Mastering UNIX® Shell Scripting

Bash, Bourne, and Korn Shell Scripting for Programmers, System Administrators, and UNIX Gurus

Second Edition

Randal K. Michael

Wiley Publishing, Inc.

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This book is dedicated to my wife Robin, the girls, Andrea and Ana, and the grandchildren, Gavin, Jocelyn, and Julia – my true inspiration.

About the Author

Randal K. Michael is a UNIX Systems Administrator working as a contract consultant. He teaches UNIX shell scripting in corporate settings, where he writes shell scripts to address a variety of complex problems and tasks, ranging from monitoring systems to replicating large databases. He has more than 30 years of experience in the industry and 15 years of experience as a UNIX Systems Administrator, working on AIX, HP-UX, Linux, OpenBSD, and Solaris.

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Contents

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I especially want to thank Jack Renfro at Chrysler Corporation for giving me my first shell scripting project so long ago. I had to start with the man pages, but that is how I learned to dig deep to get the answer. Since then I have been on a mission to automate, through shell scripting, support tasks on every system I come in contact with. I certainly value the years I was able to work with Jack.

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Introduction

In UNIX there are many ways to accomplish the same task. Given a problem to solve, we may be able to get to a solution in any number of ways. Of course, some techniques will be more efficient, use fewer system resources, and may or may not give the user feedback on what is going on or give more accurate details and more precision to the result. In this book we are going to step through every detail of creating shell scripts to solve real-world UNIX problems and tasks. The shell scripts range from using a pseudo-random number generator to creating passwords using arrays to replicating data with `rsync` to working with record files. The scope of solutions is broad and detailed. The details required to write a good shell script include commenting each step for future reference. Other details include combining many commands together into a single command statement when desirable, separating commands on several lines of code when readability and understanding the concept may be diminished, and making a script readable and easy to maintain through the life cycle. We will see the benefits of variables and files to store data, show methods to strip out unneeded data from command output, and format data for a particular purpose. Additionally, we are going to show how to write and use functions in our shell scripts and demonstrate the benefits of functions over a shell script written without functions.

This book is intended for any flavor of UNIX, but it emphasizes the AIX, HP-UX, Linux, OpenBSD, and Solaris operating systems. Almost every script in the book is also included on the book's companion web site (`www.wiley.com/go/michael2e`). Many of the shell scripts are rewritten for various UNIX flavors, when it is necessary. Other shell scripts are not platform-dependent. These script rewrites are necessary because command syntax and output vary, sometimes in a major way, between UNIX flavors. The variations are sometimes as small as extracting data out of a different column or using a different command switch to get the same result, or they can be as major as putting several commands together to accomplish the same task and get a similar output or result on different flavors of UNIX.

In each chapter we start with the very basic concepts to accomplish a task, and then work our way up to some very complex and difficult concepts. The primary purpose of a shell script is to automate repetitive and complex tasks. This alleviates keystroke errors and allows for time-scheduled execution of the shell scripts. It is always better to have the system tell us that it has a problem than to find out too late to be proactive. This book will help us to be more proactive and efficient in our dealing with the system. At every level you will gain more knowledge to allow you to move on to ever

increasingly complex ideas with ease. You are going to see different ways to solve real-world example tasks. There is not just one way to solve a challenge, and we are going to look at the pros and cons of attacking a problem in various ways. Our goal is to be confident and flexible problem solvers. Given a task, we can solve it in any number of ways, and the solution will be intuitively obvious when you complete this book.

Overview of the Book and Technology

This book is intended as a learning tool and study guide to learn how to write shell scripts to solve a multitude of problems by starting with a clear goal. We will cover most shell scripting techniques about seven times, each time hitting the topic from a different angle, solving a different problem. I have found this technique to work extremely well for retention of the material.

Each chapter ends with Lab Assignments that let you either write a new script or modify a shell script covered in the chapter. There is not a ''solutions'' book. The solution is to make it work! I urge everyone to read this book from cover to cover to get the maximum benefit. The shells covered in this book include Bash, Bourne, and Korn. C shell is not covered. Advanced topics include using `rsync` to replicate data, creating snapshot-style backups utilizing Dirvish, working with record files to parse data, and many others.

This book goes from some trivial task solutions to some rather advanced concepts that everyone from high school and college students to Systems Administrators will benefit from, and a lot in between. There are several chapters at each level of complexity scattered throughout the book. The shell scripts presented in this book are complete shell scripts, which is one of the things that sets this book apart from other shell-scripting books on the market. The solutions are explained thoroughly, with each part of the shell scripts explained in minute detail down to the philosophy and mindset of the author.

How This Book Is Organized

Each chapter starts with a typical UNIX challenge that occurs every day in the computer world. With each challenge we define a specific goal and start the shell script by defining the correct command syntax to solve the problem. After we present the goal and command syntax, we start by building the shell script around the commands. The next step is to filter the commands' output to strip out the unneeded data, or we may decide to just extract the data we need from the output. If the syntax varies between UNIX flavors, we show the correct syntax to get the same or a similar result. When we get to this point we go further to build options into the shell script to give the end user more flexibility on the command line.

When a shell script has to be rewritten for each operating system, a combined shell script is shown at the end of the chapter that will run on all the UNIX flavors studied in this book, except where noted. To do this last step, we query the system for the UNIX flavor using the `uname` command. By knowing the flavor of the operating system, we are able to execute the proper commands for each UNIX flavor by using a simple

`case` statement. If this is new to you, don't worry; everything is explained in detail throughout the book.

Each chapter targets a different real-world problem. Some challenges are very complex, whereas others are just interesting to play around with. Some chapters hit the problem from several different angles in a single chapter, and others leave you the challenge to solve on your own — of course, with a few hints to get you started. Each chapter solves the challenge presented and can be read as a single unit without referencing other chapters in the book, except where noted. Some of the material, though, is explained in great detail in one chapter and lightly covered in other chapters. Because of this variation, I recommend that you start at the beginning of the book and read and study every chapter, and solve each of the Lab Assignments through to the end of the book, because this *is* a learning experience!

Who Should Read this Book

This book is intended for anyone who works with UNIX from the command line on a daily basis. The topics covered in this book are mainly for UNIX professionals — computer science students, programmers, programmer-analysts, Systems Operators, application support personnel, Systems Administrators, and anyone who is interested in getting ahead in the support and development arenas. Beginners will get a lot out of this book, too, although some of the material may be a little high-level, so a basic UNIX book may be needed to answer some questions. Everyone should have a good working knowledge of common UNIX commands before starting this book; we do not explain basic UNIX commands in much detail.

I started my career in UNIX by learning on the job how to be a Systems Operator. I wish I had a book like this when I started. Having this history, I wanted others to get a jump-start on their careers. I wrote this book with the knowledge that I was in your shoes at one time, and I remember that I had to learn everything from the man pages, one command at a time. Use this book as a study guide, and you will have a jump-start to get ahead quickly in the UNIX world, which is getting bigger all the time.

Tools You Will Need

To get the most benefit from this book you need access to a UNIX machine, preferably with AIX, HP-UX, Linux, OpenBSD, or Solaris installed. You can run Linux, Solaris, and OpenBSD on standard PC hardware, and this is relatively inexpensive, if not free. Your default shell should be set to Bash or Korn shell. You can find your default shell by entering **echo $SHELL** on the command line. None of the shell scripts in this book requires a graphical terminal, but it does not hurt to have Gnome, CDE, KDE, or X-Windows running. This way you can work in multiple windows at the same time and cut and paste code between windows.

You also need a text editor that you are comfortable using. UNIX operating systems come with the **vi** editor, and many include **emacs**. You can also use the text editor that comes with KDE, CDE, and Gnome. Remember that the editor must be a text editor that stores files in a standard ANSII format. You will also need some time, patience, and an open, creative mind that is ready to learn.

Another thing to note is that all of the variables used in the shell scripts and functions in this book are in uppercase characters. I did this because it is much easier to follow along with the shell script if you know quickly where the variables are located in the code. When you write your own shell scripts, please use lowercase for all shell script and function variables. The reason this is important is that the operating system, and applications, use *environment variables* that are uppercase. If you are not careful, you can overwrite a critical system or application variable with your own value and hose the system; however, this is dependent on the scope of where the variable is in the code. Just a word of warning: be careful with uppercase variables!

What's on the Web Site

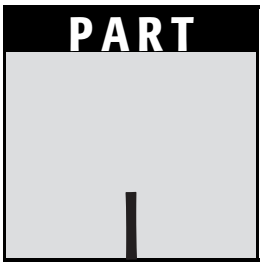
On the book's companion web site, `www.wiley.com/go/michael2e`, all the shell scripts and most of the functions that are studied in the book can be found. The functions are easy to cut and paste directly into your own shell scripts to make the scripting process a little easier. Additionally, there is a shell script *stub* that you can copy to another filename. This script stub has everything to get started writing quickly. The only thing you need to do is fill in the fields for the following: Script Name, Author, Date, Version, Platform, and Rev. List, when revisions are made. There is a place to define variables and functions, and then you have the ''BEGINNING OF MAIN'' section to start the main body of the shell script.

Summary

This book is for learning how to be creative, proactive, and professional problem solvers. Given a task, the solution will be *intuitively obvious* to you on completion of this book. This book will help you attack problems logically and present you with a technique of building on what you know. With each challenge presented you will see how to take basic syntax and turn it into the basis for a shell scripting solution. We always start with the basics and build more and more logic into the solution before we add additional options the end user can use for more flexibility.

Speaking of end users, we must always keep our users informed about how processing is proceeding. Giving the user a blank screen to look at is the worst thing that you can do, so for this we can create progress indicators. You will learn how to be proactive by building tools that monitor for specific system events and situations that indicate the beginning stages of an upcoming problem. This is where knowing how to query the system puts you ahead of the game.

With the techniques presented in this book, you will learn. You will learn about problem resolution. You will learn about starting with what you know about a situation and building a solution effectively. You will learn how to make a single shell script work on other platforms without further modifications. You will learn how to be proactive. You will learn how to use plenty of comments in a shell script. You will learn how to write a shell script that is easy to read and follow through the logic. Basically, you will learn to be an effective problem solver, and the solution to any challenge will be *intuitively obvious*!



The Basics of Shell Scripting

CHAPTER 1

Scripting Quick Start and Review

We are going to start out by giving a targeted refresher course. The topics that follow are short explanations of techniques that we always have to search the book to find; here they are all together in one place. The explanations range from showing the fastest way to process a file line-by-line to the simple matter of case sensitivity of UNIX and shell scripts. This should not be considered a full and complete list of scripting topics, but it is a very good starting point and it does point out a sample of the topics covered in the book. For each topic listed in this chapter there is a very detailed explanation later in the book.

We urge everyone to study this entire book. Every chapter hits a different topic using a different approach. The book is written this way to emphasize that there is never only one technique to solve a challenge in UNIX. All the shell scripts in this book are real-world examples of how to solve a problem. Thumb through the chapters, and you can see that we tried to hit most of the common (and some uncommon!) tasks in UNIX. All the shell scripts have a good explanation of the thinking process, and we always start out with the correct command syntax for the shell script targeting a specific goal. I hope you enjoy this book as much as I enjoyed writing it. Let's get started!

Case Sensitivity

UNIX is case sensitive. Because UNIX is case sensitive, our shell scripts are also case sensitive.

UNIX Special Characters

All of the following characters have a special meaning or function. If they are used in a way that their special meaning is not needed, they must be *escaped*. To escape,

or remove its special function, the character must be immediately preceded with a backslash, \, or enclosed within ' 'forward tic marks (single quotes).

```
\ / ; , . ~ # $ ? & * ( ) [ ] ' ' " + - ! ^ = | < >
```

Shells

A *shell* is an environment in which we can run our commands, programs, and shell scripts. There are different flavors of shells, just as there are different flavors of operating systems. Each flavor of shell has its own set of recognized commands and functions. This book works with the Bourne, Bash, and Korn shells. Shells are located in either the `/usr/bin/` directory or the `/bin/` directory, depending on the UNIX flavor and specific version.

Table 1-1

SHELL	DIRECTORY
Bourne	`/bin/sh` or `/usr/bin/sh`
Bash	`/bin/Bash` or `/usr/bin/Bash`
Korn	`/bin/ksh` or `/usr/bin/ksh`

Shell Scripts

The basic concept of a shell script is a list of commands, which are listed in the order of execution. A good shell script will have comments, preceded by a pound sign or hash mark, #, describing the steps. There are conditional tests, such as value A is greater than value B, loops allowing us to go through massive amounts of data, files to read and store data, variables to read and store data, and the script may include *functions*.

We are going to write a lot of scripts in the next several hundred pages, and we should always start with a *clear goal* in mind. With a clear goal, we have a specific purpose for the script, and we have a set of expected results. We will also hit on some tips, tricks, and, of course, the gotchas in solving a challenge one way as opposed to another to get the same result. All techniques are not created equal.

Shell scripts and functions are both *interpreted*. This means they are not compiled. Both shell scripts and functions are ASCII text that is read by the shell command interpreter. When we execute a shell script, or function, a command interpreter goes through the ASCII text line-by-line, loop-by-loop, test-by-test, and executes each statement as each line is reached from the top to the bottom.

Functions

A function is written in much the same way as a shell script but is different in that it is defined, or written, within a shell script most of the time, and is called within the

script. This way we can write a piece of code, which is used over and over, just once and use it without having to rewrite the code every time. We just call the function instead.

We can also define functions at the system level that is always available in our environment, but this is a topic for later discussion.

A function has the following form:

```
function function_name
{

     commands to execute

}
```

or

```
function_name ()
{

     commands to execute

}
```

When we write functions into our scripts we must remember to declare, or write, the function *before* we use it. The function must appear above the command statement calling the function. We can't use something that does not yet exist.

Running a Shell Script

A shell script can be executed in the following ways:

```
ksh  shell_script_name
```

will create a Korn shell and execute the `shell_script_name` in the newly created Korn shell environment. The same is true for `sh` and `Bash` shells.

```
shell_script_name
```

will execute `shell_script_name` *if the execution bit is set on the file* (see the manual page on the `chmod` command, **man chmod**). The script will execute in the shell that is *declared* on the first line of the shell script. If no shell is declared on the first line of the shell script, it will execute in the default shell, which is the user's system-defined shell. Executing in an unintended shell may result in a failure and give unpredictable results.

Table 1-2 Different Types of Shells to Declare

COMMAND	DESCRIPTION
`#!/bin/sh` or `#!/usr/bin/sh`	Declares a Bourne shell
`#!/bin/ksh` or `#!/usr/bin/ksh`	Declares a Korn shell
`#!/bin/csh` or `#!/usr/bin/csh`	Declares a C shell
`#!/bin/Bash` or `#!/usr/bin/Bash`	Declares a Bourne-Again (Bash) shell

Declare the Shell in the Shell Script

Declare the shell! If we want to have complete control over how a shell script is going to run and in which shell it is to execute, we must *declare* the shell in *the first line of the script*. If no shell is declared, the script will execute in the default shell, defined by the system for the user executing the shell script. If the script was written, for example, to execute in Bash shell, `Bash`, and the default shell for the user executing the shell script is the C shell, `csh`, the script will most likely have a failure during execution. To declare a shell, one of the declaration statements in Table 1-2 must appear on the *first line* of the shell script.

Comments and Style in Shell Scripts

Making good comments in our scripts is stressed throughout this book. What is intuitively obvious to us may be total Greek to others who follow in our footsteps. We have to write code that is readable and has an easy flow. This involves writing a script that is easy to read and easy to maintain, which means that it must have plenty of comments describing the steps. For the most part, the person who writes the shell script is not the one who has to maintain it. There is nothing worse than having to hack through someone else's code that has no comments to find out what each step is supposed to do. It can be tough enough to modify the script in the first place, but having to figure out the mindset of the author of the script will sometimes make us think about rewriting the entire shell script from scratch. We can avoid this by writing a clearly readable script and inserting plenty of comments describing what our philosophy is and how we are using the input, output, variables, and files.

