabling single bit errors.
- *sbe_report_cons*—controls single bit error console reporting.
- *corepluspid*—controls core filenames.
- *r4k_div_patch*—controls patch code for *r4kpp* binaries.
- *mload_auto_rtsyms*—controls loading of the kernel symbol table.
- *xpg4_sticky_dir*—controls removal of files in “sticky” directories.
- *tty_auto_strhold*—controls the setting of STRHOLD on tty / pty lines.
- *reset_limits_on_exec*—controls resetting of rlimit values on new setuid processes.
- *ip26_allow_ucmem*—controls whether to allow access to uncached system memory on Power Indigo2 systems.
- *restrict_fastprof*—controls whether users can do fast (1ms) user level profiling.

- *reboot_on_panic*—specifies that the system should automatically reboot after a kernel panic.
- *svr3pipe*—controls whether SVR3.2 or SVR4 pipes are used.
- *nosuidshells*—when set to 0, allows applications to create superuser-privileged shells. When set to any value other than 0, such shells are not permitted.
- *posix_tty_default*—if the value of this switch is 0, the default Silicon Graphics line disciplines are used. If the value is set to 1, POSIX line disciplines and settings are used.
- *restricted_chown*—allows you to decide whether you want to use BSD UNIX style chown(2) system call or the System V style.
- *use_old_serialnum*—When set to 1, forces the kernel to use the old method of calculating a 32-bit serial number for *sysinfo -s*. This variable affects only Onyx and Challenge L or XL systems.
- *subnetsarelocal*—When set to 1, other subnets of a directly-connected subnetted network are considered to be local.

Note that all the above listed parameters are enforced system-wide. It is not possible to select different values on a per-process basis.

dump_all_pages

Description: This parameter, when set to 1, directs the system to dump all pages, kernel, user, and free, during a system panic. When set to 0, this feature is disabled and kernel pages only are dumped during a panic.

Value: Default: 1 (0x1)

Range: 0 or 1

panic_on_sbe

Description: This parameter, when set to 1, turns on a special factory debugging mode called Single Bit Errors. When set to 0, this feature is disabled.

Value: Default: 0 (0x0)

Range: 0 or 1

sbe_log_errors

Description This parameter, when set to 1, directs the system to log single bit errors to the SYSLOG. When set to 0, this feature is disabled.

Value Default: 0 (0x0)

Range: 0 or 1

Notes This parameter applies only to systems containing ECC memory (R8000®-based systems such as CHALLENGE/Onyx).

sbe_mfr_override

Description This parameter, when set to 1, overrides the default action of disabling single bit errors if the rate of single bit errors exceeds a predetermined limit. When set to 0, this feature is disabled.

Value Default: 0 (0x0)

Range: 0 or 1

Notes This parameter applies only to systems containing ECC memory (R8000-based systems such as CHALLENGE/Onyx).

sbe_report_cons

Description This parameter, when set to 1, directs the system to display single bit errors on the system console. When set to 0, this feature is disabled.

Value Default: 0 (0x0)

Range: 0 or 1

Notes This parameter applies only to systems containing ECC memory (R8000-based systems such as CHALLENGE/Onyx)

corepluspid

Description This parameter, when set to 1, directs the system to name core files with the process ID number appended. When set to 0, this feature is disabled.

Value Default: 0 (0x0)

Range: 0 or 1

r4k_div_patch

Description This parameter, when set to 1, enables the exec patch code for binaries that have been processed with r4kpp for the divide in branch delay slot problem that occurs on R4000® SC rev 2.2 and 3.0 parts. When set to 0, this feature is disabled.

Value Default: 0 (0x0)

Range: 0 or 1

mload_auto_rtsyms

Description This parameter, when set to 1, enables the standard automatic loading of the kernel's run-time symbol table. When set to 0, this feature is disabled.

Value Default: 1 (0x1)

Range: 0 or 1

xpg4_sticky_dir

Description This parameter, when set to 1, specifies that write access to a file does not allow that file to be removed if the "sticky bit" is set in the directory in which it resides. When set to 0, such files can be removed.

Value Default: 1 (0x1)

Range: 0 or 1

tty_auto_strhold

Description This parameter, when set to 1, automatically sets STRHOLD on ttys / ptys whenever the line discipline is in canonical & echo mode and automatically clears STRHOLD otherwise. When set to 0, this feature is under user control.

Value Default: 0 (0x0)

Range: 0 or 1

reset_limits_on_exec

Description This parameter, when set to 1, directs the kernel to reset rlimit values on processes that run as **root**, in order to prevent non-**root** processes from enforcing resource limits. When set to 0, this feature is disabled and resource limits are not reset. Modifying this parameter may have security implications.

Value Default: 1 (0x1)

Range: 0 or 1

ip26_allow_ucmem

Description This parameter, when set to 0, prevents users from accessing uncached system memory on IP26 (Power Indigo^2) systems. When set to 1, this feature is allowed.

Value Default: 0 (0x0)

Range: 0 or 1

When to Change

If this parameter is set to 0, attempts to access uncached memory will cause a system panic. If the feature is allowed, there is a substantial memory performance degradation.

restrict_fastprof

Description This parameter, when set to 0, allows users to do fast (1 ms) profiling of programs with *prof*. When set to 1, this feature is disallowed.

Value Default: 0 (0x0)

Range: 0 or 1

reboot_on_panic

Description
: This parameter, when set to 1, specifies that the system should automatically reboot after a kernel panic. This is especially useful for servers or other systems that frequently go unattended or are used remotely, where the user may not conveniently be able to physically reset and reboot the system.

  When set to 0, the system must be rebooted from the console. Some systems (those with IP19, IP21, or IP22 processors, check your *hinv* listing for your processor type) store an environment variable in the PROM monitor called "*rebound*." If you have this variable and set the *reboot_on_panic* parameter to -1, your system will check the PROM environment for instructions. If the *rebound* variable is set to "*y*" then the system will reboot automatically. If the *rebound* variable is set to "*n*" the system will require manual reset. If you set a system without this environment variable to -1, it behaves as though the setting is 0 and does not automatically reboot.

Value
: Default: -1 (automatically reboot according to hardware platform implementation) or 0, depending on processor type.

  Range: -1, 0, or 1

When to Change
: Change this parameter if you wish to automatically reboot after a system panic.

svr3pipe

Description
: This parameter, when set to 1, specifies SVR3.2 style pipes, which are unidirectional. When set to 0, SVR4 style pipes are specified, which are bidirectional.

Value
: Default: 1 (SVR3.2 style pipes)

  Range: 0 or 1

When to Change
: Change this parameter if you wish to take advantage of SVR4 style pipes. SVR3 pipes are the default because they provide faster performance.

nosuidshells

Description Some programs are written so that they perform actions that require superuser privilege. In order to perform these actions, they create a shell in which the user has superuser privilege. Such shells pose a certain manageable risk to system security, but application developers are generally careful to limit the actions taken by the application in these shells. The *nosuidshells* switch, when set to 0, allows these applications to create superuser-privileged shells. When set to any value other than 0, such shells are not permitted.

Value Default: 1 (setuid shells not permitted)

When to Change
Change this switch to allow setuid shells.

posix_tty_default

Description IRIX uses a default system of line disciplines and settings for serial lines. These default settings are different from those specified by POSIX. If the value of this switch is 0, the default Silicon Graphics line disciplines are used. If the value is set to 1, POSIX line disciplines and settings are used.

Value Default: 0

Range: 0 or 1

When to Change
Change this switch if you need to use POSIX line disciplines.

restricted_chown

Description This switch allows you to decide whether you want to use a BSD UNIX style chown(2) system call or the System V style. Under the BSD version, only the Superuser can use the *chown* system call to “give away” a file—to change the ownership to another user. Under the System V version, any user can give away a file or directory. If the value of the switch is 0, System V *chown* is enabled. If the value is not zero, BSD *chown* is enabled.