For good style in our command statements, we need it to be readable. For this reason it is sometimes better, for instance, to separate a command statement onto three separate lines instead of stringing, or *piping*, everything together on the same line of code; it may be just too difficult to follow the pipe and understand what the expected result should be for a new script writer. However, in some cases it is more desirable to create a long pipe. But, again, it should have comments describing our thinking step by step. This way someone later will look at our code and say, ''Hey, now that's a groovy way to do that.''

Command readability and step-by-step comments are just the very basics of a well-written script. Using a lot of comments will make our life much easier when we have to come back to the code after not looking at it for six months, and believe me; we will look at the code again. Comment everything! This includes, but is not limited to, describing what our variables and files are used for, describing what loops are doing, describing each test, maybe including expected results and how we are manipulating the data and the many data fields. A hash mark, `#`, precedes each line of a comment.

The *script stub* that follows is on this book's companion web site at `www.wiley.com/go/michael2e`. The name is `script.stub`. It has all the comments ready to get started writing a shell script. The `script.stub` file can be copied to a new filename. Edit the new filename, and start writing code. The `script.stub` file is shown in Listing 1-1.

```
#!/bin/Bash
#
# SCRIPT: NAME_of_SCRIPT
# AUTHOR: AUTHORS_NAME
# DATE:   DATE_of_CREATION
# REV:    1.1.A (Valid are A, B, D, T and P)
#               (For Alpha, Beta, Dev, Test and Production)
#
# PLATFORM: (SPECIFY: AIX, HP-UX, Linux, OpenBSD, Solaris
#                     or Not platform dependent)
#
# PURPOSE: Give a clear, and if necessary, long, description of the
#          purpose of the shell script. This will also help you stay
#          focused on the task at hand.
#
# REV LIST:
#        DATE: DATE_of_REVISION
#        BY:   AUTHOR_of_MODIFICATION
#        MODIFICATION: Describe what was modified, new features, etc--
#
#
# set -n   # Uncomment to check script syntax, without execution.
#          # NOTE: Do not forget to put the comment back in or
#          #       the shell script will not execute!
# set -x   # Uncomment to debug this shell script
#
##########################################################
#         DEFINE FILES AND VARIABLES HERE
##########################################################
```

Listing 1-1 script.stub shell script starter listing

```
############################################################
#               DEFINE FUNCTIONS HERE
############################################################



############################################################
#                BEGINNING OF MAIN
############################################################



# End of script
```

Listing 1-1 (*continued*)

The shell script starter shown in Listing 1-1 gives you the framework to start writing the shell script with sections to declare variables and files, create functions, and write the final section, `BEGINNING OF MAIN`, where the main body of the shell script is written.

Control Structures

The following control structures will be used extensively.

if . . . then statement

```
if [ test_command ]
then

        commands

fi
```

if . . . then . . . else statement

```
if [ test_command ]
then

     commands

else

     commands

fi
```

if . . . then . . . elif . . . (else) statement

```
if  [ test_command ]

then

     commands
elif [ test_command ]
then

     commands

elif [ test_command ]
then

      commands
.
.
.
else     (Optional)

     commands

fi
```

for . . . in statement

```
for loop_variable in argument_list
do

     commands

done
```

while statement

```
while test_condition_is_true
do

     commands

done
```

until statement

```
until  test_condition_is_true
do

     commands

done
```

case statement

```
case $variable  in

match_1)

        commands_to_execute_for_1

        ;;

match_2)

        commands_to_execute_for_2

        ;;

match_3)

        commands_to_execute_for_3

        ;;
.
.
.

*)      (Optional - any other value)

        commands_to_execute_for_no_match

        ;;

esac
```

NOTE The last part of the case statement, shown here,

```
*)

    commands_to_execute_for_no_match

;;
```

is optional.

Using break, continue, exit, and return

It is sometimes necessary to *break* out of a `for` or `while` loop, *continue* in the next block of code, *exit* completely out of the script, or *return* a function's result back to the script that called the function.

- The **break** command is used to terminate the execution of the entire loop, after completing the execution of all the lines of code up to the `break` statement. It then steps down to the code following the end of the loop.
- The **continue** command is used to transfer control to the next set of code, but it continues execution of the loop.
- The **exit** command will do just what one would expect: it exits the entire script. An integer may be added to an `exit` command (for example, `exit 0`), which will be sent as the return code.
- The **return** command is used in a function to send data back, or *return a result or return code*, to the calling script.

Here Document

A *here document* is used to redirect input *into* an interactive shell script or program. We can run an interactive program within a shell script without user action by supplying the required input for the interactive program, or interactive shell script. This is why it is called a here document: the required input is here, as opposed to somewhere else.

This is the syntax for a here document:

```
program_name <<LABEL

Program_Input_1
Program_Input_2
Program_Input_3

Program_Input_#


LABEL
```

Example:

```
/usr/local/bin/My_program << EOF
Randy
Robin
Rusty
Jim
EOF
```

Notice in the here documents that there are *no spaces* in the program input lines, between the two `EOF` labels. If a space is added to the input, the here document may fail. The input that is supplied must be the *exact* data that the program is expecting, and many programs will fail if spaces are added to the input.

Shell Script Commands

The basis for the shell script is the automation of a series of commands. We can execute most any command in a shell script that we can execute from the command line. (One exception is trying to set an execution *suid* or *sgid*, *sticky bit*, within a shell script; it is not supported for security reasons.) For commands that are executed often, we reduce errors by putting the commands in a shell script. We will eliminate typos and missed device definitions, and we can do conditional tests that can ensure there are not any failures due to unexpected input or output. Commands and command structure will be covered extensively throughout this book.

Most of the commands shown in Table 1-3 are used at some point in this book, depending on the task we are working on in each chapter.

Table 1-3 UNIX Commands Review

COMMAND	DESCRIPTION
`passwd`	Changes user password
`pwd`	Prints current directory
`cd`	Changes directory
`ls`	Lists files in a directory
wildcards	`*` matches any number of characters; `?` matches a single character
`file`	Prints the type of file
`cat`	Displays the contents of a file
`pr`	Displays the contents of a file
`pg` or `page`	Displays the contents of a file one page at a time
`more`	Displays the contents of a file one page at a time
`clear`	Clears the screen
`cp` or `copy`	Copies a file
`chown`	Changes the owner of a file
`chgrp`	Changes the group of a file
`chmod`	Changes file modes, permissions
`rm`	Removes a file from the system
`mv`	Renames a file
`mkdir`	Creates a directory

Table 1-3 (*continued*)

COMMAND	DESCRIPTION
`rmdir`	Removes a directory
`grep`	Pattern matching
`egrep`	`grep` command for extended regular expressions
`find`	Locates files and directories
`>>`	Appends to the end of a file
`>`	Redirects, creates, or overwrites a file
`|`	Strings commands together, known as a pipe
`||`	Logical OR — `command1 || command2` — execute `command2` if `command1` fails
`&`	Executes in background
`&&`	Logical AND — `command1 && command2` — execute `command2` if `command1` succeeds
`date`	Displays the system date and time
`echo`	Writes strings to standard output
`sleep`	Halts execution for the specified number of seconds
`wc`	Counts the number of words, lines, and characters in a file
`head`	Views the top of a file
`tail`	Views the end of a file
`diff`	Compares two files
`sdiff`	Compares two files side by side (requires 132-character display)
`spell`	Spell checker
`lp`, `lpr`, `enq`, `qprt`	Prints a file
`lpstat`	Status of system print queues
`enable`	Enables, or starts, a print queue
`disable`	Disables, or stops, a print queue
`cal`	Displays a calendar
`who`	Displays information about users on the system
`w`	Extended `who` command

(*continued*)

Table 1-3 (*continued*)

COMMAND	DESCRIPTION
`whoami`	Displays `$LOGNAME` or `$USER` environment parameters
`who am I`	Displays login name, terminal, login date/time, and where logged in
`f`, `finger`	Displays information about logged-in users, including the users `.plan` and `.project`
`talk`	Enables two users to have a split-screen conversation
`write`	Displays a message on a user's screen
`wall`	Displays a message on all logged-in users' screens
`rwall`	Displays a message to all users on a remote host
`rsh` or `remsh`	Executes a command, or login, on a remote host
`df`	Displays filesystem statistics
`ps`	Displays information on currently running processes
`netstat`	Shows network status
`vmstat`	Shows virtual memory status
`iostat`	Shows input/output status
`uname`	Shows name of the current operating system, as well as machine information
`sar`	Reports system activity
`basename`	Displays base filename of a string parameter
`man`	Displays the online reference manual
`su`	Switches to another user, also known as super-user
`cut`	Writes out selected characters
`awk`	Programming language to parse characters
`sed`	Programming language for character substitution
`vi`	Starts the vi editor
`emacs`	Starts the emacs editor

Symbol Commands

The symbols shown in Table 1-4 are actually commands, and are used extensively in this book.

Table 1-4 Symbol Commands

COMMAND	DESCRIPTION
`( )`	Runs the enclosed command in a sub-shell
`(( ))`	Evaluates and assigns value to a variable and does math in a shell
`$(( ))`	Evaluates the enclosed expression
`[ ]`	Same as the `test` command
`< >`	Used for string comparison
`$( )`	Command substitution
`'command'`	Command substitution

Variables

A *variable* is a character string to which we assign a value. The value assigned could be a number, text, filename, device, or any other type of data. A variable is nothing more than a pointer to the actual data. We are going to use variables so much in our scripts that it will be unusual for us not to use them. In this book we are always going to specify a variable in uppercase — for example, `UPPERCASE`. Using uppercase variable names is not recommended in the real world of shell programming, though, because these uppercase variables may step on system environment variables, which are also in uppercase. Uppercase variables are used in this book to emphasize the variables and to make them stand out in the code. When you write your own shell scripts or modify the scripts in this book, make the variables lowercase text. To assign a variable to point to data, we use `UPPERCASE="value_to_assign"` as the assignment syntax. To access the data that the variable, `UPPERCASE`, is pointing to, we must add a dollar sign, `$`, as a prefix — for example, `$UPPERCASE`. To view the data assigned to the variable, we use `echo $UPPERCASE`, `print $UPPERCASE` for variables, or `cat $UPPERCASE`, if the variable is pointing to a file, as a command structure.

Command-Line Arguments

The command-line arguments `$1, $2, $3,...$9` are positional parameters, with `$0` pointing to the actual command, program, shell script, or function and `$1, $2, $3, ...$9` as the arguments to the command.

The positional parameters, `$0, $2,` and so on in a function are for the function's use and may not be in the environment of the shell script that is calling the function. Where a variable is known in a function or shell script is called the *scope* of the variable.

shift Command

The `shift` command is used to move positional parameters to the left; for example, `shift` causes `$2` to become `$1`. We can also add a number to the `shift` command to move the positions more than one position; for example, `shift 3` causes `$4` to move to the `$1` position.

Sometimes we encounter situations where we have an unknown or varying number of arguments passed to a shell script or function, `$1, $2, $3...` (also known as positional parameters). Using the `shift` command is a good way of processing each positional parameter in the order they are listed.

To further explain the `shift` command, we will show how to process an unknown number of arguments passed to the shell script shown in Listing 1-2. Try to follow through this example shell script structure. This script is using the `shift` command to process an unknown number of command-line arguments, or positional parameters. In this script we will refer to these as *tokens*.

```
#!/usr/bin/sh
#
# SCRIPT: shifting.sh
#
# AUTHOR: Randy Michael
#
# DATE:   12/30/2007
#
# REV:    1.1.A
#
# PLATFORM: Not platform dependent
#
# PURPOSE: This script is used to process all of the tokens which
# are pointed to by the command-line arguments, $1, $2, $3,etc...
#
# REV. LIST:
#

# Initialize all variables

TOTAL=0    # Initialize the TOTAL counter to zero

#  Start a while loop

while true
do
     TOTAL=`expr $TOTAL + 1`  # A little math in the
                              # shell script, a running
                              # total of tokens processed.
```

Listing 1-2 Example of using the shift command

```
    TOKEN=$1    # We always point to the $1 argument with a shift

                        process each $TOKEN

    shift           # Grab the next token, i.e. $2 becomes $1

done

echo "Total number of tokens processed: $TOTAL"
```

Listing 1-2 (*continued*)

We will go through similar examples of the `shift` command in great detail later in the book.

Special Parameters $* and $@

There are special parameters that allow accessing *all* the command-line arguments at once. `$*` and `$@` both will act the same unless they are enclosed in double quotes, `" "`.

Special Parameter Definitions

- The `$*` special parameter specifies *all* command-line arguments.
- The `$@` special parameter also specifies *all* command-line arguments.
- The `"$*"` special parameter takes the entire list as one argument with spaces between.
- The `"$@"` special parameter takes the entire list and separates it into separate arguments.

We can rewrite the shell script shown in Listing 1-2 to process an unknown number of command-line arguments with either the `$*` or `$@` special parameters, as shown in Listing 1-3.

```
#!/usr/bin/sh
#
# SCRIPT: shifting.sh
# AUTHOR: Randy Michael
# DATE:   12-31-2007
# REV:    1.1.A
# PLATFORM: Not platform dependent
#
```

Listing 1-3 Example using the special parameter `$*`

```
# PURPOSE: This script is used to process all of the tokens which
# Are pointed to by the command-line arguments, $1, $2, $3, etc... -
#
# REV LIST:
#
#

#  Start a for loop

for TOKEN in $*
do

         process each $TOKEN

done
```

Listing 1-3 (*continued*)

We could have also used the `$@` special parameter just as easily. As we see in the preceding code segment, the use of the `$@` or `$*` is an alternative solution to the same problem, and it was less code to write. Either technique accomplishes the same task.

Double Quotes, Forward Tics, and Back Tics

How do we know which one of these to use in our scripts, functions, and command statements? This decision causes the most confusion in writing scripts. We are going to set this straight now.

Depending on what the task is and the output desired, it is very important to use the correct enclosure. Failure to use these correctly will give unpredictable results.

We use `"`, double quotes, in a statement where we want to allow character or command substitution. Double quotes are required when defining a variable with data that contains white space, as shown here.

```
NAME="Randal K. Michael"
```

If the double quotes are missing we get the following error.

```
NAME=Randal K. Michael
-Bash: K.: command not found
```

We use `'`, forward tics (single quotes), in a statement where we do *not* want character or command substitution. Enclosing in `'`, forward tics, is intended to use the *literal text* in the variable or command statement, without any substitution. All special meanings and functions are removed. It is also used when you want a variable reread each time it is used; for example, `'$PWD'` is used a lot in processing the `PS1` command-line prompt. Additionally, preceding the same string with a backslash, `\`, also removes the special meaning of a character, or string.

We use `, back tics, in a statement where we want to execute a command, or script, and have its output substituted instead; this is *command substitution*. The ` key is located to the left of the **1** key, and below the Escape key, Esc, on most keyboards. Command substitution is also accomplished by using the `$(command)` command syntax. We are going to see many different examples of these throughout this book.

Using awk on Solaris

We use `awk` a lot in this book to parse through lines of text. There is one special case where, on Solaris, we must to use **nawk** instead. If we need to specify a field separator other than a blank space, which is the default field delimiter, using `awk -F :`, for example, the `awk` statement will fail on a Solaris machine. To get around this problem, use `nawk` if we find the UNIX flavor is Solaris. Add the following code segment to the variable declaration section of all your shell scripts to eliminate the problem:

```
# Setup the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) alias awk=nawk
       ;;
esac
```

Using the echo Command Correctly

We use the **echo** command to display text. The `echo` command allows a lot of cursor control using backslash operators: `\n` for a new line, `\c` to continue on the same line, `\b` to backspace the cursor, `\t` for a tab, `\r` for a carriage return, and `\v` to move vertically one line. In Korn shell the `echo` command recognizes these command options by default. In Bash shell we must add the `-e` switch to the `echo` command, `echo -e "\n"` for one new line.

We can query the system for the executing shell by querying the `$SHELL` shell variable in the script. Many Linux distributions will execute in a Bash shell even though we specify Korn shell on the very first line of the script. Because Bash shell requires the use of the `echo -e` switch to enable the backslash operators, we can use a `case` statement to *alias* the `echo` command to `echo -e` if the executing shell is `*/bin/Bash`. Now when we need to use the `echo` command, we are assured it will display text correctly.

Add the following code segment to all your Korn shell scripts in the variable declaration section, and this little problem is resolved:

```
# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.
```

```
case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac
```

Math in a Shell Script

We can do arithmetic in a shell script easily. The shell `let` command and the `((expr))` command expressions are the most commonly used methods to evaluate an integer expression. Later we will also cover the `bc` function to do floating-point arithmetic.

Operators

The shells use arithmetic operators from the C programming language (see Table 1-5), in decreasing order of precedence.

Table 1-5 Math Operators

OPERATOR	DESCRIPTION
`++ --` `</editor query>`	Auto-increment and auto-decrement, both prefix and postfix
`+`	Unary plus
`-`	Unary minus
`! ~`	Logical negation; binary inversion (one's complement)
`* / %`	Multiplication; division; modulus (remainder)
`+ –`	Addition; subtraction
`<< >>`	Bitwise left shift; bitwise right shift
`<= >=`	Less than or equal to; greater than or equal to
`< >`	Less than; greater than
`== !=`	Equality; inequality (both evaluated left to right)
`&`	Bitwise AND
`^`	Bitwise exclusive OR
`|`	Bitwise OR
`&&`	Logical AND
`||`	Logical OR

A lot of these math operators are used in the book, but not all. In this book we try to keep things very straightforward and not confuse you with obscure expressions.

Built-In Mathematical Functions

The shells provide access to the standard set of mathematical functions. They are called using C function call syntax. Table 1-6 shows a list of shell functions.

Table 1-6 Built-In Shell Functions

NAME	FUNCTION
`abs`	Absolute value
`log`	Natural logarithm
`acos`	Arc cosine
`sin`	Sine
`asin`	Arc sine
`sinh`	Hyperbolic sine
`cos`	Cosine
`sqrt`	Square root
`cosh`	Hyperbolic cosine
`tan`	Tangent
`exp`	Exponential function
`tanh`	Hyperbolic tangent
`int`	Integer part of floating-point number

We do not have any shell scripts in this book that use any of these built-in shell functions except for the `int` function to extract the integer portion of a floating-point number.

File Permissions, suid and sgid Programs

After writing a shell script we must remember to set the file permissions to make it *executable*. We use the `chmod` command to change the file's mode of operation. In addition to making the script executable, it is also possible to change the mode of the file to always execute as a particular user (`suid`) or to always execute as a member of a particular system group (`sgid`). This is called setting the *sticky bit*. If you try to `suid` or `sgid` a shell script, it is ignored for security reasons.

Setting a program to always execute as a particular user, or member of a certain group, is often used to allow all users, or a set of users, to run a program in the proper environment. As an example, most system-check programs need to run as an administrative user, sometimes `root`. We do not want to pass out passwords, so we can just make the program always execute as `root` and it makes everyone's life easier. We can use the options shown in Table 1-7 in setting file permissions. Also, please review the `chmod` man page, **man chmod**.

By using combinations from the `chmod` command options, you can set the permissions on a file or directory to anything that you want. Remember that setting a shell script to `suid` or `sgid` is ignored by the system.

Table 1-7 chmod Permission Options

`4000`	Sets user ID on execution
`2000`	Sets group ID on execution
`1000`	Sets the link permission to directories or sets the save-text attribute for files
`0400`	Permits read by owner
`0200`	Permits write by owner
`0100`	Permits execute or search by owner
`0040`	Permits read by group
`0020`	Permits write by group
`0010`	Permits execute or search by group
`0004`	Permits read by others
`0002`	Permits write by others
`0001`	Permits execute or search by others

chmod Command Syntax for Each Purpose

The `chmod` command can be used with the octal file permission representation or by r, w, x notation. Both of these examples produce the same result.

To Make a Script Executable

```
chmod 754 my_script.sh
```

or

```
chmod u+rwx,g+rx,o+r my_script.ksh
```

The owner can read, write, and execute. The group can read and execute. The world can read.

To Set a Program to Always Execute as the Owner

```
chmod 4755 my_program
```

The program will always execute as the owner of the file if it is not a shell script. The owner can read, write, and execute. The group can read and execute. The world can read and execute. So, no matter who executes this file, it will always execute as if the owner actually executed the program.

To Set a Program to Always Execute as a Member of the File Owner's Group

```
chmod 2755 my_program
```

The program will always execute as a member of the file's group, as long as the file is not a shell script. The owner of the file can read, write, and execute. The group can read and execute. The world can read and execute. So, no matter who executes this program, it will always execute as a member of the file's group.

To Set a Program to Always Execute as Both the File Owner and the File Owner's Group

```
chmod 6755 my_program
```

The program will always execute as the file's owner and as a member of the file owner's group, as long as the program is not a shell script. The owner of the file can read, write, and execute. The group can read and execute. The world can read and execute. No matter who executes this program, it will always execute as the file owner and as a member of the file owner's group.

Running Commands on a Remote Host

We sometimes want to execute a command on a remote host and have the result displayed locally. An example would be getting filesystem statistics from a group of machines. We can do this with the **rsh** command. The syntax is `rsh hostname command_to_execute`. This is a handy little tool but two system files will need to be set up on all of the hosts before the `rsh` command will work. The files are `.rhosts`, which would be created in the user's home directory and have the file permissions of 600 (permission to read and write by the owner only), and the `/etc/hosts.equiv` file.

For security reasons the `.rhosts` and `hosts.equiv` files, by default, are not set up to allow the execution of a remote shell. *Be careful*! The systems' security could be threatened. Refer to each operating system's documentation for details on setting up these files.

Speaking of security, a better solution is to use Open Secure Shell (OpenSSH) instead of `rsh`. OpenSSH is a freeware encrypted replacement for `rsh`, `telnet`, and `ftp`, for the most part. To execute a command on another machine using OpenSSH, use the following syntax:

```
ssh user@hostname command_to_execute
```

or

```
ssh -l user hostname command_to_execute
```

This command prompts you for a password if the encryption key pairs have not been set up. Setting up the key pair relationships manually usually takes a few minutes, or you can use one of the `keyit` scripts shown in Listings 1-4 and 1-5 to set up the keys for you. The details of the procedure are shown in the `ssh` manual page (**man ssh**). You can download the OpenSSH code from `http://www.openssh.org`.

The `keyit.dsa` script in Listing 1-4 will set up DSA keys, if the DSA keys exist.

```
#!/bin/Bash
#
# SCRIPT: keyit.dsa
# PURPOSE: This script is used to set up DSA SSH keys. This script must
#     be executed by the user who needs the keys setup.

REM_HOST=$1

cat $HOME/.ssh/id_dsa.pub | ssh $REM_HOST "cat >> ~/.ssh/authorized_keys"
```

Listing 1-4 keyit.dsa script used to set up DSA SSH keys

The `keyit.rsa` script in Listing 1-5 will set up the RSA keys, if the RSA keys exist.

```
#!/bin/Bash
#
# SCRIPT: keyit.rsa
# PURPOSE: This script is used to set up RSA SSH keys.
This script must be executed by the user who needs the keys setup.

REM_HOST=$1

cat $HOME/.ssh/id_rsa.pub | ssh $REM_HOST "cat >> ~/.ssh/authorized_keys"
```

Listing 1-5 keyit.rsa script used to set up RSA SSH keys

If you need to set up the encryption keys for a new user, first `su` to that user ID, and then issue one of the following commands.

To set up DSA keys issue this command:

```
ssh-keygen -t dsa
```

To set up RSA keys issue this one:

```
ssh-keygen -t rsa
```

Read the `ssh-keygen` man page for more details: **man ssh-keygen**.

Setting Traps

When a program is terminated before it would normally end, we can catch an exit signal. This is called a *trap*. Table 1-8 lists some of the exit signals.

Table 1-8 Exit Signals

0	–	Normal termination, end of script
1	`SIGHUP`	Hang up, line disconnected
2	`SIGINT`	Terminal interrupt, usually Ctrl + C
3	`SIGQUIT`	Quit key, child processes to die before terminating
9	`SIGKILL`	`kill -9` command, cannot trap this type of exit status
15	`SIGTERM`	`kill` command's default action
19	`SIGSTOP`	Stop, usually Ctrl + z

To see the entire list of supported signals for your operating system, enter the following command:

```
# kill -l     [That's kill -(ell)]
```

This is a really nice tool to use in our shell scripts. On catching a trapped signal we can execute some cleanup commands before we actually exit the shell script. Commands can be executed when a signal is trapped. If the following command statement is added in a shell script, it will print to the screen ''EXITING on a TRAPPED SIGNAL'' and then make a clean exit on the signals 1, 2, 3, and 15. We cannot `trap` a `kill -9`.

```
trap 'echo "\nEXITING on a TRAPPED SIGNAL";exit' 1 2 3 15
```

We can add all sorts of commands that may be needed to clean up before exiting. As an example, we may need to delete a set of files that the shell script created before we exit.

User-Information Commands

Sometimes we need to query the system for some information about users on the system.

who Command

The **who** command gives this output for each logged-in user: *username*, *tty*, *login time*, and *where* the user *logged in from*:

```
rmichael     pts/0          Mar 13 10:24          192.168.1.104
root         pts/1          Mar 15 10:43          (yogi)
```

w Command

The **w** command is really an extended `who`. The output looks like the following:

```
12:29PM    up 27 days,   21:53,2 users, load average  1.03,  1.17, 1.09
User       tty      login@         idle     JCPU  PCPU    what
rmichael   pts/0    Mon10AM 0      3:00     1             w
root       pts/1    10:42AM 37     5:12     5:12          tar
```

Notice that the top line of the preceding output is the same as the output of the **uptime** command. The `w` command gives a more detailed output than the `who` command by listing job process time and total user process time, but it does not reveal *where* the users have logged in *from*. We often are interested in this for security purposes. One nice thing about the `w` command's output is that it also lists *what* the users are doing at the instant the command `w` is entered. This can be very useful.

last Command

The **last** command shows the history of who has logged in to the system since the `wtmp` file was created. This is a good tool when you need to do a little investigation of who logged in to the system and when. The following is example output:

```
root      ftp     booboo            Aug 06 19:22 - 19:23  (00:01)
root      pts/3   mrranger          Aug 06 18:45   still logged in.
root      pts/2   mrranger          Aug 06 18:45   still logged in.
root      pts/1   mrranger          Aug 06 18:44   still logged in.
root      pts/0   mrranger          Aug 06 18:44   still logged in.
root      pts/0   mrranger          Aug 06 18:43 - 18:44  (00:01)
root      ftp     booboo            Aug 06 18:19 - 18:20  (00:00)
root      ftp     booboo            Aug 06 18:18 - 18:18  (00:00)
root      tty0                      Aug 06 18:06   still logged in.
root      tty0                      Aug 02 12:24 - 17:59 (4+05:34)
reboot    ~                         Aug 02 12:00
shutdown  tty0                      Jul 31 23:23
root      ftp     booboo            Jul 31 21:19 - 21:19  (00:00)
root      ftp     bambam            Jul 31 21:19 - 21:19  (00:00)
root      ftp     booboo            Jul 31 20:42 - 20:42  (00:00)
root      ftp     bambam            Jul 31 20:41 - 20:42  (00:00)
```

The output of the `last` command shows the username, the login port, where the user logged in from, the time of the login/logout, and the duration of the login session.

ps Command

The **ps** command will show information about current system processes. The `ps` command has many switches that will change what we look at. Table 1-9 lists some common command options.

Table 1-9 Common ps Command Options

`ps`	The user's currently running processes
`ps -f`	Full listing of the user's currently running processes
`ps -ef`	Full listing of all processes, except kernel processes
`ps -A`	All processes, including kernel processes
`ps -Kf`	Full listing of kernel processes
`ps auxw`	Wide listing sorted by percentage of CPU usage, `%CPU`

Communicating with Users

Communicate with the system's users and let them know what is going on! All Systems Administrators have the *maintenance window* where we can finally get control and handle some offline tasks. This is just one example of a need to communicate with the system users, if any are still logged in.

The most common way to get information to the system users is to use the `/etc/motd` file. This file is displayed each time the user logs in. If users stay logged in for days at a time they will not see any new messages of the day. This is one reason why real-time communication is needed. The commands shown in Table 1-10 allow communication to, or between, users who are currently logged into the system.

Table 1-10 Commands for Real-Time User Communication

`wall`	Writes a message on the screen of all logged-in users on the *local* host.
`rwall`	Writes a message on the screen of all logged-in users on a *remote* host.
`write`	Writes a message to an individual user. The user must currently be logged in.
`talk`	Starts an interactive program that allows two users to have a conversation. The screen is split in two, and both users can see what each person is typing.

NOTE When using these commands, be aware that if a user is using a program — for example, an accounting software package — and has that program's screen on the terminal, the user might not get the message or the user's screen may become scrambled.

Uppercase or Lowercase Text for Easy Testing

We often need to test text strings like filenames, variables, file text, and so on, for comparison. It can sometimes vary so widely that it is easier to uppercase or lowercase the text for ease of comparison. The **tr** and **typeset** commands can be used to uppercase and lowercase text. This makes testing for things like variable input a breeze. Following are some examples of using the `tr` command:

Variable values:

Expected input	`TRUE`
Real input	`TRUE`
Possible input	`true` `TRUE` `True` `True`, and so on

Upcasing:

```
UPCASEVAR=$(echo $VARIABLE | tr '[a-z]' '[A-Z]')
```

Downcasing:

```
DOWNCASEVAR=$(echo $VARIABLE | tr '[A-Z]' '[a-z]')
```

In the preceding example of the `tr` command, we `echo` the string and use a pipe (`|`) to send the output of the `echo` statement to the `tr` command. As the preceding examples show, uppercasing uses `'[a-z]' '[A-Z]'`.

NOTE The single quotes are required around the square brackets.

```
'[a-z]' '[A-Z]'     Used for lower to uppercase
'[A-Z]' '[a-z]'     Used for upper to lowercase
```

No matter what the user input is, we will always have the *stable* input of `TRUE`, if uppercased, and `true`, if lowercased. This reduces our code testing and also helps the readability of the script.

We can also use `typeset` to control the attributes of a variable in the shell. In the previous example we are using the variable `VARIABLE`. We can set the attribute to always translate all of the characters to uppercase or lowercase. To set the case attribute of the variable `VARIABLE` to always translate characters assigned to it to uppercase, we use

```
typeset -u VARIABLE
```

The `-u` switch to the `typeset` command is used for uppercase. After we set the attribute of the variable `VARIABLE`, using the `typeset` command, anytime we assign text characters to `VARIABLE` they are automatically translated to uppercase characters.

Example:

```
typeset  -u  VARIABLE
VARIABLE="True"
echo $VARIABLE

TRUE
```

To set the case attribute of the variable `VARIABLE` to always translate characters to lowercase, we use

```
typeset -l VARIABLE
```

Example:

```
typeset  -l  VARIABLE
VARIABLE="True"
echo $VARIABLE
true
```

Check the Return Code

Whenever we run a command there is a response back from the system about the last command that was executed, known as the *return code*. If the command was successful the return code will be `0`, zero. If it was *not* successful the return will be something other than `0`, zero. To check the return code we look at the value of the `$?` shell variable.

As an example, we want to check if the `/usr/local/bin` directory exists. Each of these blocks of code accomplishes the exact same thing:

```
test   -d   /usr/local/bin
if  [ "$?" -eq 0 ]  # Check the return code
then        # The return code is zero

     echo '/usr/local/bin does exist'

else          # The return code is NOT zero


     echo '/usr/local/bin does NOT exist'

fi
```

or

```
if  test  -d  /usr/local/bin
then          # The return code is zero

     echo '/usr/local/bin does exist'

else          # The return code is NOT zero

     echo '/usr/local/bin does NOT exist'
fi
```

or

```
if [ -d  /usr/local/bin ]
then          # The return code is zero

     echo '/usr/local/bin does exist'

else          # The return code is NOT zero

     echo '/usr/local/bin does NOT exist'
fi
```

Notice that we checked the return code using `$?` once. The other examples use the control structure's built-in test. The built-in tests do the same thing of processing the return code, but the built-in tests hide this step in the process. All three of the previous examples give the exact same result. This is just a matter of personal choice and readability.