Value Default: 0

Range: 0 or 1

When to Change

Change this switch to choose which behavior you prefer for the chown(2) system call.

use_old_serialnum

Description When set to 1, this parameter forces the kernel to use the old method (before IRIX Version 5) of calculating a 32-bit serial number for *sysinfo -s*. This variable affects only Onyx and Challenge L or XL systems.

Value Default: 0

Range: 0 or 1

When to Change

Change this parameter on your Challenge or Onyx system if you need to use some older software that requires a 32-bit serial number.

subnetsarelocal

Description When set to 1, all other subnets of a directly-connected subnetted network are considered to be local.

Value Default: 0

Range: 0 or 1

When to Change

Change this parameter if no subnetted systems are directly connected to any external network, such as the internet.

Timer parameters

Timer parameters control the functioning of system clocks and timing facilities. The following parameters are defined:

- *fasthz*—sets the profiling / fast itimer clock speed.
- *itimer_on_clkcpu*—determines whether *itimer* requests are queued on the clock processor or on the running processor, respectively.
- *timetrim* – the system clock is adjusted every second by the signed number of nanoseconds specified by this parameter.

fasthz

Description This parameter is used to set the profiling / fast *itimer* clock speed.

Value Default: 1000

Range: 500-2500

When to Change
Change this parameter to give a finer or coarser grain for such system calls as gettimeofday(3B), getitimer(2) and settimer(2).

itimer_on_clkcpu

Description This parameter is set to either 0 or 1, to determine whether *itimer* requests are queued on the clock processor or on the running processor, respectively.

Value Default: 0

Range: 0 or 1

When to Change
If a process uses the gettimeofday(2) call to compare the accuracy of the *itimer* delivery, then you should set this parameter to 1, to take advantage of the clock processor. If the *itimer* request is for the purpose of implementing a user frequency-based scheduler, then set this parameter to 0 to queue the requests on the current running processor.

timetrim

Description The system clock is adjusted every second by the signed number of nanoseconds specified by this parameter. This adjustment is limited to 3 milliseconds or 0.3%. The timed(1M) and timeslave(1M) utilities periodically place suggested values in */var/adm/SYSLOG*.

Value Default: 0

Range: 0-0.3% of a second (3 milliseconds)

When to Change
Change this parameter as suggested by *timed* and *timeslave*. Read the relevant reference pages before taking any action.

NFS Parameters

The following parameters control the kernel-level functions of the Network File System (NFS). Reducing these values is likely to cause significant performance decreases in your system:

- *portmap_timeout*—sets the portmapper query timeout.
- *sm_timeout*—sets the status monitor timeout.
- *GraceWaitTime*—sets the NLM grace period wait time.
- *first_retry*—sets the number of retries on the first contact with the portmapper.
- *normal_retry*—sets the number of retries on later attempts to contact the portmapper.
- *lockd_grace_period*—sets the grace period for NMI timeouts.
- *lock_share_requests*—applies the corresponding IRIX file locks to share requests.
- *lockd_blocking_thresh*—sets the number of daemons allowed to block before a new daemon is created.
- *nfs_portmon*—set to 0, clients may use any available port. If it is set to 1, clients must use only privileged ports.
- *svc_maxdupreqs*—sets the number of cached NFS requests.

portmap_timeout

Description	This parameter specifies the portmapper query timeout, in 1/10 second increments.
Value	Default: 5 (0x5)
	Range: 1 to 200 (20 seconds)
Notes	Note that decreasing timeouts can severely degrade system performance.

sm_timeout

Description This parameter specifies the status monitor communication timeout in 1/10 second increments.

Value Default: 5 (0x5)

Range: 1 to 150 (15 seconds)

Notes Note that decreasing normal and working timeouts can severely degrade system performance.

GraceWaitTime

Description This parameter specifies the NLM grace period, in seconds.

Value Default: 5 (0x5)

Range: 1 to 60 (1 minute)

Notes Note that decreasing normal and working timeouts can severely degrade system performance.

first_retry

Description This parameter specifies the number of retries to be made for the first contact with the portmapper.

Value Default: 1 (0x1)

Range: 0 to 10000

normal_retry

Description This parameter specifies the number of subsequent retries after communication has once been established with the portmapper.

Value Default: 1 (0x1)

Range: 0 to 10000

lockd_grace_period

Description This parameter specifies the NLM grace period, in seconds.

Value Default: 45 (0x2d)

Range: 1 to 3600 (1 hour)

lock_share_requests

Description This parameter determines whether or not the system will apply IRIX file locks to share requests.

Value Default: 0 (0x0)

Range: 0 or 1

lockd_blocking_thresh

Description This parameter specifies the number of daemons allowed to block before a new lock daemon will be spawned.

Value Default: 0 (0x0)

Range: 0 to 1000

nfs_portmon

Description This parameter determines whether or not a client must use a “privileged” port for NFS requests. Only processes with superuser privilege may bind to a privileged port. The *nfs_portmon* parameter is binary. If it is set to 0, clients may use any available port. If it is set to 1, clients must use only privileged ports.

Value Default: 0

Range: 0 or 1

When to Change

You should change this parameter only if it is absolutely necessary to maintain root privilege on your NFS mounted file systems and you have checked each NFS client to be sure that it requests a privileged port. If there are any clients requesting non-privileged ports, they will be unable to mount the file systems.

Additionally, changing the value of *nfs_portmon* to 1 can give a false sense of security. A process must have *root* privilege in order to bind to a privileged port, but a single “insecure” machine compromises the security of this privilege check.

svc_maxdupreqs

Description This parameter sets the number of cached NFS requests.

Value Default: 409

Range: 400-4096

When to Change

This parameter should be adjusted to the service load so that there is likely to be a response entry when the first retransmission comes in.

Socket Parameters

This section describes socket parameters. Both UDS sockets and TCP/IP sockets are covered.

Under UNIX domain sockets, there is a pair of buffers associated with each socket in use. There is a buffer on the receiving side of the socket, and on the sending side. The size of these buffers represent the maximum amount of data that can be queued. The behavior of these buffers differs depending on whether the socket is a streams socket or a data-gram socket.

On a streams socket, when the sender sends data, the data is queued in the receive buffer of the receiving process. If the receive buffer fills up, the data begins queueing in the sendspace buffer. If both buffers fill up, the socket blocks any further data from being sent.

Under data-gram sockets, when the receive buffer fills up, all further data-grams sent are discarded and the error EWOULDBLOCK is generated. Because of this behavior, the default receive buffer size for data-gram sockets is twice that of the send buffer.

In order to improve networking performance with a large number of connections, TCP and UDP packet lookup is performed using a hashing scheme. The number of hash buckets used by the lookup code is normally computed at system boot time, and is based on the number of megabytes of available system RAM. UDP uses four buckets per megabyte of system RAM, plus one additional bucket. TCP uses eight buckets per megabyte of system RAM, plus one additional bucket.

Each hash bucket requires 24 bytes of RAM on a 32-bit system, and 48 bytes of RAM on a 64-bit system. So, for example, on a 128MB Challenge XL system, UDP would use 513 hash buckets and TCP would use 1025 hash buckets. At 48 bytes per bucket, a total of 73824 bytes of system RAM are used hold hash table information when the default auto-configuration is used. On a 64MB Indy, which has less memory and a smaller word size, the total memory consumption using the default values is 18456 bytes of system RAM.

If the default size is not optimal for your system, the table sizes can be changed using the *udp_hashtablesz* and *tcp_hashtablesz* parameters listed below. Note that the kernel enforces some restrictions on the values that may be specified. The sizes do not include the dynamic space allocation for each TCP or UDP socket during its life time. These parameters are part of the “inpcb” parameter group, and are modified using systune(1M).

The following parameters control sockets:

- *unpst_sendspace*—UNIX domain socket stream send buffer size.
- *unpst_recvspace*—UNIX domain socket stream receive buffer size.
- *unpdg_sendspace*—UNIX domain socket data-gram send buffer size.
- *unpdg_recvspace*—UNIX domain socket data-gram receive buffer size.
- *udp_hashtablesz*—UNIX domain socket hash table size.
- *tcp_sendspace*—TCP / IP socket send buffer size.
- *tcp_recvspace*—TCP / IP socket receive buffer size.
- *tcp_hashtablesz*—TCP / IP hash table size.

unpst_sendspace

Description This parameter controls the default size of the *send* buffer on streams sockets.

Value Default: 0x4000 (16KB)

When to Change

It is generally recommended that you change the size of socket buffers individually, since changing this parameter changes the send buffer size on all streams sockets, using a tremendous amount of kernel memory. Also, increasing this parameter increases the amount of time necessary to wait for socket response, since all sockets will have more buffer space to read.

See the setsockopt(2) reference page for more information on setting specific socket options.

unpst_recvspace

Description This parameter controls the default size of the receive buffer of streams sockets.

Value Default: 0x4000 (16 Kbytes)

When to Change

It is generally recommended that you change the size of socket buffers on an individual basis, since changing this parameter changes the receive buffer size on all streams sockets, using a tremendous amount of kernel memory. Also, increasing this parameter will increase the amount of time necessary to wait for socket response, since all sockets will have more buffer space to read.

See the setsockopt(2) reference page for more information on setting specific individual socket options.

unpdg_sendspace

Description This parameter controls the size of a data-gram that can be sent over a socket.

Value Default: 0x2000 (8 KB)

When to Change

Data-gram sockets operate slightly differently from streams sockets. When a streams socket fills the receive buffer, all data is then sent to the send buffer, and when the send buffer fills up, an error message is issued. Data-gram sockets allow data-grams to fill the receive buffer, and when the receive buffer is full, all future data-grams are discarded, and the error EWOULDBLOCK is generated. Therefore, the *unpdg_sendspace* parameter serves only to limit the size of a data-gram to not more than can be received by the receive buffer.

Note that the default data-gram socket receive buffers are twice the size of the default data-gram send buffers, thus allowing the process to appear the same as the streams sockets.

It is generally recommended that you not change the size of this parameter without also changing the default receive buffer size for data-gram sockets. If you raise the value of this parameter (*unpdg_sendspace*) without raising the receive buffer size (*unpdg_recvspace*), you will allow the sending half of the socket to send more data than can be received by the receiving half. Also it is generally recommended that socket buffer sizes be set individually via the setsockopt(2) system call. See the setsockopt(2) reference page for more information on setting specific individual socket options.

unpdg_recvspace

Description This parameter controls the default size of data-gram socket receive buffers.

Value Default: 0x4000 (16 Kbytes)

When to Change

It is generally recommended that you change the size of socket buffers individually, since changing this parameter changes the receive buffer size on all data-gram sockets, using a tremendous amount of kernel memory. Also, increasing this parameter increases the amount of time necessary to wait for socket response, since all sockets will have more buffer space to read.

See the setsockopt(2) reference page for more information on setting specific individual socket options.

udp_hashtablesz

Description This parameter controls the size of the UDP hash table.

Value Default: 0 (Auto-configure)

Range: 64-2048

When to Change

This should not normally need to be changed, but might be changed in order to reduce the consumption of system RAM on systems that are not used to handle large numbers of networking applications, or to increase the number of hash buckets on systems that primarily provide networking services.

Using a zero value specifies that the table is to be sized based on system RAM. A non-zero value specifies the number of hash buckets to use for UDP. The system automatically adjusts this number to support the requirements of the hashing algorithm. For example, entering a value of 512 will create 513 buckets.

Restrictions The system silently enforces a minimum value of 64 hash buckets and a maximum value of 2048 hash buckets.

tcp_sendspace

Description This parameter controls the default size of the send buffer on TCP/IP sockets. There is a pair of buffers associated with each socket in use. There is a buffer on the receiving side of the socket, and on the sending side. The size of these buffers represent the maximum amount of data that can be queued.

Value Default: 60Kbytes

Range: 0-512Kbytes

When to Change

The *tcp_sendspace* parameter may require tuning for slow throughput links, and for compatibility with TCP implementations based on 4.2BSD. For slow throughput links (such as lower speed PPP or SLIP connections), lower the value of this and the *tcp_recvspace* parameters until the best performance level is found. Very slow links such as PPP or SLIP over modems usually find a 3 Kbyte or 4 Kbyte buffer size to be the most efficient.

The *tcp_sendspace* parameter may require tuning for slow throughput links, and for compatibility with TCP implementations based on 4.2BSD. For slow throughput links (such as a Wide Area Net with a lower speed PPP or SLIP component), lower the value of this and the *tcp_recvspace* parameters on systems where the connection goes from fast (ethernet, FDDI, etc.) to slow (PPP or SLIP) until the best performance level is found. Very slow links such as PPP or SLIP over modems usually find a 3 Kbyte or 4 Kbyte buffer size to be the most efficient.

Conversely, high speed connections may profit from increasing the buffer size incrementally from 60 KBytes until maximum performance is achieved.

See the setsockopt(2) reference page for more information on setting specific socket options.

tcp_recvspace

Description — This parameter controls the default size of the TCP / IP receive buffer. There is a pair of buffers associated with each socket in use. There is a buffer on the receiving side of the socket, and on the sending side. The size of these buffers represent the maximum amount of data that can be queued.

Value — Default: 60 Kbytes

Range: 0-512Kbytes

When to Change

The *tcp_recvspace* parameter may require tuning for slow throughput links, and for compatibility with TCP implementations based on 4.2BSD. For slow throughput links (such as a Wide Area Net with a lower speed PPP or SLIP component), lower the value of this and the *tcp_sendspace* parameters on systems where the connection goes from fast (ethernet, FDDI, etc.) to slow (PPP or SLIP) until the best performance level is found. Very slow links such as PPP or SLIP over modems usually find a 3 Kbyte or 4 Kbyte buffer size to be the most efficient.

Conversely, high speed connections may profit from increasing the buffer size incrementally from 60 KBytes until maximum performance is achieved.

See the setsockopt(2) reference page for more information on setting specific individual socket options.

tcp_hashtablesz

Description This parameter controls the size of the TCP hash table.

Value Default: 0 (Auto-configure)

Range: 64-8192

When to Change

This parameter should not normally need to be changed, but might be changed in order to reduce the consumption of system RAM on systems that are not used to handle large numbers of networking applications, or to increase the number of hash buckets on systems that primarily provide networking services.

Using a zero value specifies that the table is to be sized based on system RAM. A non-zero value specifies the number of hash buckets to use for TCP. The system automatically adjusts this number to support the requirements of the hashing algorithm. For example, entering a value of 512 will create 1025 buckets, since TCP uses the extra space for processing connections in the TIME-WAIT state.

Restrictions The system silently enforces a minimum value of 64 hash buckets and a maximum value of 8192 hash buckets.

VINO Parameters

This section describes Indy Video In No Out tunable parameters. The following parameter pertains to VINO:

- *vino_mtune_dmrbpages*—Limits the size of the DMA descriptor table used by the VINO video capture.

vino_mtune_dmrbpages

Description — The *vino_mtune_dmrbpages* parameter limits the size of the DMA descriptor table used by the VINO video capture. This in turn limits how many pages allocated to the Digital Media Ring Buffers are usable when capturing video. The number of pages in *vino_mtune_dmrbpages* is what the DMRB size specifically for VINO is limited to when allocated.

Value — Default: 0 (auto-configure)

If this parameter is set to zero, then a default based on the amount of memory available at run time is used. If a limit of less than that is desired, set this variable to the maximum number of pages that the ring buffers can use. A value of -1 indicates do not preallocate any space for VINO DMA descriptors.

Notes — Note that if a DMA descriptor table size is needed that is greater than the size specified here and cannot be allocated contiguously at run time (possibly due to memory fragmentation), then the video transfer will not be started, and will return an ENOMEM error. The error recovery is to attempt the capture with a smaller DMRB.