Time-Based Script Execution

We write a lot of shell scripts that we want to execute on a timed interval or run once at a specific time. This section addresses these needs with several examples.

Cron Tables

A *cron table* is a system file that is read every minute by the system and will execute any entry that is scheduled to execute in that minute. By default, any user can create a cron table with the `crontab -e` command, but the Systems Administrator can control which users are allowed to create and edit cron tables with the `cron.allow` and `cron.deny` files. When a user creates his or her own cron table, the commands, programs, or scripts will execute in that user's environment. It is the same thing as running the user's `$HOME/.profile` before executing the command.

The `crontab -e` command starts the default text editor, `vi` or `emacs`, on the user's cron table.

NOTE **When using the `crontab` command, the current user ID is the cron table that is acted on. To list the contents of the current user's cron table, issue the `crontab -l` command.**

Cron Table Entry Syntax

It is important to know what each field in a cron table entry is used for. The following cron table entry executes the script, `/usr/local/bin/somescript.ksh`, at 3:15 a.m., January 8, on any day of the week that January 8 falls on. Notice that we used a *wildcard* for the weekday field.

```
_____________________________ Minute of the Hour (0-59)
|  _____________________________ Hour of the Day (0-23)
|  |  _____________________ Day of the Month (1-31)
|  |  |  _________________ Month of the Year (1-12)
|  |  |  |  __________ Day of the Week (0 - 6 for Sunday through Saturday)
|  |  |  |  |  __________ Command to Execute (Full path is required)
|  |  |  |  |  |
|  |  |  |  |  |
15 3  8  1  *  /usr/local/bin/somescript.Bash 2>&1 >/dev/null
```

The following cron table entry is another example:

```
0 0 1 1 *  /usr/bin/banner "Happy New Year" > /dev/console
```

At midnight on New Year's Eve, 00:00 hours on January 1, on any weekday, this cron table entry writes to the system's console (`/dev/console`) **Happy New Year** in large banner letters. Wildcard characters are defined in this table.

Wildcards:

`*`	Match any number of characters
`?`	Match a single character

at Command

Like a cron table, the **at** command executes commands based on time. Using the `at` command, we can schedule a job to run *once*, at a specific time. When the job is executed, the `at` command will send an email of the standard output and standard error to the user who scheduled the job to run, unless the output is redirected. As Systems Administrators we can control which users are allowed to schedule jobs with the `at.allow` and `at.deny` files. Refer to each operating system's man pages before modifying these files, and refer to them to learn the many ways to use the `at` command for timed controlled command execution. To execute a command in 10 minutes, use the following syntax:

```
echo '/usr/local/bin/somescript.Bash' | at now + 10 minutes
```

You can also use the `at` command interactively by typing the following:

```
at now + 10 minutes     Enter
```

Then type the full pathname of the command to execute, press Enter, and then press Ctrl+D. Here is an example:

```
at now + 10 minutes
/usr/local/bin/somescript.Bash
Ctrl+D
```

For more `at` command options, see the `at` command manual page, **man at**.

Output Control

How is the script going to run? Where will the output go? These questions come under output control.

Silent Running

To execute a script in *silent mode* we can use the following syntax:

```
/PATH/script_name 2>&1 > /dev/null
```

In this command statement the `script_name` shell script will execute without any output to the screen. The reason for this is that the command is terminated with the following:

```
2>&1 > /dev/null
```

By terminating a command like this it redirects standard error (`stderr`), specified by file descriptor 2, to standard output (`stdout`), specified by file descriptor 1. Then we have another redirection to `/dev/null`, which sends all of the output to the bit bucket.

We can call this *silent running*. This means that there is absolutely no output from the script going to our screen. Inside the script there may be some output directed to files or devices, a particular terminal, or even the system's console, `/dev/console`, but none to the user's screen. This is especially useful when executing a script from one of the system's cron tables.

In the following example cron table entry, we want to execute a script named `/usr/local/bin/systemcheck.ksh`, which needs to run as the `root` user, every 15 minutes, 24 hours a day, 7 days a week, and not have any output to the screen. There will not be any screen output because we are going to end the cron table entry with the following:

```
2>&1 > /dev/null
```

Inside the script it may do some kind of notification such as paging staff or sending output to the system's console, writing to a file or a tape device, but output such as `echo "Hello World"` would go to the *bit bucket*. But `echo "Hello World" > /dev/console` *would* go to the system's defined console if this command statement was within the shell script.

This cron table entry would need to be placed in the `root` cron table (must be logged in as the `root` user) with the following syntax:

```
5,20,35,50 * * * *  /usr/local/bin/systemcheck.ksh  2>&1 >/dev/null
```

NOTE **Most system check–type scripts need to be in the root cron table. Of course, a user must be logged in as root to edit root's cron table.**

The preceding cron table entry would execute the `/usr/local/bin/systemcheck.ksh` every 15 minutes, at 5, 20, 35, and 50 minutes, each hour, 24 hours a day, 7 days a week. It would not produce any output to the screen due to the final `2>&1 > /dev/null`. Of course, the minutes selected to execute can be any. We sometimes want to spread out execution times in the cron tables so that we don't have a lot of CPU-intensive scripts and programs starting execution at the same time.

Using getopts to Parse Command-Line Arguments

The `getopts` command is built into the shell. It retrieves valid command-line options specified by a single character preceded by a - (minus sign) or + (plus sign). To specify that a command switch requires an argument to the switch, it is followed by a `:` (colon). If the switch does not require any argument, the `:` should be omitted. All of the options put together are called the `OptionString`, and this is followed by some variable name. The argument for each switch is stored in a variable called `OPTARG`. If the entire `OptionString` is preceded by a `:` (colon), any unmatched switch option causes a `?` to be loaded into the `VARIABLE`. The form of the command follows:

```
getopts OptionString VARIABLE [ Argument ... ]
```

The easiest way to explain this is with an example. For a script we need seconds, minutes, hours, days, and a process to monitor. For each one of these we want to supply an argument — that is, `-s 5 -m10 -p my_backup`. In this we are specifying 5 seconds, 10 minutes, and the process is `my_backup`. Notice that there does not have to be a space between the switch and the argument, and they can be entered in any order. This is what makes `getopts` so great! The command line to set up our example looks like this:

```
SECS=0        # Initialize all to zero
MINUTES=0
HOURS=0
DAYS=0
PROCESS=      # Initialize to null
```

```
while getopts :s:m:h:d:p: TIMED 2>/dev/null
do
    case $TIMED in
       s) SECS=$OPTARG
          ;;
       m) (( MINUTES = $OPTARG * 60 ))
          ;;
       h) (( HOURS = $OPTARG * 3600 ))
          ;;
       d) (( DAYS = $OPTARG * 86400 ))
          ;;
       p) PROCESS=$OPTARG
          ;;
       \?) usage
           exit 1
           ;;
    esac
done

(( TOTAL_SECONDS = SECONDS + MINUTES + HOURS + DAYS ))
```

There are a few things to note in the `getopts` command. The `getopts` command needs to be part of a `while` loop with a `case` statement within the loop for this example. On each option we specified, `s`, `m`, `h`, `d`, and `p`, we added a `:` (colon) after each switch. This tells `getopts` that an argument is required. The `:` (colon) *before* the `OptionString` list tells `getopts` that if an unspecified option is given, to set the `TIMED` variable to the `?` character. This allows us to call the `usage` function and `exit` with a return code of `1`. The first thing to be careful of is that `getopts` does not care what arguments it receives, so we have to take action if we want to exit. The last thing to note is that the first line of the `while` loop has output redirection of standard error (file descriptor 2) to the bit bucket. Anytime an unexpected argument is encountered, `getopts` sends a message to standard error (file descriptor 2). Because we expect this to happen, we can just ignore the messages and discard them to `/dev/null`. We will study `getopts` a lot in this book.

Making a Co-Process with Background Function

We also need to cover setting up a co-process. A co-process is a communications link between a foreground and a background process. The most common question is *why* is this needed? In one of the scripts we are going to call a function that will handle all of the process monitoring for us while we do the timing control in the main script. The problem arises because *we need to run this function in the background and it has an infinite loop*. Within this background process-monitoring function there is an infinite loop. Without the ability to tell the loop to break out, it will continue to execute on its own after the main script, and function, is interrupted. We know what this causes — *one or more defunct processes*! From the main script we need a way to communicate with this loop, thus background function, to tell it to break out of the loop and exit the function cleanly when the countdown is complete and if the script is interrupted, `Ctrl+C`. To

solve this little problem we kick off our `proc_watch` function as a *co-process* in the background. How do we do this, you ask? *"Pipe it to the background"* is the simplest way to put it, and that is what it looks like, too. Look at the next example code block in Listing 1-6.

```
############################
function trap_exit
{
     # Tell the co-process to break out of the loop
     BREAK_OUT='Y'
     print -p $BREAK_OUT   # Use "print -p" to talk to the co-process
}
############################
function proc_watch
{
# This function is started as a co-process!!!

    while :      # Loop forever
    do
          Some Code Here

          read $BREAK_OUT  # Do NOT need a "-p" to read!
          if [[ $BREAK_OUT = 'Y' ]]
          then
               return 0
          fi
    done
}

############################
##### Start of Main ########
############################

### Set a Trap ###

trap 'trap_exit; exit 2' 1 2 3 15

TOTAL_SECONDS=300
BREAK_OUT='N'

proc_watch |&       # Start proc_watch as a co-process!!!!

PW_PID=$1           # Process ID of the last background job

until (( TOTAL_SECONDS == 0 ))
do
     (( TOTAL_SECONDs = TOTAL_SECONDS - 1 ))
```

Listing 1-6 Example code using a co-process

```
     sleep 1
done

BREAK_OUT='Y'

# Use "print -p" to communicate with the co-process variable

print -p $BREAK_OUT

kill $PW_PID     # Kill the background co-process

exit 0
```

Listing 1-6 (*continued*)

In the code segment in Listing 1-6, we defined two functions. The `trap_exit` function will execute on `exit` signals 1, 2, 3, and 15. The other function is the `proc_watch` function, which is the function that we want to start as a background process. As you can see in `proc_watch`, it has an infinite loop. If the main script is interrupted without a means to exit the loop, within the function the loop *alone* will continue to execute! To solve this we start the `proc_watch` as a co-process by ''piping it to the background'' using *pipe ampersand*, `|&`, as a suffix. Then when we want to communicate to this co-process background function we use `print -p $VARIABLE_NAME`. Inside the co-process function we just use the standard `read $VARIABLE_NAME`. This is the mechanism that we are going to use to break out of the loop if the main script is interrupted on a trapped signal; of course, we *cannot* catch a `kill -9` with a trap.

Try setting up the scenario described previously with a background function that has an infinite loop. Then press the Ctrl+C key sequence to kill the main script, and do a `ps -ef | more`. You will see that the background *loop* is still executing! Get the PID, and do a `kill -9` on that PID to kill it. Of course, if the loop's exit criteria is ever met, the loop will exit on its own.

Catching a Delayed Command Output

Have you ever had a hard time trying to catch the output of a command that has a delayed output? This can cause a lot of frustration when you *just miss it*! There is a little technique that allows you to catch these delayed responses. The trick is to use an `until` loop. Look at the code shown here:

```
OUTFILE="/tmp/outfile.out"   # Define the output file
cat /dev/null > $OUTFILE     # Create a zero size output file

# Start an until loop to catch the delayed response
```

```
until [ -s $OUTFILE ]
do
     delayed_output_command >> $OUTFILE
done

# Show the resulting output

more $OUTFILE
```

This code segment first defines an output file to store the delayed output data. We start with a zero-sized file and then enter an `until` loop that will continue `until` the `$OUTFILE` is no longer a zero-sized file, and the `until` loop exits. The last step is to show the user the data that was captured from the delayed output.

Fastest Ways to Process a File Line-by-Line

Most shell scripts work with files, and some use a file for data input. This next section shows the fastest methods studied in Chapter 2, ''24 Ways to Process a File Line-by-Line.'' The two fastest techniques for processing a file line-by-line are shown in Listings 1-7 and 1-8.

```
function while_read_LINE_bottom_FD_OUT
{

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 1-7 Method 12 tied for first place

The method in Listing 1-7 is tied for first place. This method uses my favorite input redirection for files by redirecting input at the bottom of the loop, after the `done` loop terminator. This method does use a file descriptor for redirecting standard output, `stdout`, to file descriptor 1.

The input redirection using `done < $INFILE` greatly speeds up any loop that requires file input. The nice thing about this method of input redirection is that it is intuitive to use for beginners to shell scripting. I was actually surprised that this method tied, actually won by 10 mS, using file descriptors for both input and output files, as shown in Listing 1-8.

```
function while_read_LINE_FD_IN_AND_OUT
{
# Method 22

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


while read LINE
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 1-8 Method 22 tied for first place

I tend not to use the method in Listing 1-8 when I write shell scripts, because it can be difficult to maintain through the code life cycle. If a user is not familiar with using file descriptors, a script using this method is extremely hard to understand. The method in Listing 1-7 produces the same timing results, and it is much easier to understand. Listing 1-9 shows the second-place loop method.

```
for_LINE_cat_FILE_cmdsub2_FD_OUT ()
{
# Method 16

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 1-9 Method 16 made second place in timing tests

The method shown in Listing 1-10 is another surprise: a `for` loop using command substitution with file descriptor file output redirection.

```
for_LINE_cat_FILE_FD_OUT ()
{
# Method 15

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE
```

Listing 1-10 Method 15 made third place in timing tests

```
exec 4<&1
exec 1> $OUTFILE


for LINE in `cat $INFILE`
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 1-10 (*continued*)

The method in Listing 1-11 is the fastest method to process a file line-by-line that does not use file descriptors.

```
function while_read_LINE_bottom
{
# Method 2

# Zero out the $OUTFILE

>$OUTFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 1-11 The fastest method not using file descriptors

I use this technique in almost every shell script that does file parsing, simply because of the ease of maintaining the shell script throughout the life cycle.

Using Command Output in a Loop

The technique shown here is a nice little trick to execute a command and use the command's output in a loop without using a pipe:

```
while read LINE
do
    echo "$LINE"

done <  <(command)
```

I know this looks a bit odd. I got this trick from one of my co-workers, Brian Beers. What we are doing here is input redirection from the bottom of the loop, after the `done` loop terminator, specified by the `done <` notation. The `< (command)` notation executes the command and points the command's output into the bottom of the loop.

NOTE **The space between < < in < <(command) is required!**

Mail Notification Techniques

In a lot of the shell scripts in this book it is a good idea to send notifications to users when errors occur, when a task is finished, and for many other reasons. Some of the email techniques are shown in this section.

Using the mail and mailx Commands

The most common notification method uses the **mail** and **mailx** commands. The basic syntax of both these commands is shown in Listing 1-12.

```
mail -s "This is the subject" $MAILOUT_LIST < $MAIL_FILE

or

cat $MAIL_FILE | mail -s "This is the subject" $MAILOUT_LIST

or

mailx -s "This is the subject" $MAILOUT_LIST < $MAIL_FILE

or

cat $MAIL_FILE | mailx -s "This is the subject" $MAILOUT_LIST
```

Listing 1-12 Examples using the mail and mailx commands

Not all systems support the `mailx` command, but the systems that do have support use the same syntax as the `mail` command. To be safe when dealing with multiple UNIX platforms, always use the `mail` command.

Using the sendmail Command to Send Outbound Mail

In one shop I worked at I could not send outbound mail from the user named root. The *from* field had to be a valid email address that was recognized by the mail server,

and `root` is not valid. To get around this little problem I changed the command that I used from `mail` to `sendmail`. The `sendmail` command allows us to add the `-f` switch to indicate a valid internal email address for the *from* field. The `sendmail` command is in `/usr/sbin/sendmail` on AIX, HP-UX, Linux, and OpenBSD, but on SunOS the location changed to `/usr/lib/sendmail`. Look at the `send_notification` function in Listing 1-13.

```
function send_notification
{
if [ -s $MAIL_FILE -a  "$MAILOUT" = "TRUE" ];
then
        case $(uname) in
        AIX|HP-UX|Linux|OpenBSD) SENDMAIL="/usr/sbin/sendmail"
                         ;;
        SunOS)           SENDMAIL="/usr/lib/sendmail"
                         ;;
        esac

        echo "\nSending email notification"
        $SENDMAIL -f randy@$THISHOST $MAIL_LIST < $MAIL_FILE
fi
}
```

Listing 1-13 send_notification function

The `mail` and `mailx` commands also support specifying a from field by using the `-r` switch, as shown in Listing 1-14.

```
mail -r randy@$THISHOST -s "This is the subject" \
$MAILOUT_LIST < $MAIL_FILE

or

cat $MAIL_FILE | mail -r randy@$THISHOST -s
"This is the subject" $MAILOUT_LIST

or

mailx -r randy@$THISHOST -s "This is the subject"
$MAILOUT_LIST < $MAIL_FILE

or

cat $MAIL_FILE | mailx -r randy@$THISHOST -s
"This is the subject" $MAILOUT_LIST
```

Listing 1-14 Specifying a from field with mail and mailx

Both techniques should allow you to get the message out quickly.

Creating a Progress Indicator

Anytime that a user is forced to wait as a long process runs, it is an excellent idea to give the user some feedback. This section deals with progress indicators.

A Series of Dots

The `echo` command prints a single dot on the screen, and the backslash `c`, `\c`, specifies a continuation on the same line without a new line or carriage return. To make a series of dots we will put this single command in a loop, with some sleep time between each dot. We will use a `while` loop that loops forever with a 10-second sleep between printing each dot on the screen:

```
while true
do
     echo ".\c"
     sleep 10
done
```

A Rotating Line

The `rotate_line` function, shown in Listing 1-15, shows what appears to be a rotating line as the process runs.

```
function rotate_line
{
INTERVAL=1     # Sleep time between "twirls"
TCOUNT="0"     # For each TCOUNT the line twirls one increment

while :        # Loop forever...until this function is killed
do
     TCOUNT=`expr $TCOUNT + 1`   # Increment the TCOUNT

     case $TCOUNT in
          "1") echo '-'"\b\c"
               sleep $INTERVAL
               ;;
          "2") echo '\\'"\b\c"
               sleep $INTERVAL
               ;;
          "3") echo "|\b\c"
               sleep $INTERVAL
               ;;
```

Listing 1-15 rotate_line function

```
          "4") echo "/\b\c"
               sleep $INTERVAL
               ;;
          *)     TCOUNT="0" ;;  # Reset the TCOUNT to "0", zero.
     esac
done
}
```

Listing 1-15 (*continued*)

To use `rotate_line` in a shell script, use the technique shown in Listing 1-16 to start and stop the rotation.

```
#######################################
######## Beginning of Main ############
#######################################

rotate_line &   # Run the function in the background

ROTATE_PID=$!   # Capture the PID of the last background process

/usr/local/bin/my_time_consuming_task.ksh

# Stop the rotating line function

kill -9 $ROTATE_PID

# Cleanup...this removes the left over line.

echo "\b\b  "
```

Listing 1-16 Using rotate_line in a shell script

Elapsed Time

The `elapsed_time` function requires as input the number of seconds, and produces as output the time represented in hours, minutes, and seconds. Listing 1-17 shows the `elapsed_time` function.

```
elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && echo "[Elapsed time: $SEC seconds]\c"
```

Listing 1-17 elapsed_time function

```
(( SEC >= 60  &&  SEC < 3600 )) && echo "[Elapsed time: $(( SEC / 60 )) \
min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && echo "[Elapsed time: $(( SEC / 3600 )) hr \
$(( (SEC % 3600) / 60 )) min $(( (SEC % 3600) % 60 )) sec]\c"
}
```

Listing 1-17 (*continued*)

An example using the `elapsed_time` function follows:

```
elapsed_time 6465
[Elapsed time: 1 hr 47 min 45 sec]
```

Note that the `elapsed_time` function continues on the same line of text without a new line. To add a new line, change the ending `\c` to `\n` on each of the three `echo` commands.

Working with Record Files

We often want to add a filename to each record in a record file. The code shown in Listing 1-18 shows a merge process where we loop through a list of record filenames and, as we append each record file to build the big batch-processing file, we append the record filename to each record. Check out Listing 1-18, and we will cover the details at the end.

```
MERGERECORDFILE=/data/mergerecord.$(date +%m%d%y)
RECORDFILELIST=/data/branch_records.lst

while read RECORDFILENAME
do

    sed s/$/$(basename $RECORDFILENAME)/g \
$RECORDFILENAME >> $MERGERECORDFILE

done  < $RECORDFILELIST
```

Listing 1-18 Code for a merge process for fixed-length record files

Listing 1-18 is a merge script for fixed-length record files. We first define a couple of files. The `MERGERECORDFILE` variable definition specifies the name of the resulting merged record data file. The `RECORDFILELIST` variable defines the file that contains a list of record files that must be merged. Notice the use of the `basename` command to strip the directory part of the `$RECORDFILENAME` on each loop iteration. As we feed the `while` loop from the bottom, after `done`, to process the `$RECORDFILELIST`

file line-by-line, we assign a new record file to the RECORDFILENAME variable. We use this new value in our sed statement that appends the record filename to the end of each record in the file. As the last step, this record file is appended to the end of the $MERGERECORDFILE file. Listing 1-19 shows the same technique working with variable-length record files.

```
MERGERECORDFILE=/data/mergerecord.$(date +%m%d%y)
RECORDFILELIST=/data/branch_records.lst
FD=:

while read RECORDFILENAME
do

sed s/$/${FD}$(basename $RECORDFILENAME)/g \
$RECORDFILENAME >> $MERGERECORDFILE

done  < $RECORDFILELIST
```

Listing 1-19 Code for a merge process for variable-length record files

Listing 1-19 is a merge script for variable-length record files. The only difference between this script and Listing 1-18 is that we added the field delimiter variable, FD. We define the field delimiter and then add the field delimiter between the end of the record and the record filename.

Working with Strings

A useful thing to know when working with fixed-length record files is the string length. The length of a string assigned to a variable can be found using the following syntax:

```
echo ${#VAR}
```

For example, if I assign the VAR variable the string 1234567890, the string length should be 10:

```
VAR=1234567890
echo ${#VAR}
10
```

We sometimes need the string length for fixed-length records to pad the extra space in a data field that the data does not fill up. As an example, the TOTAL field is defined as characters 46–70, which is 25 characters long. It is unlikely that anyone would ever owe that kind of cash, but that is the data field we have to work with. This field is right-justified and filled with leading zeros, as shown here:

```
0000000000000000000009825
```

If we change a record field and the data is not as long as the data field, we need to pad the rest of the data field with something — in this case, zeros. The hard way to pad the data with leading zeros is to check the original data for the string length, and then get the string length of the new data and start looping to add the correct number of leading zeros followed by the new data. It is so much easier to do this task with the `typeset` command. The `-Z` switch specifies right justification with leading zeros. Well, that's just what we need here. Our `TOTAL` variable is 25 characters long. The following `typeset` command makes this definition for us:

```
typeset -Z25 TOTAL
```

Now we can change the `TOTAL` data field to a different value and not worry about how many leading zeros to add. As an example, let's change the total to `0` — we paid this bill off!

```
TOTAL=0
echo $TOTAL
0000000000000000000000000
```

The `typeset` command can do a lot of the work for us. Table 1-11 shows more `typeset` options you might find handy.

Table 1-11 Options for the typeset Command

SWITCH	RESULTING TYPESET
`-L`	Left-justify and remove blank spaces.
`-R`	Right-justify and fill with leading blanks.
`-Zn`	Right-justify to *n* length and fill with leading zeros if the first non-blank character is a digit.
`-i`	Variable is an integer.
`-l`	Convert uppercase characters to lowercase characters.
`-u`	Convert lowercase characters to uppercase characters.
`-x`	Automatically export this variable.

NOTE **Using + instead of - turns off the `typeset` definition.**

Creating a Pseudo-Random Number

There is a built-in shell variable that will create a pseudo-random number called `RANDOM`. The following code segment creates a pseudo-random number between 1 and an upper limit defined by the user:

```
RANDOM=$$      # Initialize the seed to the PID of the script
UPPER_LIMIT=$1

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

echo "$RANDOM_NUMBER"
```

If the user specified the `UPPER_LIMIT` to be 100, the result would be a pseudo-random number between 1 and 100.

Using /dev/random and /dev/urandom

We can also use the `/dev/random` and `/dev/urandom` character special files to produce pseudo-random numbers. Trying to read the `/dev/random` and `/dev/urandom` character special files directly with `dd` returns non-printable binary data. To get some usable random numbers, we need to pipe the `dd` command output to the `od`, octal dump, command. Specifically, we use `od` to dump the data to an unsigned integer. The code shown in Listing 1-20 assigns an unsigned random integer to the `RN` variable.

```
RN=$(dd if=/dev/random count=1 2>/dev/null \
    | od -t u4 | awk '{print $2}'| head -n 1)
```

Listing 1-20 Using /dev/random to return a random number

Notice in Listing 1-20 that the `dd` command uses `/dev/random` as the input file. We set the `count` equal to `1` to return one byte of data. Then, *and this is important*, we send all the standard error output, specified by file descriptor 2, to the bit bucket. If we omit the `2 > /dev/null` redirection, we get unwanted data. The remaining standard output is piped to the `od` command to convert the binary data to an unsigned integer, specified by the `-t u4` command switch. By changing the value assigned to `u`, we change the length of the random number returned. To create a 64-bit, not 64-character, random number, we just change the `-t u4` to `-t u8`. More examples are in Chapter 11, ''Pseudo-Random Number and Data Generation.''

Checking for Stale Disk Partitions in AIX

Ideally, we want the stale disk partition value to be zero, 0. If the value is greater than zero we have a problem. Specifically, the mirrored disks in this Logical Volume are not in sync, which translates to a worthless mirror. Take a look at the following command statement:

```
LV=apps_lv

NUM_STALE_PP=$(lslv -L $LV | grep "STALE PP" | awk '{print $3}'
```

This statement saves the number of stale PPs into the `NUM_STALE_PP` variable. We accomplish this feat by command substitution, specified by the `VARIABLE=$( commands )` notation.

Automated Host Pinging

Depending on the operating system that you are running, the `ping` command varies if you want to send three pings to each host to see if the machines are up. The `ping_host` function shown in Listing 1-21 can `ping` from AIX, HP-UX, Linux, OpenBSD, and SunOS machines.

```
function ping_host
{
HOST=$1 # Grab the host to ping from ARG1.
PING_COUNT=3
PACKET_SIZE=54

# This next case statement executes the correct ping
# command based on the Unix flavor

case $(uname) in

AIX|OpenBSD|Linux)
           ping -c${PING_COUNT} $HOST 2>/dev/null
           ;;
HP-UX)
           ping $HOST $PACKET_SIZE $PING_COUNT 2>/dev/null
           ;;
SunOS)
           ping -s $HOST $PACKET_SIZE $PING_COUNT 2>/dev/null
           ;;
*)
           echo "\nERROR: Unsupported Operating System - $(uname)"
           echo "\n\t...EXITING...\n"
           exit 1
esac
}
```

Listing 1-21 ping_host function

The main body of the shell script must supply the hostname to ping. This is usually done with a `while` loop.

Highlighting Specific Text in a File

The technique shown here highlights specific text in a file with reverse video while displaying the entire file. To add in the reverse video piece, we have to do some

command substitution within the `sed` statement using the `tput` commands. Where we specify the `new_string`, we will add in the control for reverse video using command substitution, one to turn highlighting on and one to turn it back off. When the command substitution is added, our `sed` statement will look like the following:

```
sed s/string/$(tput smso)string$(tput rmso)/g
```

We also want the string to be assigned to a variable, as in the next command:

```
sed s/"$STRING"/$(tput smso)"$STRING"$(tput rmso)/g
```

Notice the double quotes around the string variable, `"$STRING"`. Do not forget to add the double quotes around variables!

As an experiment using command substitution, try this next command statement to highlight the machine's hostname in the `/etc/hosts` file on any UNIX machine:

```
cat /etc/hosts | sed s/'hostname'/$(tput smso)'hostname'$(tput rmso)/g
```

Keeping the Printers Printing

Keeping the printers enabled in a large shop can sometimes be overwhelming. There are two techniques to keep the printers printing. One technique is for the AIX ''classic'' printer subsystem, and the other is for System V and CUPS printing.

AIX "Classic" Printer Subsystem

To keep AIX ''classic'' printer subsystem print queues running, use either of the following commands:

```
enable $(enq -AW | tail +3 | grep DOWN | awk '{print $1}') 2>/dev/null
```

or

```
enable $(lpstat -W | tail +3 | grep DOWN | awk '{print $1}') 2>/dev/null
```

System V and CUPS Printing

To keep System V and CUPS printers printing any of the following commands:

```
lpc enable $(lpstat -a | grep 'not accepting' | awk '{print $1}')

lpc start $( lpstat -p | grep disabled | awk '{print $2}')

lpc up all        # Enable all printing and queuing
```

It is a good idea to use the `root` cron table to execute the appropriate command every 15 minutes or so.

Automated FTP File Transfer

You can use a here document to script an FTP file transfer. The basic idea is shown here:

```
ftp -i -v -n wilma <<END_FTP

user randy mypassword
binary
lcd /scripts/download
cd /scripts
get auto_ftp_xfer.ksh
bye

END_FTP
```

Using rsync to Replicate Data

We use `rsync` much the same way that we use `rcp` and `scp`. All three methods require a source and destination file or directory, and there are command-line switches that allow us to save file permissions, links, ownership, and so on, as well as to copy directory structures recursively. A few examples are the best way to learn how to use `rsync`. Let's start with this simple `rsync` statement:

```
rsync  myscript.Bash  yogi:/scripts/
```

This would transfer the file `myscript.Bash` from the current directory on the local machine to the `/scripts` directory on the `yogi` server. Now, if the `myscript.Bash` file already exists on the server `yogi`, in the `/scripts` directory, then the *rsync remote-update protocol* is used to update the file by sending only the differences between the source and destination files:

```
rsync -avz yogi:/scripts/data /scripts/tmp
```

This `rsync` statement will recursively transfer all the files and directories in the `/scripts/data` directory on the `yogi` machine to the `/scripts/tmp` directory on the local machine. The `-a rsync` switch specifies *archive mode*, which preserves the permissions, ownerships, symbolic links, attributes, and so on, and specifies a recursive copy in the transfer. The `-z rsync` switch specifies compression is to be used in the transfer to reduce the amount of data in the transfer. Note that this example will create a new directory on the local machine `/scripts/tmp/data`. The `-v rsync` switch specifies verbose mode.

```
rsync -avz yogi:/scripts/data/ /scripts/tmp
```

Notice the trailing slash on the source: `yogi:/scripts/data/`

This trailing slash changes the behavior of `rsync` to eliminate creating the additional directory on the destination, as the previous example produced: `/scripts/tmp/data`. The trailing slash on the *source* side tells `rsync` to *copy the directory contents*, as opposed to *copy the directory name and all of its contents*.

```
rsync -avz /scripts/data /scripts/tmp
rsync -avz /scripts/data/ /scripts/tmp
```

As you can see by these two examples, we can copy files locally as well as remotely. Notice that local file copying does not have a hostname specified by the `hostname:` notation.

Simple Generic rsync Shell Script

A simple generic shell script for `rsync` consists only of defining some variables to point to the file/directory we want to copy, and a one-line `rsync` statement. Check out Listing 1-22 and we will cover the details at the end.