Extended Accounting Parameters

The following parameters control system accounting features. The parameters are:

- *do_procacct*—controls BSD process accounting.
- *do_extpacct*—controls extended process accounting.
- *do_sessacct*—controls array session accounting.
- *use_astbl*—controls array session table.
- *narsess*—controls the number of entries in an array session table.

- *dfltash*—controls the default array session handle for special sessions.
- *minash*—controls the first array session handle that can be assigned by the kernel.
- *maxash*—controls the largest array session handle that can be assigned by the kernel before wrapping back to *minash*.
- *asmachid*—controls the machine ID for generating global ASHs.
- *dfltprid*—controls the default project ID for special sessions.

do_procacct

Description The *do_procacct* parameter, when set to 1, directs the system to perform BSD system accounting. When set to 0, the system does not perform the accounting, overriding the acct(2) system call.

Value Default: 1

Range: 0-1

do_extpacct

Description The *do_extpacct* parameter, when set to 1, directs the system to perform extended process accounting. When set to 0, the system does not perform the accounting.

Value Default: 0

Range: 0-1

do_sessacct

Description The *do_sessacct* parameter, when set to 1, directs the system to perform array session accounting when a process exits. When set to 0, the system does not perform the accounting.

Value Default: 0

Range: 0-1

use_astbl

Description — The *use_astbl* parameter, when set to 1, directs the system to allocate array sessions in a single preallocated table. When set to 0, the system array sessions are allocated dynamically.

Value — Default: 0 for 32-bit kernels, 1 for 64-bit kernels

Range: 0-1

narsess

Description — The *narsess* parameter specifies the number of entries in an array session table. When set to 0, the system auto-configures the value at 1/10th of the value of *nproc*.

Value — Default: 0 (autoconfigured at 1/10th *nproc*)

Range: 10-10000

dfltash

Description — The *dfltash* parameter specifies the default array session handle for special system sessions and other sessions that bypass ordinary session handle assignment.

Value — Default: 0

Range: 0-0x7fffffffffffffff

minash

Description — The *minash* parameter specifies the first array session handle that can be assigned by the kernel.

Value — Default: 1

Range: 1-0x7fffff00

maxash

Description — The *maxash* parameter specifies the largest array session handle that can be assigned by the kernel before wrapping back to minash.

Value — Default: 65535

Range: 255 -0x7fffffff

asmachid

Description — The *asmachid* parameter specifies the system ID for generating global ASHs. No other system in an array should have the same system ID. If 0 is specified, the kernel will only generate local ASHs.

Value — Default: 0

Range: 0 -0x7fff

dfltprid

Description — The *dfltprid* parameter specifies the default project ID for special system sessions and other sessions that bypass ordinary project ID assignment.

Value — Default: 0

Range: 0 -0x7fffffffffffffff

Appendix B

Troubleshooting System Configuration Using System Error Messages

This appendix lists error messages you may receive from the IRIX operating system and offers references to appropriate areas of the documentation describing the system functions that are likely related to the error message.

System errors are often accompanied by several error messages that together will lead you to determining the actual problem. Read the section for each message and use your best judgement to determine which messages reflect the core problem and which are caused by the effects of the core problem on other parts of the system. For example, you may see a message indicating that the system disk is full from the kernel, as well as one from the objectserver. Creating space on the system disk is likely to solve this problem, and the objectserver message can safely be ignored.

For error messages not covered in this guide or related IRIX Administration Guides, see the file */usr/include/sys/errno.h*, the intro(2) reference page, and the *Owner's Guide* for your system.

Some error messages are "customized" with specific information from your system configuration. Where this is the case, the messages listed in this appendix may contain an ellipsis (...) to indicate specific information that has been left out of the example, or the notation is made that the message you receive may be similar to the listed message, rather than an exact match.

Disk Space Messages

The following messages deal with standard disk operations, such as messages indicating you are low on or out of available disk space.

- `unix: <disk id>: Process ... ran out of disk space`
- `unix: <disk id>: Process ... ran out of contiguous space`
- `objectserver: The system disk is 100% full`
- `objectserver: The /usr disk directory is 100% full`
- `objectserver: The system disk is 95% full`
- `objectserver: The /usr disk directory is 95% full`

If the disk becomes completely full, you will not be able to create new files or write additional information to existing files. If the system disk becomes full, your system may not respond to commands.

Note: Do not shut down or restart the system until you free up some disk space. Without free disk space, the system may not be able to restart properly.

Please release disk space in one of these ways:

1. Empty your dumpster by choosing “Empty Dumpster” from the Desktop toolchest.
2. Remove or archive old or large files or directories.
    - To find old or large files, double-click the *launch icon* to start the Search tool, then use its online help.
    - It’s a good idea to search for files named *core*; these are often very large, and are created by an application when it encounters a problem.
    - If you remove the files from the desktop, empty your dumpster again.
    - To archive files (copy them onto a backup tape), use the Backup & Restore tool; start it by double-clicking the launch icon.

3. If your system disk is almost full, check:
    - */var/tmp* and */tmp*: These are public directories that often become full; delete unwanted files or directories that you find here.
    - */var/adm/SYSLOG*: If this file seems very large (over 200 KB), remove all but a few lines of it; do not remove the entire file.
    - */var/adm/crash*: When the system has a serious failure (crash), it places information into two files: *vmcore.*<*number*> and *unix.*<*number*>. If you find files with these names, back them up to tape so you can give the files to your local support organization, then remove the files from your system.
    - If you remove the files from the desktop, empty your dumpster again.
    - *mbox* in all home directories. If these files are large, ask the owners to please delete all but critical messages.
4. Remove optional or application software.
    - To start the Software Manager, choose “Software Manager” from the System toolchest.

If you want to be notified at a different level of disk use (for example, to be notified when the disk is 90% full), a *Privileged User* can follow these steps:

1. Start the Disk Manager by double-clicking the *launch icon*.
2. Click the button beneath the photo of the disk whose warning threshold you want to change (the system disk is labeled 0,1).
3. Highlight the number in the *Notify when* field, type 90, then click *OK*.

Also, see “Disk Usage Commands” on page 121.

General System Messages

The following messages indicate general system configuration issues that should be noted or attended to.

File Permission Issues

You may see the message:

- `unix: WARNING: inode 65535: illegal mode 177777`

This message indicates that a program attempted to access a file to which it has no access permission.

The *find* command can be used to identify the filename, permissions, and directory path that the file resides in. Use the **-inum** option of *find* to specify the inode number in order to locate the file. Once the file has been located, the permissions of the file can be changed by the owner of the file or the superuser (**root**).

IP (Network) Address Issues

The following issues pertain to the basic configuration of your system for the network and the immediate networking hardware.

Default Internet Address

You may see the message:

- `unix: network: WARNING IRIS'S Internet address is the default`

The IP address is not set on this system. To set the IP address, see "Setting the Network Address" on page 78.

Duplicate IP Address

You may see the messages:

- `unix: arp: host with ethernet address ... is using my IP address ...`
- `unix: arp: host with ethernet address ... is still using my IP address ...`

Your system's IP address is the same as another system's. Each system on the network must have a unique IP address so the network can send information to the correct location. Typically an address conflict occurs when a new system is added to the network and the system's Administrator assigns an IP address that is already in use.

Check to make certain your system is using the correct IP address and then contact the owner of the other system to determine which system needs to change its address.

Ethernet Cable Issues

You may see the following messages:

- `unix: ec0: no carrier: check Ethernet cable`

This message indicates that the Ethernet cable has become loose, or some connection has been lost. This message may appear if the other systems on the network have been shut down and turned off.

- `unix: ec0: late xmit collision`

This message indicates that the Ethernet interface has detected a transmission by another system on the network that was sent beyond the boundaries of the Ethernet standard transmission timing.

The most common causes of the late collisions are due to networks that have been configured outside of the network specification boundaries:

- Long AUI transceiver cables. The length of the AUI cable should not exceed 50 meters.
- New or recently added network segments that extend the network's total length.
- Faulty or failing transceivers.
- Faulty or failing Ethernet controllers.

If the problem persists, contact your network administrator or your local support provider.

Root Filesystem Not Found

If your root filesystem is not found at boot time, check to be sure that there is not an incorrect *$root* variable set in the PROM. If there is an incorrect *$root* variable, simply enter **`unsetenv root`** at the monitor prompt and then reboot.

login and su Issues

These messages are typically informational. They appear when another user attempts to log on to the system or use another account and the attempt either fails or succeeds.

login Messages

You may see the message:

- `login: failed: <user> as <user>`

The *login* failures indicate that the user didn't specify the correct password or misspelled the login name. The */var/adm/SYSLOG* file contains the hostname that the user attempted to log in from and the account (username) the user attempted to log in to on the local system.

su Messages

You may see the message:

- `su: failed: ttyq# changing from <user> to root`

The *su* messages are typically informational. They appear when a user attempts to switch user accounts. Typically users are attempting to become **root** or superuser when this message appears.

The *su* failures indicate that the user didn't specify the correct password or misspelled the login name. The */var/adm/SYSLOG* file contains the hostname, tty port number (*ttyq#*), the name of the user that attempted to perform the *su* command, and the account the user attempted to use.

Network Bootup Issues

This message indicates that the *bootp* program was remotely invoked from your system:

- `bootp: reply boot file /dev/null`

Usually a filename that is given after the *bootp* command contains code that can remotely startup a remote system. This startup file can be used to restart a diskless system, boot an installation program (*sa*), boot a system into *sash*, or boot X-terminals. The *bootp* program is a communications program that talks between the systems and the remote network device and facilitates the reading of the startup file across the network.

Operating System Rebuild Issues

You may see the following message:

- `lboot: Automatically reconfiguring the operating system`

This informational message indicates that there has been a change to one or more of the operating system files or to the system hardware since the system last restarted. The system may automatically build a new kernel to incorporate the changes, and the changes should take place once the system has been rebooted.

The operating system file changes that can cause this message to be displayed include installing additional software that requires kernel modifications and additions or changes in some kernel tunable parameters. If this message appears every time the system boots, then check the date on one of the operating system files. The date on the file may have been set to a date in the future.

Power Failure Detected

You may see the following message:

- `unix: WARNING: Power failure detected`

This message indicates that the system has detected that the AC input voltage has fallen below an acceptable level. This is an informational message that is logged to */var/adm/SYSLOG*.

Although this is an informational message, it's a good idea to check all of the AC outlets and connections, and check the system components for disk drive failures or overheated boards. On CHALLENGE and Onyx systems, the system controller attempts to gracefully shut down the system; this includes stopping all processes and synchronizing the disk. For additional information, refer to the section titled Using System Controller in the *Challenge and Onyx Diagnostic Roadmap*.

SCSI Controller Reset

You may see messages similar to the following:

- `unix: wd93 SCSI Bus=0 ID=7 LUN=0: SCSI cmd=0x12 timeout after 10 sec. Resetting SCSI`
- `unix: Integral SCSI bus ... reset`

This message indicates that the SCSI controller has made an inquiry of the device (where the ID number is located) and it did not respond.

This message is a notification to the user that the system has encountered a problem accessing the SCSI device. There are several reasons why this message may have been displayed:

- The SCSI device that was being accessed doesn't support the type of inquiry that the controller has made.
- There is a physical problem with the SCSI device or controller.

If this message continues to appear, look at the */var/adm/SYSLOG* file and see if there are any messages that follow this one to help isolate or identify the problem, or contact your local support provider.

syslogd Daemon Issues

You may see the following message:

- `syslogd: restart`

The *syslogd* messages are typically informational only. The messages indicate the start and stop of the *syslogd* daemon. These messages are written to */var/adm/SYSLOG* when the system is shut down or rebooted.

System Clock and Date Issues

You may see this message:

- `unix: WARNING: clock gained ... days`

This is an informational message that indicates that the system has been physically turned off for *x* number of days (where *x* is indicated by the message found in */var/adm/SYSLOG*).

To correct this problem, you should reset the system date and time. For more information on setting the system time, see the date(1) reference page and "Changing the Date and Time" on page 82 of this Guide.

You may see this message:

- `unix: WARNING: CHECK AND RESET THE DATE!`

This message is typically preceded by several different types of time and date messages. Some of the messages are informational, and others indicate a problem with the system date, time, or hardware. Check the log file */var/adm/SYSLOG* for other clock, date, or time-related problems. If you don't see any other date, time, or clock messages, try setting the *verbose* option of *chkconfig* on.

For more information on setting the date, and tim, see the date(1) reference page and "Changing the Date and Time" on page 82 of this Guide. For *chkconfig* options, refer to the chkconfig(1M) reference page.

Time Server Daemon Messages

- `timed: slave to gate-host-name`

The time server daemon (*timed*) logs informational entries into */var/adm/SYSLOG*. No action is required by the user. The *timed* daemon will automatically perform the necessary adjustments. Refer to the timed(1M) reference page for more information about the time server daemon.

System Restarting Information

You may see the following messages:

- `INFO: The system is shutting down.`
- `INFO: Please wait.`
- `syslogd: going down on signal 15`
- `syslogd: restart`
- `unix: [WIRIX Release ...`
- `unix: Copyright 1987-1995 Silicon Graphics, Inc`
- `unix: All Rights Reserved.`

The messages logged during system startup contain information about the operating system environment that the system is using. The startup messages include the version of the IRIX operating system that is loaded on the system, and Silicon Graphics copyright information. The operating system version information can be helpful to support providers when you report any problems that the system may encounter.

The messages that are logged during system *shutdown* are also sent to */var/adm/SYSLOG*. These are informational messages that are broadcast to all users who are logged onto the system and the system console. There is no action required.

Trap Held or Ignored

You may see these messages:

- `unix: WARNING: Process ... generated trap, but has signal 11 held or ignored`
- `unix: Process ... generated trap, but has signal 11 held or ignored`

This message indicates that the process is an infinite loop, therefore the signal/trap message that followed was held or ignored.

This message is usually caused by a temporary “out of resources” condition or a bug in the program. If it is a resource issue, you should be able to execute the program again without seeing this message again. If the message reappears after executing the program, you might have encountered a bug in the program.

Memory and Swap Messages

The following messages you may see deal with issues of system memory and swap space, and the way the system manages these resources.

Growreg Insufficient Memory

You may see this message:

- `unix: growreg - temporarily insufficient memory to expand region`

This message indicates that there is not enough memory (both real and virtual) available for use by programs running on your system. There is no memory available to start any new processes or programs.

If this message continues to appear, you can correct the problem as directed in the troubleshooting section titled “Swapping and Paging Messages” on page 302.

Panic Page Free

If you see this message:

- `PANIC: panic pagefree: page use 0`

This indicates that the system thinks that an address of a page of memory is out of the legal range of values, or that the system is trying to free a page of memory that is already marked as free.

This panic message results in the system halting immediately and ungracefully. When the system halts, it attempts to save the contents of the kernel stack and memory usage information in a crash file. The page free panic is usually caused by a physical memory problem or possible disk corruption. If this message occurs again, contact your local support provider.

Physical Memory Problems

You may see a message similar to this:

- `unix: CPU Error/Addr 0x301 <RD PAR>: 0xbd59838`

Your system contains several modular banks of random-access memory; each bank contains a SIMM. One or more of these SIMMs is either loose or faulty. You must correct the problem so your system and software applications can run reliably.

Follow these steps:

1. Shut down the system.
2. Refer to your *Owner's Guide*. It shows you how to visually identify a loose SIMM and re-seat it. If the SIMM is not loose, you may need to replace it. Contact your local support organization.

   If your *Owner's Guide* does not contain information about SIMMs, contact your local support organization.