```
#!/bin/Bash
#
# SCRIPT: generic_rsync.Bash
# AUTHOR: Randy Michael
# DATE: 11/18/2007
# REV: 1.0
# PURPOSE: This is a generic shell script to copy files
#          using rsync.
#
# set -n # Uncomment to check script syntax without execution
# set -x # Uncomment to debug this script
#
# REV LIST:
#
#
################################################
# DEFINE FILES AND VARIABLES HERE
################################################

# Define the source and destination files/directories

SOURCE_FL="/scripts/"
DESTIN_FL="booboo:/scripts"

################################################
# BEGINNING OF MAIN
################################################

# Start the rsync copy
```

Listing 1-22 generic_rsync.Bash script

```
rsync -avz "$SOURCE_FL" "$DESTIN_FL"

# End of generic_rsync.Bash
```

Listing 1-22 (*continued*)

As you can see, there is not much to this shell script. We define the source and destination files/directories to the `SOURCE_FL` and `DESTIN_FL` variables, respectively. Next we use these variables in our `rsync` statement:

```
rsync -avz "$SOURCE_FL" "$DESTIN_FL"
```

This `rsync` command will recursively transfer all the files and subdirectories in the local `/scripts/` directory (notice the trailing slash on the source) to the `/scripts` directory on the `booboo` server using compression to reduce the amount of data transferred. Notice that the trailing slash avoided creating a second `scripts` directory on the destination: `/scripts/scripts/`.

Capturing a List of Files Larger than $MEG

Who filled up that filesystem? If you want to look quickly for large files, use the following syntax:

```
# Search for files > $MEG_BYTES starting at the $SEARCH_PATH
#
HOLD_FILE=/tmp/largefiles.list
MEG_BYTES=$1
SEARCH_PATH=$(pwd)  # Use the current directory

find $SEARCH_PATH -type f -size +${MEG_BYTES}000000c -print > $HOLDFILE
```

Note that in the `find` command after the `-size` parameter there is a plus sign (`+`) preceding the file size, and there is a `c` added as a suffix. This combination specifies files larger than `$MEG_BYTES` measured in bytes, as opposed to blocks.

Capturing a User's Keystrokes

In most large shops there is a need, at least occasionally, to monitor a user's actions. You may even want to audit the keystrokes of anyone with `root` access to the system or other administration-type accounts, such as `oracle`. Contractors onsite can pose a particular security risk. Typically when a new application comes into the environment, one or two contractors are onsite for a period of time for installation, troubleshooting, and training personnel on the product.

The code shown in Listing 1-23 uses the `script` command to capture all the keystrokes.

```
TS=$(date +%m%d%y%H%M%S)            # File time stamp
THISHOST=$(hostname|cut -f1-2 -d.) # Host name of this machine
LOGDIR=/usr/local/logs/script      # Directory to hold the logs
LOGFILE=${THISHOST}.${LOGNAME}.$TS # Creates the name of the log file
touch $LOGDIR/$LOGFILE             # Creates the actual file

# Set the command prompt
export PS1="[$LOGNAME:$THISHOST]@"'$PWD> '

#################### RUN IT HERE ##########################

chown  $LOGNAME ${LOGDIR}/${LOGFILE} # Let the user own the log file
                                     # while the script executes
chmod 600 ${LOGDIR}/${LOGFILE}    # Change permission to RW for the owner


script ${LOGDIR}/${LOGFILE}        # Start the script monitoring session

chown root ${LOGDIR}/${LOGFILE}    # Change the ownership to root
chmod 400 ${LOGDIR}/${LOGFILE}     # Set permission to read-only by root
```

Listing 1-23 Capturing a user's keystrokes

Using the bc Utility for Floating-Point Math

On UNIX machines there is a utility called `bc` that is an interpreter for arbitrary-precision arithmetic language. The `bc` command is an interactive program that provides arbitrary-precision arithmetic. You can start an interactive `bc` session by typing `bc` on the command line. Once in the session you can enter most complex arithmetic expressions as you would in a calculator.

The code segment shown in Listing 1-24 creates the mathematical expression for the `bc` utility and then uses a here document to load the expression into `bc`.

```
# Loop through each number and build a math statement that
# will add all of the numbers together.

for X in $NUM_LIST
do
      ADD="$ADD $PLUS $X"
      PLUS="+"
done

#########################################################

# Do the math here by using a here document to supply
```

Listing 1-24 Example of using bc in a shell script

```
# input to the bc command. The sum of the numbers is
# assigned to the SUM variable.

SUM=$(bc <<EOF
scale=$SCALE
(${ADD})
EOF)
```

Listing 1-24 (*continued*)

This is about as simple as `bc` gets. This is just a taste. Look for more later in the book.

Number Base Conversions

There are a lot of occasions when we need to convert numbers between bases. The code that follows shows some examples of how to change the base.

Using the typeset Command

Using the `typeset` command is valid up to base 36.

```
Convert a base 10 number to base 16

# typeset -i16 BASE_16_NUM
# BASE_16_NUM=47295
# echo $BASE_16_NUM

16#b8bf

Convert a base 8 number to base 16

[root@yogi:/scripts]> typeset -i16 BASE_16_NUM
[root@yogi:/scripts]> BASE_16_NUM=8#472521
[root@yogi:/scripts]> echo $BASE_16_NUM

16#735c9
```

Using the printf Command

We can use the `printf` command to convert base-10 numbers to octal and hexadecimal notation, as shown here:

```
Convert a base 10 number to base 8

# printf %o 20398

47656
```

```
Convert a base 10 number to base 16

# printf %x 20398

4fae
```

We can display a number in exponential notation with the `printf` command with the following syntax:

```
# printf %e 20398

2.039800e+04
```

Create a Menu with the select Command

There are many times when you just need to provide a menu for the end user to select from, and this is where a `select` statement comes in. The menu prompt is assigned to the `PS3` system variable, and the `select` statement is used a lot like a `for` loop. A `case` statement is used to specify the action to take on each selection.

```
#!/bin/Bash
#
# SCRIPT: select_system_info_menu.Bash
# AUTHOR: Randy Michael
# DATE: 1/17/2008
# REV: 1.0
#
# PURPOSE: This shell script uses the shell's select
# command to create a menu to show system information

# Clear the screen
clear

# Display the menu title header
echo -e "\n\tSYSTEM INFORMATION MENU\n"

# Define the menu prompt

PS3="Select an option and press Enter: "

# The select command defines what the menu
# will look like

select i in OS Host Filesystems Date Users Quit
do
   case $i in
```

```
        OS)     echo
                uname
                ;;
        Host)   echo
                hostname
                ;;
        Filesystems)
                echo
                df -k | more
                ;;
        Date)   echo
                date
                ;;
        Users)  echo
                who
                ;;
        Quit)   break
                ;;
    esac

    # Setting the select command's REPLY variable
    # to NULL causes the menu to be redisplayed

    REPLY=

    # Pause before redisplaying the menu

    echo -e "\nPress Enter to Continue...\c"
    read

    # Ready to redisplay the menu again

    # clear the screen

    clear

    # Display the menu title header

    echo -e "\n\tSYSTEM INFORMATION MENU\n"

done

# Clear the screen before exiting

clear
```

Notice in this code segment the use of the `select` statement. This looks just like a `for` loop with a list of possible values. Next is an embedded `case` statement that allows us to specify the action to take when each selection is made.

The output of this simple menu is shown here:

```
        SYSTEM INFORMATION MENU

1) OS           3) Filesystems  5) Users
2) Host         4) Date         6) Quit
Select an option and press Enter: 1

Linux

Press Enter to Continue...
```

Removing Repeated Lines in a File

The `uniq` command is used to report and remove repeated lines in a file. This is a valuable tool for a lot of scripting and testing.

If you have a file that has repeated lines named `my_list` and you want to save the list without the repeated lines in a file called `my_list_no_repeats`, use the following command:

```
# uniq my_list my_list_no_repeats
```

If you want to see a file's output without repeated lines, use the following command:

```
# cat repeat_file | uniq
```

Removing Blank Lines from a File

The easiest way to remove blank lines from a file is to use a `sed` statement. The following syntax removes the blank lines:

```
# cat my_file | sed /^$/d
```

or

```
# sed /^$/d my_file
```

Testing for a Null Variable

Variables that have nothing assigned to them are sometimes hard to deal with. The following test will ensure that a variable is either Null or has a value assigned to it. The double quotes are very important and must be used!

```
VAL=   # Creates a NULL variable

if [[ -z "$VAL" && "$VAL" = '' ]]
then
     echo "The VAL variable is NULL"
fi
```

or

```
VAL=25

if [[ ! -z "$VAL" && "$VAL" != '' ]]
then
     echo "The VAL variable is NOT NULL"
fi
```

Directly Access the Value of the Last Positional Parameter, $#

To access the value of the `$#` positional parameter directly, use the following regular expression:

```
eval '$'$#
```

or

```
eval \$$#
```

There are a lot of uses for this technique, as you will see later in this book.

Remove the Column Headings in a Command Output

There are many instances when we want to get rid of the column headings in a command's output. A lot of people try to use `grep -v` to pattern-match on something unique in the heading. A much easier and more reliable method is to use the `tail` command. An example is shown here with the `df` command output:

```
[root:yogi]@/scripts# df -k
Filesystem    1024-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4            32768     15796   52%     1927    12% /
/dev/hd2          1466368     62568   96%    44801    13% /usr
/dev/hd9var         53248      8112   85%     1027     8% /var
/dev/hd3           106496     68996   36%      245     1% /tmp
/dev/hd1             4096      3892    5%       55     6% /home
```

```
/proc                    -         -    -         -     -  /proc
/dev/hd10opt        655360     16420   98%    16261    10% /opt
/dev/scripts_lv      102400     24012   77%     1137     5% /scripts
/dev/lv_temp        409600    147452   65%       29     1% /tmpfs
```

Now look at the same output with the column headings removed:

```
[root:yogi]@/scripts# df -k | tail +2
/dev/hd4             32768     15796   52%     1927    12% /
/dev/hd2           1466368     62568   96%    44801    13% /usr
/dev/hd9var          53248      8112   85%     1027     8% /var
/dev/hd3            106496     68996   36%      245     1% /tmp
/dev/hd1              4096      3892    5%       55     6% /home
/proc                    -         -    -         -     -  /proc
/dev/hd10opt        655360     16420   98%    16261    10% /opt
/dev/scripts_lv      102400     24012   77%     1137     5% /scripts
/dev/lv_temp        409600    147452   65%       29     1% /tmpfs
```

Just remember to add one to the total number of lines that you want to remove.

Arrays

The shell supports one-dimensional arrays. The maximum number of array elements is 1,024. When an array is defined, it is automatically dimensioned to 1,024 elements. A one-dimensional array contains a sequence of *array elements*, which are like the boxcars connected together on a train track. An array element can be just about anything, except for another array. I know; you're thinking that you can use an array to access an array to create two- and three-dimensional arrays. This can be done, but it is beyond the scope of this book.

Loading an Array

An array can be loaded in two ways. You can define and load the array in one step with the `set -A` command, or you can load the array one element at a time. Both techniques are shown here:

```
set -A MY_ARRAY alpha beta gamma
```

or

```
X=0  # Initialize counter to zero.
# Load the array with the strings alpha, beta, and gamma
for ELEMENT in alpha gamma beta
do
      MY_ARRAY[$X]=$ELEMENT
      ((X = X + 1))
done
```

The first array element is referenced by 0, not 1. To access array elements use the following syntax:

```
echo ${MY_ARRAY[2]  # Show the third array element
gamma

echo ${MY_ARRAY[*]  # Show all array elements
alpha beta gamma

echo ${MY_ARRAY[@]  # Show all array elements
alpha beta gamma

echo ${#MY_ARRAY[*]}  # Show the total number of array elements
3

echo ${#MY_ARRAY[@]}  # Show the total number of array elements
3

echo ${MY_ARRAY}      # Show array element 0 (the first element)
alpha
```

We will use arrays in shell scripts in several chapters in this book.

Testing a String

One of the hardest things to do in a shell script is to test the user's input from the command line. The shell script shown in Listing 1-25 will do the trick using regular expressions to define the string composition.

```
#!/bin/ksh
#
#  SCRIPT: test_string.ksh
#  AUTHOR: Randy Michael
#  REV: 1.0.D  - Used for developement
#  DATE: 10/15/2007
#  PLATFORM: Not Platform Dependent
#
#  PURPOSE: This script is used to test a character
#           string, or variable, for its composition.
#           Examples include numeric, lowercase or uppercase
#           characters, alpha-numeric characters, and IP address.
#
#  REV LIST:
#
#
# set -x # Uncomment to debug this script
```

Listing 1-25 test_string.ksh shell script

```
# set -n # Uncomment to verify syntax without any execution.
#        # REMEMBER: Put the comment back or the script will
#        # NOT EXECUTE!
#
######################################################
############### DEFINE FUNCTIONS HERE ################
######################################################

test_string ()
{
# This function tests a character string

# Must have one argument ($1)

if (( $# != 1 ))
then
     # This error would be a programming error

     print "ERROR: $(basename $0) requires one argument"
     return 1
fi
# Assign arg1 to the variable --> STRING

STRING=$1

# This is where the string test begins

case $STRING in

+([0-9]).+([0-9]).+([0-9]).+([0-9]))
          # Testing for an IP address - valid and invalid
          INVALID=FALSE

          # Separate the integer portions of the "IP" address
          # and test to ensure that nothing is greater than 255
          # or it is an invalid IP address.

          for i in $(echo $STRING | awk -F . '{print $1, $2, $3, $4}')
          do
              if (( i > 255 ))
              then
                   INVALID=TRUE
              fi
          done

          case $INVALID in
          TRUE) print 'INVALID_IP_ADDRESS'
                ;;
```

Listing 1-25 (*continued*)

```
         FALSE) print 'VALID_IP_ADDRESS'
                ;;
          esac
          ;;
+([0-1])) # Testing for 0-1 only
          print 'BINARY_OR_POSITIVE_INTEGER'
          ;;
+([0-7])) # Testing for 0-7  only
          print 'OCTAL_OR_POSITIVE_INTEGER'
          ;;
+([0-9])) # Check for an integer
          print 'INTEGER'
          ;;
+([-0-9])) # Check for a negative whole number
           print 'NEGATIVE_WHOLE_NUMBER'
           ;;
+([0-9]|[.][0-9]))
           # Check for a positive floating point number
           print 'POSITIVE_FLOATING_POINT'
           ;;
+(+[0-9][.][0-9]))
           # Check for a positive floating point number
           # with a + prefix
           print 'POSITIVE_FLOATING_POINT'
           ;;
+(-[0-9][.][0-9]))
           # Check for a negative floating point number
           print 'NEGATIVE_FLOATING_POINT'
           ;;
+([-.0-9]))
           # Check for a negative floating point number
           print 'NEGATIVE_FLOATING_POINT'
           ;;
+([+.0-9]))
           # Check for a positive floating point number
           print 'POSITIVE_FLOATING_POINT'
           ;;
+([a-f])) # Test for hexidecimal or all lowercase characters
          print 'HEXIDECIMAL_OR_ALL_LOWERCASE'
          ;;
+([a-f]|[0-9])) # Test for hexidecimal or all lowercase characters
          print 'HEXIDECIMAL_OR_ALL_LOWERCASE_ALPHANUMERIC'
          ;;
+([A-F])) # Test for hexidecimal or all uppercase characters
          print 'HEXIDECIMAL_OR_ALL_UPPERCASE'
          ;;
+([A-F]|[0-9])) # Test for hexidecimal or all uppercase characters
          print 'HEXIDECIMAL_OR_ALL_UPPERCASE_ALPHANUMERIC'
```

Listing 1-25 (*continued*)

```
          ;;
+([a-f]|[A-F]))
          # Testing for hexidecimal or mixed-case characters
          print 'HEXIDECIMAL_OR_MIXED_CASE'
          ;;
+([a-f]|[A-F]|[0-9]))
          # Testing for hexidecimal/alpha-numeric strings only
          print 'HEXIDECIMAL_OR_MIXED_CASE_ALPHANUMERIC'
          ;;
+([a-z]|[A-Z]|[0-9]))
          # Testing for any alpha-numeric string only
          print 'ALPHA-NUMERIC'
          ;;
+([a-z])) # Testing for all lowercase characters only
          print 'ALL_LOWERCASE'
          ;;
+([A-Z])) # Testing for all uppercase numbers only
          print 'ALL_UPPERCASE'
          ;;
+([a-z]|[A-Z]))
          # Testing for mixed case alpha strings only
          print 'MIXED_CASE'
          ;;
          *) # None of the tests matched the string composition
             print 'INVALID_STRING_COMPOSITION'
          ;;
esac
}


######################################################

usage ()
{
echo "\nERROR: Please supply one character string or variable\n"
echo "USAGE: $THIS_SCRIPT {character string or variable}\n"
}

######################################################
############# BEGINNING OF MAIN ####################
######################################################

# Query the system for the name of this shell script.
# This is used for the "usage" function.

THIS_SCRIPT=$(basename $0)

# Check for exactly one command-line argument
```

Listing 1-25 (*continued*)

```
if (( $# != 1 ))
then
     usage
     exit 1
fi

# Everything looks okay if we got here. Assign the
# single command-line argument to the variable "STRING"

STRING=$1

# Call the "test_string" function to test the composition
# of the character string stored in the $STRING variable.

test_string $STRING

# End of script
```

Listing 1-25 (*continued*)

This is a good start, but this shell script does not cover everything. Play around with it to see if you can make some improvements.

NOTE **Bash shell does not support the `+([0-9])`-type regular expressions.**

Summary

This chapter is just a primer to get you started with a quick review and some little tricks and tips. In the next 27 chapters, we are going to write a lot of shell scripts to solve some real-world problems. Sit back and get ready to take on the UNIX world!

The first thing that we are going to study is 24 ways to process a file line-by-line. I have seen a lot of good and bad techniques for processing a file line-by-line over the past 15 years, and some have been rather inventive. The next chapter presents the 24 techniques that I have seen the most; at the end of the chapter there is a shell script that times each technique to find the fastest. Read on, and find out which one wins the race. See you in the next chapter!

CHAPTER 2

24 Ways to Process a File Line-by-Line

Have you ever created a really slick shell script to process file data and found that you have to wait until after lunch to get the results? The script may be running so slowly because of how you are processing the file. Over my many years of UNIX administration I have seen some rather, well, let's call them *creative* ways to process a file line-by-line. I have listed 24 of these methods in this chapter. Some techniques are very fast, and some make you wait for half a day. Then there are a few that, on first look, should work but do not. The techniques used in this chapter are measurable, and I created a shell script that will time each method so that you can see which method suits your needs.

When processing an ASCII text/data file, we are normally inside a loop of some kind. Then, as we go through the file from the top to the bottom, we process each line of text. A UNIX shell script is really not meant to work on a text file character-by-character (Pearl is better for this), but you can accomplish the task using various techniques. The task for this chapter is to show the line-by-line parsing techniques by parsing each entire line at once, not character by character. We are also going to look at using file descriptors as a method of file input and output redirection for file processing.

Command Syntax

First, as always, we need to go over the command syntax that we are going to use. The commands that we want to concentrate on in this chapter have to deal with `while` and `for` loops. When parsing a file in a loop, we need a method to read in the entire line of data to a variable. The most prevalent command is **read**. The `read` command is flexible in that you can extract individual strings as well as the entire line. Speaking of lines, the **line** command is another alternative to grab a full line of text. Some operating

systems do not support the `line` command. For example, the `line` command is not available on OpenBSD and some versions of Linux and Solaris.

In addition to the `read` and `line` commands, we need to look at the different ways to use the `while` and `for` loops, which is the major cause of fast or slow execution times. A loop can be used as a standalone loop in a predefined configuration; it can be used in a command pipe or with file descriptors. Each method has its own set of rules. The use of the loop is critical to get the quickest execution times.

Using File Descriptors

Under the covers of the UNIX operating system, files are referenced, copied, and moved by unique numbers known as *file descriptors*. You already know about three of these file descriptors:

```
0 - stdin
1 - stdout
2 - stderr
```

We redirect output using the `stdout` (standard output) and `stderr` (standard error) a lot in this book, using several different techniques. This is the first time we are going to use the `stdin` (standard input) file descriptor. For a short definition of each of these we can talk about the devices on the computer. Standard input usually comes into the computer from the keyboard or mouse. Standard output usually has output to the screen or to a file. Standard error is where commands, programs, and scripts route error messages. We have used `stderr` before to send the error messages to the bit bucket, or `/dev/null`, and (more commonly) to combine the `stdout` and `stderr` outputs together. You should remember a command like the following one:

```
some_command 2>&1
```

The preceding command sends all the error messages to the same output device that standard output goes to, which is normally the terminal. We can also use other file descriptors. Valid descriptor values range from 0 to 19 on most operating systems. You have to do a lot of testing when you use the upper values to ensure that they are not reserved by the system for some reason. You will see more on using file descriptors in some of the following code listings.

Creating a Large File to Use in the Timing Test

Before I get into each method of parsing the file, I want to show you a little script you can use to create a file of random alphanumeric characters that is exactly a user-specified number of MB in size. The number of characters per line is 80, including the new-line character. The method to create a file of random alphanumeric characters is to load an array with upper- and lowercase alpha characters as well as the numbers 0–9. We then use a random number, in a loop, to point to array elements and append each character as we build each line. A `while` loop is used to create 12,800 lines per

MB the user specifies. To create a 1 MB random character file, you need only add the number of MB as a parameter to the shell script name. Using the shell script in Listing 2-1, you create a 1 MB, 12,800-line file, with the following syntax:

```
# random_file.Bash 1
```

The full shell script is shown in Listing 2-1.

```
#!/bin/Bash
#
# SCRIPT: random_file.Bash
# AUTHOR: Randy Michael
# DATE: 8/3/2007
# REV: 1.0
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to create a
#      specific size file of random characters.
#      The methods used in this script include
#      loading an array with alphanumeric
#      characters, then using the /dev/random
#      character special file to seed the RANDOM
#      shell variable, which in turn is used to
#      extract a random set of characters from the
#      KEYS array to build the OUTFILE of a
#      specified MB size.
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check script syntax
#        # without any execution. Do not forget
#        # to put the comment back in or the
#        # script will never execute.
#
##########################################
# DEFINE FILES AND VARIABLES HERE
##########################################

typeset -i MB_SIZE=$1
typeset -i RN
typeset -i i=1
typeset -i X=0
OUTFILE=largefile.random.txt
>$OUTFILE
THIS_SCRIPT=$(basename $0)
CHAR_FILE=${WORKDIR}/char_file.txt
```

Listing 2-1 random_file.Bash shell script

```
##########################################
# DEFINE FUNCTIONS HERE
##########################################

build_random_line ()
{
# This function extracts random characters
# from the KEYS array by using the RANDOM
# shell variable

C=1
LINE=
until (( C > 79 ))
do
   LINE="${LINE}${KEYS[$(($RANDOM % X + 1))]}"
   (( C = C + 1 ))
done

# Return the line of random characters

echo "$LINE"
}

########################################

elasped_time ()
{
SEC=$1

(( SEC < 60 )) &&  echo -e "[Elasped time: \
$SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && echo -e \
"[Elasped time: $(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && echo -e "[Elasped time: \
$(( SEC / 3600 )) hr $(( (SEC % 3600) / 60 )) min \
$(( (SEC % 3600) % 60 )) sec]\c"
}

########################################

load_default_keyboard ()
{
# Loop through each character in the following list and
# append each character to the $CHAR_FILE file. This
# produces a file with one character on each line.

for CHAR in 1 2 3 4 5 6 7 8 9 0 q w e r t y u i o \
```

Listing 2-1 (*continued*)

```
             p a s d f g h j k l  z x c v b n m \
             Q W E R T Y U I O P A S D F G H J K L \
             Z X C V B N M 0 1 2 3 4 5 6 7 8 9
do
     echo "$CHAR" >> $CHAR_FILE
done
}
########################################

usage ()
{
echo -e "\nUSAGE: $THIS_SCRIPT Mb_size"
echo -e "Where Mb_size is the size of the file to build\n"
}

########################################
# BEGINNING OF MAIN
########################################

if (( $# != 1 ))
then
     usage
     exit 1
fi

# Test for an integer value

case $MB_SIZE in
[0-9]) : # Do nothing
          ;;
       *) usage
          ;;
esac

# Test for the $CHAR_FILE

if [ ! -s "$CHAR_FILE" ]
then
     echo -e "\nNOTE: $CHAR_FILE does not esist"
     echo "Loading default keyboard data."
     echo -e "Creating $CHAR_FILE...\c"
     load_default_keyboard
     echo "Done"
fi

# Load Character Array

echo -e "\nLoading array with alphanumeric character elements"
```

Listing 2-1 (*continued*)

```
while read ARRAY_ELEMENT
do
    (( X = X + 1 ))
    KEYS[$X]=$ARRAY_ELEMENT

done < $CHAR_FILE
echo "Total Array Character Elements: $X"

# Use /dev/random to seed the shell variable RANDOM

echo "Querying the kernel random number generator for a random seed"

RN=$(dd if=/dev/random count=1 2>/dev/null \
    | od -t u4 | awk '{print $2}'| head -n 1)

# The shell variable RANDOM is limited to 32767

echo "Reducing the random seed value to between 1 and 32767"

RN=$(( RN % 32767 + 1 ))

# Initialize RANDOM with a new seed

echo "Assigning a new seed to the RANDOM shell variable"

RANDOM=$RN

echo "Building a $MB_SIZE MB random character file ==> $OUTFILE"
echo "Please be patient; this may take some time to complete..."
echo -e "Executing: .\c"

# Reset the shell SECONDS variable to zero seconds.

SECONDS=0

TOT_LINES=$(( MB_SIZE * 12800 ))

until (( i > TOT_LINES ))
do
     build_random_line >> $OUTFILE
     (( $(( i % 100 )) == 0 )) && echo -e ".\c"
     (( i = i + 1 ))
done

# Capture the total seconds
```

Listing 2-1 (*continued*)

```
TOT_SEC=$SECONDS

echo -e "\n\nSUCCESS: $OUTFILE created at $MB_SIZE MB\n"

elasped_time $TOT_SEC

# Calculate the bytes/second file creation rate

(( MB_SEC = ( MB_SIZE * 1024000 ) / TOT_SEC ))

echo -e "\n\nFile Creation Rate: $MB_SEC bytes/second\n"

echo -e "File size:\n"
ls -l $OUTFILE
echo

##########################################
# END OF random_file.Bash SCRIPT
##########################################
```

Listing 2-1 (*continued*)

Each line produced by the `random_file.Bash` script is the same length and consists of random alphanumeric characters. The user specifies size in MB — thus, the total number of lines to create as a parameter to the shell script. The first few lines of the resulting file from the `random_file.Bash` shell script in Listing 2-1 are shown in Listing 2-2. Your file's data will vary from this example, of course.

```
1fv765J85HBPbPym059qseLx2n5MH4NPKFhgtuFCeU2ep6B19chh4RY7ZmpXIvXrS7348y0NdwiYT61
1RkW75vBjGiNZH4Y9HxXfQ2VShKS70znTLxlRPfn3I7zvNZW3m3zQ1NzG62Gj1xrdPD7M2rdE2AcOr3
Pud2ij43br4K3729gbG4n19Ygx5NGI0212eHN154RuC4MtS4qmRphb2O9FJgzK8IcFW0sTn71niwLyi
JOqBQmA5KtbjV34vp3lVBKCZp0PVJ4Zcy7fd5R1Fziseux4ncio32loIne1a7MPVqyIuJ8yv5IJ6s5P
485YQX0ll7hUgqepiz9ejIupjZb1003B7NboGJMga2Rllu19JC0pn4OmrnxfN025RMU6Qkv54v2fqfg
UmtbXV2mb4IuoBo113IgUg0bh8n2bhZ768Iiw2WMaemgGR6XcQWi0T6Fvg0MkiYELW2ia1oCO83sK06
2X05sU4Lv9XeV7BaOtC8Y5W7vgqxu69uwsFALripdZS7C8zX1WF6XvFGn4iFF1e5K560nooInX514jb
0SI6B1m771vqoDA73u1ZjbY7SsnS07eLxp96GrHDD75731bJXJa4Uz3t0LW2dCWNy6H3YmojVXQVYA1
v3TPxyeJD071S20SBh4xoCCRH4PhqAWBijM9oXyhdZ6MM0t2JWegRo1iNJN5p0IhZDmLttr1SCHBvP1
kM3HbgpOjlQLU8B0JjkY8q1c9NLSbGynKTbf9Meh95QU8rIAB4mDH80zUIEG2qadxQ0191686FHn9Pi
```

Listing 2-2 Example output from the random_file.Bash script

24 Methods to Parse a File Line-by-Line

The following sections describe 24 of the parsing techniques I have seen over the years, most of them common but also a few very uncommon methods. I have put

them all together in one shell script separated as functions. After the functions are defined, I execute each method, or function, while timing the execution using the shell's **time** command. To get accurate timing results, I use a 1 MB file that has 12,800 lines, where each line is the same 80-character length. (We built this file using the `random_file.Bash` shell script.) A 12,800-line file is an extremely large file to be parsing line-by-line in a shell script, at 1 MB, but my Linux and AIX machines are so fast that I needed a large file to get the timing data greater than zero!

Now it is time to look at the 24 methods to parse a file line-by-line. Each method uses a `while` or `for` statement to create a loop. The only command(s) within the loop are to read an input file and to send output to an output file, specified by `$INFILE` and `$OUTFILE`, respectively. The thing that makes each method different is how the `while` and `for` loops are used. You should also notice that each function contains a *no-op*, specified by the `:` (colon) character. A no-op does not do anything, and always has a 0 (zero) return code. I use the no-op here as a placeholder in case you pull one of the functions out to use; you can remove the guts of the loop, and the function will not bomb because nothing is within the loop.

Method 1: cat_while_read_LINE

Let's start with the most common method that I see, which is using the **cat** command to list the entire file and piping the output to a `while read` loop. On each loop iteration a single line of text is read into a variable named `LINE`. This continuous loop will run until all the lines in the file have been processed one at a time.

The pipe is the key to the popularity of this method. It is intuitively obvious that the output from the previous command in the pipe is used as input to the next command in the pipe. As an example, if I execute the **df** command to list filesystem statistics and it scrolls across the screen out of view, I can use a pipe to send the output to the **more** command, as in the following command:

```
df | more
```

When the `df` command is executed, the pipe stores the output in a temporary system file. Then this temporary system file is used as input to the `more` command, allowing us to view the `df` command output one page/line at a time. Our use of piping output to a `while` loop works the same way; the output of the `cat` command is used as input to the `while` loop and is read into the `LINE` variable on each loop iteration. Look at the complete function in Listing 2-3.

```
function cat_while_read_LINE
{
# Method 1

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 2-3 cat_while_read_LINE function

```
cat $INFILE | while read LINE
do
     echo "$LINE" >> $OUTFILE
     :
done
}
```

Listing 2-3 (*continued*)

Each of these test loops is created as a function so that we can time each method using the shell script. You could also use the `()` GNU function definition if you wanted, as shown in Listing 2-4.

```
cat_while_read_LINE ()
{
# Method 1

# Zero out the $OUTFILE

>$OUTFILE

cat $INFILE | while read LINE
do
      echo "$LINE" >> $OUTFILE
      :
done
}
```

Listing 2-4 Using the ( ) declaration method function

Whether you use the `function` or the `()` technique, you get the same result. I tend to use the `function` method more often so that when someone edits the script they will know the block of code is a function. For beginners, the word ''function'' helps a lot in understanding the whole shell script. The `$INFILE` and `$OUTFILE` variables are set in the main body of the shell script.

Method 2: while_read_LINE_bottom

You are now entering one of my favorite methods of parsing through a file. We still use the `while read LINE` syntax, but this time we *feed the loop from the bottom* instead of using a pipe. You will find that this is one of the fastest ways to process each line of a file, and it is still intuitive to understand. The first time you see this method it looks a little unusual, but it does work very well.