Recoverable Memory Errors

The following are informational messages. They indicate that the hardware detected a memory parity error and was able to recover from the parity condition. No action is required unless the frequency of this message increases. Please note the hexadecimal number, which represents the memory location in a SIMM.

- `unix: Recoverable parity error at or near physical address 0x9562f68 <0x308>, Data: 0x8fbf001c/0x87b00014`

  This message indicates that the system has tried to read a programs allotted memory space and an error has been returned. The error that returns usually indicates a memory parity error.

- `unix: Recoverable memory parity error detected by CPU at 0x9cc4960 <0x304> code:30`

  This is an informational message that indicates that the *Central Processing Unit (CPU)* detected a memory parity error and is reporting it to */var/adm/SYSLOG*. No action is required unless the frequency of this message increases. Please note the hexadecimal number, which represents the memory location in a *SIMM*.

- `unix: Recoverable memory parity error corrected by CPU at 0x9cc4960 <0x304> code:30`

  This is an informational message that indicates that the Central Processing Unit (CPU) detected a memory parity error and was able to recover from the parity condition. No action is required unless the frequency of this message increases. Please note the hexadecimal number, which represents the memory location in a *SIMM*.

Savecore I/O Error

If you see this message:

- `savecore: read: I/O Error`

This message indicates that when the system rebooted after a system crash, the program *savecore* was not able to read */dev/swap* in order to save the memory core image at the time of the crash.

The program *savecore* is executed after the system restarts with superuser permissions. If *savecore* was not able to read the memory core image (*/dev/swap*), then it is possible that you have disk problems within the swap partition. This message might be followed by disk error messages. If the problem persists, then you should contact your local support provider.

Swapping and Paging Messages

Swapping and Paging are the methods by which the operating system manages the limited memory resources in order to accommodate multiple processes and system activities. In general, the operating system keeps in actual RAM memory only those portions of the running programs that are currently or recently in use. As new sections of programs are needed, they are paged (or “faulted”) into memory, and as old sections are no longer needed they are paged out.

Swapping is similar to paging, except that entire processes are swapped out, instead of individual memory pages, as in paging. The system maintains a section of hard disk for swapping. If this space is filled, no further programs can be swapped out, and thus no further programs can be created.

The following messages may indicate a swapping or paging problem:

- `Swap out failed on logical swap`

  For some reason, the operating system was unable to write the program to the swap portion of the disk. No action is necessary as the process is still in memory. See “Swap Space” on page 126.

- `Paging Daemon (vhand) not running - NFS server down?`

  The system determines that *vhand* is not executing, possibly because it is waiting for an I/O transfer to complete to an NFS server (especially if the NFS file system is hand mounted). No action should be necessary as the system will restart *vhand* when needed.

- `bad page in process (vfault)`

  The page being faulted into memory is not a recognized type. The recognized types are demand fill, demand zero, in file, or on swap. Reboot your system and if the error persists, check your application and your disk.

- `unix: WARNING: Process ... killed due to bad page read`

  The page being faulted into memory could not be read for some reason and the process was killed. Restart the program or reboot the system, and if the error persists, check your application and your disk.

- `unix: Process ... killed due to insufficient memory/swap`

  Your system uses a combination of physical memory (RAM) and a small portion of the disk (swap space) to run applications. Your system does not have enough memory and swap space at this time. It had to stop a program from running to free up some memory.

- `unix: ... out of logical swap space during fork - see swap(1M)`

  Your system does not have enough memory and swap space at this time. It could not start a new process.

If you run out of swap space or memory frequently, you should:

1. Exit from applications when you are not using them. Remember to check all your Desks.
2. Order additional memory from your local support or sales organization.

3. Turn on virtual swap space. Refer to the swap(1M) reference page and “Swap Space” on page 126 first.

   The Administrator should log in as **root** and enter the command:

   ```
   chkconfig
   ```

   If the *chkconfig* listing shows a line that says `vswap off`, give the commands:

   ```
   chkconfig vswap on
   ```

   ```
   /etc/init.d/swap start
   ```

   If *vswap* was already on, go on to the next step.

4. Create a file that the system can use for additional swap space. Note that this decreases your available disk space by the size of the file. If you create a 10 MB swap file, you’ll no longer have access to that 10MB of disk space.

   To create a 10 MB swap file, the Administrator should log in as **root** and enter these commands:

   ```
   mkdir -p /var/swap
   ```

   ```
   /usr/sbin/mkfile 10m /var/swap/swap1
   ```

   ```
   /sbin/swap -a /var/swap/swap1
   ```

   To make this permanent, so you have the swap space available every time you restart the system, add this line to the */etc/fstab* file:

   ```
   /var/swap/swap1 swap swap pri=3
   ```

   For more information, see the swap(1M) reference page or “Swap Space” on page 126.

5. You can permanently increase swap space by repartitioning the disk. You can find instructions to do this in the *IRIX Admin: Disks and Filesystems* volume.

Other Memory Messages

You may see the following error messages or similar messages from time to time:

- `unix: Memory Parity Error in SIMM S9 (Bank 0, Byte 2)`

  The CPU detected a memory parity error in the listed SIMM. A parity error indicates that some or all of the individual memory bits may have been incorrectly read or written. Note the SIMM information and reboot the system. If the same SIMM shows repeated errors, check the SIMM as described in “Physical Memory Problems” on page 300.

- `unix: Process...sent SIGBUS due to Memory Error in SIMM S9`

  Note the SIMM information and reboot the system. If the same SIMM shows repeated errors, check the SIMM as described in “Physical Memory Problems” on page 300.

- `Ran out of action blocks`

  A resource used by the multiprocessor kernel for inter-CPU interrupts has run out. If this happens frequently, use the systune(1M) command to increase the value of the parameter *nactions* as described in the section titled “Tuning the Operating System” on page 203.

- `mfree map overflow`

  Fragmentation of some resource (such as message queues) contributed to the loss of some of the resource. No action is necessary.

System Panic Messages

The following messages indicate problems that should be resolved by rebooting the system. You should not be overly concerned about these instances unless they become frequent. There are other PANIC messages that are generated by the kernel not listed here. Follow these instructions for all PANIC messages.

- `bumprcnt - region count list overflow`

  This message indicates an unresolvable problem with the operating system. Reboot your system.

- `PANIC: kernel fault`

  This message indicates that the kernel experienced an unresolvable problem and shut itself down. By the time you see this message in the system message log, you will have rebooted the system. Note the message exactly on paper in your system log book for reference if it happens again.

The system is said to have panicked if the software or hardware reached a state where it could no longer operate. If the system fails again, or if you receive an unusually large number of error messages, please contact your local support provider. It helps the support provider if you save this information:

- If there are any files in the */var/adm/crash* directory, back them up to tape. Double-click the *launch icon* to start the Backup & Restore tool.
- After you back up the files, you can remove them.
- Check the System Log Viewer and save all the messages that you see. Double-click the *launch icon* to start the System Log Viewer.
- Have you changed any kernel tunable parameters recently? If so, try resetting them to their former or default or self-configuring settings. See “Tuning the Operating System” on page 203.

Appendix C

IRIX Directories and Files

This section briefly describes the directories and files that a system administrator uses frequently. For additional information on the formats of the system files, refer to the IRIX section 4 reference pages.

IRIX Root Directories

The main directories of the *root* file system (*/*) are as follows:

/	Contains hardware-specific files and files required to start the system.
bin	Contains publicly executable commands. (Some are *root*-only.)
debug	Provides a link to */proc*.
dev	Contains special files that define all of the devices on the system.
etc	Contains administrative programs and tables.
lib	Contains public libraries.
lost+found	Used by fsck(1M) to save disconnected files and directories.
proc	Provides an interface to running processes that may be used by debuggers such as dbx(1).
tmp	Used for temporary files.
usr	Used to mount the */usr* file system and for files that are the same from system to system. These files are not writable.
var	Used for files that are specific to each system. There is typically a symbolic link to */usr* for each file in */var*.

Other Important IRIX System Directories

The following directories are important in the administration of your system:

/etc/init.d	Contains shell scripts used in upward and downward transitions to all system run levels. These files are linked to files beginning with *S* (start) or *K* (kill) in */etc/rcn.d*, where *n* is replaced by the appropriate run level number.
/etc/config	Contains start-up and run-time configuration information.
/etc/rc0.d	Contains files executed by */etc/rc0* to bring the system to run-level 0. Files in this directory are linked from files in the */etc/init.d* directory and begin with either a *K* or an *S*. *K* indicates processes that are killed, and *S* indicates processes that are started when entering run-level 0.
/etc/rc2.d	Contains files executed by */etc/rc2* for transitions to system run-level 2. Files in this directory are linked from files in the */etc/init.d* directory and begin with either a *K* or an *S*. *K* indicates processes that should be killed, and *S* indicates processes that should be started, when entering run-level 2.
/etc/rc3.d	Contains files executed by */etc/rc3* for transitions to system run-level 3. Files in this directory are linked from files in the */etc/init.d* directory and begin with either a *K* or an *S*. *K* indicates processes that should be stopped, and *S* indicates processes that should be started when entering run-level 3.
/var/adm/acct	Contains information collected by the accounting subsystem.
/var/adm/crash	Contains crash dumps of the system. After analysis, and if appropriate, these dumps can safely be removed unless your support provider has requested otherwise. See the savecore(1) reference page for more information.
/var/adm/sa	Contains information collected by sar(1).
/usr/people	Contains the home directories of users of the system or network. This directory can be a link to */var/people* or a mount point for a totally separate file system.
/usr/share	This directory contains files that are the same on all systems.
/var/spool	Contains spooling directories. The directories in this directory hold outbound mail, print requests, and other data.

/var/spool/cron/crontabs
: Contains *crontab* files for the *adm*, *root*, and *sys* logins and ordinary users listed in *cron.allow*.

/var/sysgen/master.d
: Contains files that define the configuration of hardware devices, software services and utilities, and aliases.

/var/sysgen/stune
: Contains files that define the default settings of all kernel tunable parameters.

/var/sysgen/mtune
: Contains files that define the current settings of all kernel tunable parameters.

Important IRIX System Files

The following files are important in the administration of your system:

/etc/cshrc	Contains the standard (default) environment for */bin/csh* users.
/etc/exports	Contains the list of NFS file systems exported at boot time to NFS clients if the optional NFS software is installed.
/etc/fstab	Specifies the filesystem(s) to be mounted.
/etc/gettydefs	Contains information used by *getty* to set the speed and terminal settings for a line.
/etc/group	Describes each group to the system.
/etc/hosts	Contains information about the known hosts on the network.
/etc/hosts.equiv	Contains a list of hosts trusted for non-superuser *rlogin* and *rsh* execution.
/etc/inittab	Contains the instructions to define the processes created or terminated by *init* for each initialization state.
/etc/issue	Displays a message to users before logging in to the system over the network or on serial lines.
/etc/lvtab	Contains information describing the logical volumes used by the workstation. This file is read by the logical volumes utilities.

/etc/motd Contains a brief “message of the day.”

/etc/passwd Identifies each user to the system.

/etc/profile Contains the standard (default) environment for */bin/sh* users.

/etc/rc0 Contains a script that executes shell scripts in */etc/rc0.d* to bring the system to run-level 0.

/etc/rc2 Contains a script that executes shell scripts in */etc/rc2.d* and */etc/rc.d* on transitions to system run-level 2.

/etc/shutdown Contains a shell script that gracefully shuts down the system in preparation for system backup or for scheduled downtime.

/etc/sys_id Contains the system name.

/etc/ttytype Contains a list, ordered by terminal port, of what kind of terminal is likely to log in to that port.

/etc/TIMEZONE
Used to set the default time zone shell variable *TZ*.

/etc/utmp Contains the information on the current runstate of the system.

/etc/wtmp Contains a history of system logins.

/etc/xwtmp Contains an extended history of system logins.

/var/adm/sulog Contains a history of *su* command usage. This file should be checked periodically for excessive size and archived.

/var/adm/SYSLOG
Contains system and daemon error messages.

/var/yp/ypdomain
Contains the domain name if the workstation is using NIS.

/var/cron/log Contains a history of all the actions taken by *cron*. This file should be checked periodically for excessive size and reduced if necessary.

/usr/lib/cron/cron.allow
Contains a list of users allowed to use crontab(1). This file cannot exist on the system at the same time as *cron.deny*.

/usr/lib/cron/cron.deny
Contains a list of users who are denied access to crontab(1). It is checked if */usr/lib/cron/cron.allow* does not exist.

IRIX Device Special Files

This section contains a listing of many of the most important device files and directories that reside in the */dev* directory structure.

dsk/	Directory containing block device files for disks; see ips(7), dks(7), and xyl(7) for disk partition device names.
rdsk/	Directory containing raw (character) device files for disks; see ips(7), dks(7), and xyl(7) for disk partition device names.
root	Generic *root* partition (block device).
rroot	Generic *root* partition (raw device).
usr	Generic *usr* partition (block device).
rusr	Generic *usr* partition (raw device).
swap	Generic *swap* partition (block device).
rswap	Generic *swap* partition (raw device).
vh	Generic *root* volume header (block device).
rvh	Generic *root* volume header (raw device).
mt/	directory containing block device files for tapes; see ts(7) for ISI quarter-inch tape drive device names; see tps(7) for SCSI quarter-inch tape drive device names; see xmt(7) for Xylogics half-inch tape drive names.
rmt/	directory containing raw device files for tapes; see ts(7) for ISI quarter-inch tape drive device names; see tps(7) for SCSI quarter-inch tape drive device names; see xmt(7) for Xylogics half-inch tape drive names.
tape	Generic tape device; bytes are swapped in order to be backward-compatible with the IRIS Series 2000 and 3000 workstations; see mtio(7).
nrtape	Generic no-rewind tape device; bytes are swapped in order to be backward-compatible with the IRIS Series 2000 and 3000 workstations; see mtio(7).
tapens	Generic tape device; bytes are not swapped; see mtio(7).
nrtapens	Generic no-rewind tape device; bytes are not swapped; see mtio(7).

mem	Memory; see mem(7).
mmem	Mappable memory; see mmem(7).
kmem	Kernel memory; see kmem(7).
null	Null device (zero length on input, data sink on output); see null(7).
SA/	Block devices used by system administration tools; see sysadm(1M) and sa(7).
rSA/	Raw devices used by system administration tools; see sysadm(1M) and sa(7).
audio	Audio interface.
dn_ll	File used to create 4DDN logical links; see dn_ll(7).
dn_netman	File used by 4DDN network management software; see dn_netman(7).
cent	Centronics® color graphics printer device.
tek	Tektronix™ color graphics printer device.
vers	Versatec® color graphics printer device.
vp0	Hard link to *vers*.
*gpib**	GPIB (IEEE-488) device; see gpib(7).
gse	Spectragraphics coax device; see gse(7).
plp	Parallel line printer interface; see plp(7).
prf	File used by operating system profiler; see prf(7).
t3270	Raw device file for IBM 3270™ Cluster Controller; see t3270(7).
hl/	Directory containing files used by IRIS GTX series machines hardware spinlock driver; see usnewlock(3P).
log	Named pipe that is read by the system logging daemon; see syslogd(1M).
ptc	Clonable pseudo-tty controller; see clone(7), ptc(7).
grconc	Master pseudo-teletype for the graphics console; see pty(7).
grcons	Slave pseudo-teletype for the graphics console; see pty(7).

gm	Logical console device for the Graphics Manager on the IRIS GT and GTX model machines. Messages from the software running on the 68020 on the GM board will appear as output on this device.
grin /	Directory containing the individual logical graphics input devices.
console	System console device.
syscon	Hard link to */dev/console*.
systty	Hard link to */dev/console*.
queue	Graphics queue device. Graphics programs call “select” on this device in order to be notified when there is input in their graphics queue. This device can’t be actually read or written.
dials	Device for serial port connected to dial and button box.
keybd	Device for serial port connected to keyboard.
mouse	Device for serial port connected to mouse.
tablet	Device for serial port connected to digitizing tablet.
ttyd[*1-12*]	Serial ports 1–12.
ttyf[*1-12*]	Serial ports 1–12 for devices that understand hardware flow control.
ttym[*1-12*]	Serial ports 1–12 for modems.
*ttyq**	Pseudo tty devices; see *pty*(7).
zero	Zero device (infinite zeros on reads); see *zero*(7).

ASCII Conversion Table

The ASCII character set defines a 1-to-1 mapping of characters to 8-bit values. The following tables provide an easy reference for converting the ASCII characters into their octal, hexadecimal, and decimal equivalents. These tables are also available in the ascii(5) reference page.

Table C-1 ASCII Map to Octal Values

000 nul	001 soh	002 stx	003 etx	004 eot	005 enq	006 ack	007 bel
010 bs	011 ht	012 nl	013 vt	014 np	015 cr	016 so	017 si
020 dle	021 dc1	022 dc2	023 dc3	024 dc4	025 nak	026 syn	027 etb
030 can	031 em	032 sub	033 esc	034 fs	035 gs	036 rs	037 us
040 sp	041!	042 “	043 #	044 $	045 %	046 &	047 ‘
050 (	051)	052 *	053 +	054 ,	055 -	056 .	057 /
060 0	061 1	062 2	063 3	064 4	065 5	066 6	067 7
070 8	071 9	072 :	073 ;	074 <	075 =	076 >	077 ?
100 @	101 A	102 B	103 C	104 D	105 E	106 F	107 G
110 H	111 I	112 J	113 K	114 L	115 M	116 N	117 O
120 P	121 Q	122 R	123 S	124 T	125 U	126 V	127 W
130 X	131 Y	132 Z	133 [	134 \	135]	136 ^	137 _
140 `	141 a	142 b	143 c	144 d	145 e	146 f	147 g
150 h	151 i	152 j	153 k	154 l	155 m	156 n	157 o
160 p	161 q	162 r	163 s	164 t	165 u	166 v	167 w
170 x	171 y	172 z	173 {	174 |	175 }	176 ~	177 del

Table C-2 ASCII Map to Hexadecimal Values

00 nul	01 soh	02 stx	03 etx	04 eot	05 enq	06 ack	07 bel
08 bs	09 ht	0a nl	0b vt	0c np	0d cr	0e so	0f si
10 dle	11 dc1	12 dc2	13 dc3	14 dc4	15 nak	16 syn	17 etb
18 can	19 em	1a sub	1b esc	1c fs	1d gs	1e rs	1f us
20 sp	21 !	22 “	23 #	24 $	25 %	26 &	27 ‘
28 (	29)	2a *	2b +	2c ,	2d -	2e .	2f /
30 0	31 1	32 2	33 3	34 4	35 5	36 6	37 7
38 8	39 9	3a :	3b ;	3c <	3d =	3e >	3f ?
40 @	41 A	42 B	43 C	44 D	45 E	46 F	47 G
48 H	49 I	4a J	4b K	4c L	4d M	4e N	4f O
50 P	51 Q	52 R	53 S	54 T	55 U	56 V	57 W
58 X	59 Y	5a Z	5b [	5c \	5d]	5e ^	5f _
60 `	61 a	62 b	63 c	64 d	65 e	66 f	67 g
68 h	69 i	6a j	6b k	6c l	6d m	6e n	6f o
70 p	71 q	72 r	73 s	74 t	75 u	76 v	77 w
78 x	79 y	7a z	7b {	7c |	7d }	7e ~	7f del

Table C-3 ASCII Map to Decimal Values

0 nul	1 soh	2 stx	3 etx	4 eot	5 enq	6 ack	7 bel
8 bs	9 ht	10 nl	11 vt	12 np	13 cr	14 so	15 si
16 dle	17 dc1	18 dc2	19 dc3	20 dc4	21 nak	22 syn	23 etb
24 can	25 em	26 sub	27 esc	28 fs	29 gs	30 rs	31 us
32 sp	33 !	34 “	35 #	36 $	37 %	38 &	39 ‘
40 (	41)	42 *	43 +	44 ,	45 -	46 .	47 /
48 0	49 1	50 2	51 3	52 4	53 5	54 6	55 7
56 8	57 9	58 :	59 ;	60 <	61 =	62 >	63 ?
64 @	65 A	66 B	67 C	68 D	69 E	70 F	71 G
72 H	73 I	74 J	75 K	76 L	77 M	78 N	79 O
80 P	81 Q	82 R	83 S	84 T	85 U	86 V	87 W
88 X	89 Y	90 Z	91 [	92 \	93]	94 ^	95 _
96 `	97 a	98 b	99 c	100 d	101 e	102 f	103 g
104 h	105 i	106 j	107 k	108 l	109 m	110 n	111 o
112 p	113 q	114 r	115 s	116 t	117 u	118 v	119 w
120 x	121 y	122 z	123 {	124 |	125 }	126 ~	127 del

Appendix D

Encapsulated PostScript File v.3.0 vs. PostScript File Format

In the course of maintaining your system, you are likely to receive files in various versions of the PostScript format. Following are some of the main differences between the Encapsulated PostScript File (EPSF) version 3.0 format and PostScript file format:

- EPSF is used to describe the appearance of a single page, while the PostScript format is used to describe the appearance of one or more pages.
- EPSF requires the following two DSC (document structuring conventions) Header comments:

  ```
  %!PS-Adobe-3.0 EPSF-3.0 %%BoundingBox: llx lly urx ury
  ```

  If a PS 3.0 file conforms to the document structuring conventions, it should start with the comment:

  ```
  %!PS-Adobe-3.0
  ```

  A PS file does not have to contain any DSC comment statements if it does not conform to the DS conventions.
- Some PostScript language operators, such as *copypage*, *erasepage*, or *exitserver* must not be used in an EPS file.

  Certain rules must be followed when some other PostScript operators, such as *nulldevice*, *setscreen*, or *undefinefont* are used in an EPS file.

  All PostScript operators can be used in a PS file.
- An EPS file can be (and usually is) inserted into a PS file, but a PS file must not be inserted into an EPS file if that will violate the rules for creating valid EPS files.
- An EPS file may contain a device-specific screen preview for the image it describes. A PS file usually contains screen previews only when EPS files are included in that PS file.
- The recommended filename extension for EPS files is .**EPS** or .**eps**, while the recommended filename extension for PS files is .**PS** or .**ps**.

The EPSF format was designed for importing the PostScript description of a single page or part of a page, such as a figure, into a document, without affecting the rest of the description of that document. EPS code should be encapsulated, i.e., it should not interfere with the PS code that may surround it, and it should not depend on that code.

The EPSF format is usually used for the output from a program that was designed for the preparation of illustrations or figures, (such as Adobe Illustrator®) and as input into desktop publishing programs (such as Adobe System's FrameMaker®). Most desktop publishing programs can produce the description of a document in the PostScript format that may include the imported EPS code.

For more information about these formats, see the book *PostScript Language Reference Manual*, Second Edition, Addison-Wesley Publishing Company, Inc., Reading, MA, 1990. You can get several documents on the EPS and PS formats from the Adobe Systems PostScript file server by entering the following at a UNIX prompt, and then following the instructions you get from the file server:

mail ps-file-server@adobe.com
Subject: help
Ctrl-D

You can get a description of the EPSF format in the PS format by sending the following message to that file server:

`send Documents EPSF2.0.ps`

Appendix E

Bibliography and Suggested Reading

Internet Request For Comment documents are available from the Internet Network Information Center (INTERNIC) at the following address:

Network Solutions
Attn: InterNIC Registration Services
505 Huntmar Park Drive
Herndon, VA 22070
Phone: 1-800-444-4345 or 1-703-742-4777

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