Look at the code in Listing 2-5, and we will go over the function at the end.

```
function while_read_LINE_bottom
{
# Method 2

# Zero out the $OUTFILE

>$OUTFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 2-5 while_read_LINE_bottom function

We made a few modifications to the function from Listing 2-3. The `cat $FILENAME` to the pipe was removed. Then we use *input redirection* to let us read the file from the bottom of the loop. By using the `<$FILENAME` notation after the `done` loop terminator we feed the `while` loop from the bottom, which greatly increases the input throughput to the loop. When we time each technique, this method will stand out close to the top of the list.

Method 3: cat_while_LINE_line

Now we are getting into some of the ''creative'' methods that I have seen in some shell scripts. As previously stated, not all UNIX operating systems support the `line` command. You will not find it in OpenBSD, nor in some versions of Linux and Solaris. The `line` command is available in AIX and HP-UX, and some releases of Linux and Solaris.

Using this loop strategy replaces the `read` command from Listings 2-3, 2-4, and 2-5 with the `line` command in a slightly different command structure. Look at the function in Listing 2-6, and you will see how it works at the end.

```
function cat_while_LINE_line
{
# Method 3

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 2-6 cat_while_LINE_line function

```
cat $INFILE | while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :
done
}
```

Listing 2-6 (*continued*)

The function in Listing 2-6 is interesting. Because we are not using the `read` command to assign the line of text to a variable, we need some other technique. If your machine supports the `line` command, then this is an option. To see if your UNIX machine has the `line` command, enter the following command:

```
which line
```

The response should be something like `/usr/bin/line`. Otherwise, you will see the `$PATH` list that was searched, followed by `"line" not found`.

The `line` command is used to grab one whole line of text at a time. The `read` command does the same thing if you use only one variable with the `read` statement; otherwise the line of text will be broken up between the different variables used in the `read` statement.

On each loop iteration the `LINE` variable is assigned a whole line of text using command substitution. This is done using the `LINE=`line`` command syntax. The `line` command is executed, and the result is assigned to the `LINE` variable. Of course, I could have used any variable name, such as this:

```
MY_LINE=`line`
TEXT=`line`
```

Please notice that the single tic marks are really *back tics* (`` `command` ``), which are located in the top-left corner of most keyboards below the ESC-key. Executing a command and assigning the output to a variable is called *command substitution*. Look for the timing data for this technique when you run the timing script. This extra variable assignment may have quite an effect on the timing result.

Method 4: while_LINE_line_bottom

Again, this is one of the more obscure techniques that I have seen in any shell script. This time we are going to feed our `while` loop from the bottom, but we'll use the `line` command instead of the `read` statement to assign the text to the `LINE` variable. This method is similar to the last technique, but we removed the `cat $FILENAME` to the pipe and instead we redirect input into the loop from the bottom, after the `done` loop terminator.

Look at the function in Listing 2-7, and you will see how it works at the end.

```
function while_LINE_line_bottom
{
# Method 4

# Zero out the $OUTFILE

>$OUTFILE

while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 2-7 while_LINE_line_bottom function

We use command substitution to assign the line of file text to the `LINE` variable as we did in the previous method. The only difference is that we are feeding the `while` loop from the bottom using input redirection of the `$FILENAME` file. You should be getting the hang of what we are doing by now. As you can see, there are many ways to parse through a file, but you are going to see that not all of these techniques are very good choices. This method is one of the poorer choices.

Next we are going to look at the other method of command substitution. The last two methods used the `line` command using the syntax `LINE=`line``. We can also use the `LINE=$(line)` technique. Is there a speed difference?

Method 5: cat_while_LINE_line_cmdsub2

Look familiar? This is the same method as Method 3 except for the way we use command substitution. As I stated in the beginning, we need a rather large file to parse through to get accurate timing results. When we do our timing tests, we might see a difference between the two command-substitution techniques. Just remember that the `line` command is not available on all UNIX operating systems.

Study the function in Listing 2-8, and we will cover the function at the end.

```
function cat_while_LINE_line_cmdsub2
{
# Method 5

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 2-8 cat_while_LINE_line_cmdsub2 function

```
cat $INFILE | while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :
done
}
```

Listing 2-8 (*continued*)

The only thing we are looking for in the function in Listing 2-8 is a timing difference between the two command-substitution techniques. As each line of file text enters the loop, the `line` command assigns the text to the `LINE` variable. Let's see how Methods 3 and 5 show up in the loop timing tests, because the only difference is the command-substitution assignment method.

Method 6: while_LINE_line_bottom_cmdsub2

This method is the same technique used in Listing 2-7 except for the command substitution. In this function we are going to use the `LINE=$(line)` technique. We are again feeding the `while` loop input from the bottom, after the `done` loop terminator. Please review the function in Listing 2-9.

```
function while_LINE_line_bottom_cmdsub2
{
# Method 6

# Zero out the $OUTFILE

>$OUTFILE

while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 2-9 while_LINE_line_bottom_cmdsub2 function

By the look of the loop structure, you might assume that this `while` loop is very fast executing, but you will be surprised at how slow it is. The main reason is the variable assignment, but the `line` command has a large effect, too.

Method 7: for_LINE_cat_FILE

This is the first method to use a `for` loop. I think you will be surprised at the speed of this technique. Check out the code in Listing 2-10 and we will cover the details at the end.

```
for_LINE_cat_FILE ()
{
# Method 7

# Zero out the $OUTFILE

>$OUTFILE

for LINE in `cat $INFILE`
do
    echo "$LINE" >> $OUTFILE
    :
done
}
```

Listing 2-10 for_LINE_cat_FILE function

In Listing 2-10 we use a `for` loop in concert with command substitution to `cat` the file. On each loop iteration the `LINE` variable is assigned a full line of text. Look for the timing results at the end of this chapter.

Method 8: for_LINE_cat_FILE_cmdsub2

This method again changes our command substitution from the back tics `` `command` `` to `$(command)`. The timing results for Methods 7 and 8 should be interesting. As previously stated, the `line` command is available on AIX, HP-UX, and some versions of Linux and Solaris, but not on OpenBSD. Again we are using a `for` loop. Check out Listing 2-11 and we will cover the details at the end.

```
for_LINE_cat_FILE_cmdsub2 ()
{
# Method 8

# Zero out the $OUTFILE

>$OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE" >> $OUTFILE
    :
done
}
```

Listing 2-11 for_LINE_cat_FILE_cmdsub2 function

Again, on each loop iteration the `LINE` variable is assigned a full line of text data, and we send this data to the `$OUTFILE` by appending each line, specified by `echo "$LINE">>$OUTFILE`, as we process the file from top to bottom.

Method 9: while_line_outfile

I put this method in, but notice there is no variable assignment for each line of data in the input file. All we are doing here is using input redirection after the `done` loop terminator, and then using the `line` command to append each line of data to the `$OUTFILE`. Look at the code in Listing 2-12.

```
while_line_outfile ()
{
# Method 9

# Zero out the $OUTFILE

>$OUTFILE

# This function processes every other
# line of the $INFILE, so do not use
# this method

while read
do
    line >>$OUTFILE
    :
done < $INFILE
}
```

Listing 2-12 while_line_outfile function

The function in Listing 2-12 has a big problem: it only processes every other line of the input file. Do *not* use this method! Without any variable assignment it is not very useful anyway.

Method 10: while_read_LINE_FD_IN

So far we have been doing some very straightforward kinds of loops. Have you ever used *file descriptors* to parse through a file? The use of file descriptors is sometimes a little hard to understand. I'm going to do my best to make this easy! Under the covers of the UNIX operating system, files are referenced by file descriptors. You should already know three file descriptors right off the bat. The three that I am talking about are `stdin`, `stdout`, and `stderr`. Standard input, or `stdin`, is specified as file descriptor 0. This is usually the keyboard or mouse. Standard output, or `stdout`, is specified as file descriptor 1. Standard output can be your terminal screen or some kind of a file.

Standard error, or `stderr`, is specified as file descriptor 2. Standard error is how the system and programs and scripts are able to send out or suppress error messages.

You can use these file descriptors in combination with one another. I'm sure that you have seen a shell script send all output to the bit bucket, or `/dev/null`. Look at the following command:

```
my_shell_script.Bash >/dev/null  2>&1
```

The result of the preceding command is to run completely silent. In other words, there is not any external output produced. Internally the script may be reading and writing to and from files and may be sending output to a specific terminal, such as `/dev/console`. You may want to use this technique when you run a shell script as a cron table entry or when you just are not interested in seeing any output.

In the previous example we used two file descriptors. We can also use other file descriptors to handle file input and storage. Throughout the remaining sections of this chapter, we are going to associate file descriptor 3 with `stdin`, file descriptor 0, and then redirect input through file descriptor 0. And for output redirection we will associate file descriptor 4 with `stdout`, file descriptor 1, then redirect output to our `$OUTFILE`. On most UNIX systems valid file descriptors range from 0 to 19. In our case we are going to use file descriptor 3, but we could have just as easily used file descriptor 5. Later we will use this same file descriptor technique for output redirection using file descriptor 4.

There are two steps to use a file descriptor for input redirection. The first step is to associate file descriptor 3 with `stdin`, file descriptor 0. We use the following syntax for this step:

```
exec 3<&0
```

Now all the keyboard and mouse input is going to our new file descriptor 3. The second step is to send our input file, specified by the variable `$INFILE`, into file descriptor 0 (zero), which is standard input. This second step is done using the following syntax:

```
exec 0< $INFILE
```

At this point any command requiring input will receive the input from the `$INFILE` file. Now is a good time for an example. Look at the function in Listing 2-13.

```
function while_read_LINE_FD_IN
{
# Method 10

# Zero out the $OUTFILE
>$OUTFILE
```

Listing 2-13 while_read_LINE_FD_IN function

```
# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-13 (*continued*)

Within the function in Listing 2-13 we have our familiar `while` loop to read one line of text at a time. But the beginning of this function does a little file descriptor redirection. The first `exec` command redirects `stdin` to file descriptor 3. The second `exec` command redirects the `$INFILE` file into `stdin`, which is file descriptor 0. Now the `while` loop can just execute without our having to worry about how we assign a line of text to the `LINE` variable. When the `while` loop exits we redirect the previously reassigned `stdin`, which was sent to file descriptor 3, back to its original file descriptor 0, and then close file descriptor 3.

```
exec 0<&3
exec 3>&-
```

In other words, we set it back to the system's default value and close the file descriptor we used for input redirection.

Pay close attention to this method in the timing tests later in this chapter. We have many more examples using file descriptors that utilize some of our previous `while` loops. Please make sure you compare all of the timing results at the end of the chapter to see how these methods fare.

Method 11: cat_while_read_LINE_FD_OUT

Again, we are going to use file descriptors, but this time for standard output. For this method we are going to associate file descriptor 4 with `stdout`, file descriptor 1. Then we redirect standard output to our `$OUTFILE`. Study Listing 2-14 and we will cover the details at the end.

```
function cat_while_read_LINE_FD_OUT
{
# Method 11

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

cat $INFILE | while read LINE
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-14 cat_while_read_LINE_FD_OUT function

In Listing 2-14 we associate standard output with file descriptor 4 with the following syntax:

```
exec 4<&1
```

The next step is to redirect standard output to our `$OUTFILE`, as shown here:

```
exec 1> $OUTFILE
```

Now that the file descriptors are set up for output redirection, we execute our loop to process the file. We `cat` the input file and pipe the output to our `while read` loop. After our loop completes, we need to put everything back to the default configuration. To do this, we restore standard output, and close file descriptor 4. The next two lines of code put us back to the default:

```
exec 1<&4
exec 4>&-
```

The notation `exec 4>&-` closes file descriptor 4. Be sure to check out the timing data at the end of this chapter.

Method 12: while_read_LINE_bottom_FD_OUT

As with all our functions using file descriptors, we first set up our redirection so that the `$OUTFILE` file remains open for writing. This function uses file descriptors for standard output, but uses normal input redirection as we have seen in many other methods. Study Listing 2-15 and we will cover the function at the end.

```
function while_read_LINE_bottom_FD_OUT
{
# Method 12

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-15 while_read_LINE_bottom_FD_OUT function

Notice in Listing 2-15 that we do not need to append output on each loop iteration because we took care of the output redirection with file descriptors.

We first associate file descriptor 4 with standard output, file descriptor 1. We then redirect standard output to out `$OUTFILE`. Once this is set up, we execute our `while` loop, feeding the loop from the bottom. When the loop has completed, we restore standard output and close file descriptor 4 with the following syntax:

```
exec 1<&4
exec 4>&-
```

This is a fast method of processing a file, but is it the winner? Keep reading to find the absolute fastest method.

Method 13: while_LINE_line_bottom_FD_OUT

This section is similar to Method 12 but we replace `while read LINE` with `while LINE='line'`. Study the function in Listing 2-16 and we will cover the details at the end.

```
function while_LINE_line_bottom_FD_OUT
{
# Method 13

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=`line`
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-16 while_LINE_line_bottom_FD_OUT function

I hope you are getting the hang of file descriptors! We use `exec 4<&1` to associate file descriptor 4 to standard output, file descriptor 1. Next we use `exec 1>$OUTFILE` to redirect all output to our `$OUTFILE`. Now we can execute our `while` loop to process the file data one line at a time. Notice that we feed the `while` loop from the bottom using input redirection after the `done` loop terminator, and, on each loop iteration, assign the entire line of file data to the `LINE` variable. The **echo** command sends each line of data to standard output, which we redirected to our `$OUTFILE` using file descriptor 4. When our loop terminates execution, we restore standard output and close file descriptor 4.

Method 14: while_LINE_line_bottom_cmdsub2_FD_OUT

This section is the same as Method 13 with the exception of our command-substitution method. Here we replace the `` `command` `` with the `$(command)` notation. Study Listing 2-17 and check out the timing data at the end of this chapter.

```
function while_LINE_line_bottom_cmdsub2_FD_OUT
{
# Method 14

# Zero out the $OUTFILE
>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=$(line)
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-17 while_LINE_line_bottom_cmdsub2_FD_OUT function

We are only interested in the difference in timing between Method 13 and Method 14 for this section. Be sure to see the execution time difference at the end of this chapter. Pay special attention to the *user* and *sys* times.

Method 15: for_LINE_cat_FILE_FD_OUT

Now we are back to our `for` loop method of parsing a file line-by-line. This time we are using file descriptors for output redirection to our `$OUTFILE`. This is a surprisingly fast method to process a file. It is not the fastest method, but it ranks close to the top. Study Listing 2-18 and we will cover the details at the end.

```
for_LINE_cat_FILE_FD_OUT ()
{
# Method 15

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


for LINE in `cat $INFILE`
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-18 for_LINE_cat_FILE_FD_OUT function

Are you getting the file descriptor thing yet? In Listing 2-18 we associate standard output with file descriptor 4, then redirect standard output to our `$OUTFILE`, as we have been doing in the last several sections.

Our `for` loop assigns one line of file text data to the `LINE` variable as we `cat` the `$INFILE` using the back tic (`` `command` ``) command-substitution method. Our `echo` command does not require any redirection to the `$OUTFILE` because we took care of the output with file descriptor 4. When the `for` loop completes execution, we restore standard output and close file descriptor 4. Please be sure to check the timing data at the end of this chapter.

Method 16: for_LINE_cat_FILE_cmdsub2_FD_OUT

We are again interested in the difference in execution timing between the `` `command` `` and `$(command)` command-substitution techniques. Other than the command substitution, Listing 2-19 is the same as Listing 2-18.

```
for_LINE_cat_FILE_cmdsub2_FD_OUT ()
{
# Method 16

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-19 for_LINE_cat_FILE_cmdsub2_FD_OUT function

Be sure to compare the timing data for Methods 15 and 16 at the end of this chapter.

Method 17: while_line_outfile_FD_IN

Now we are back to using a file descriptor for input redirection. This is one of those methods that, at first look, should work. However, this function picks up only every other line of the input file data. Do *not* use this method! But *do* study it.

In Method 17 we are attempting to use a file descriptor for file input and the `line` command to redirect output to the `$OUTFILE`. Check out Listing 2-20.

```
while_line_outfile_FD_IN ()
{
# Method 17

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 2-20 while_line_outfile_FD_IN function

```
# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# This function processes every other
# line of the $INFILE, so do not use
# this method

while read
do
    line >> $OUTFILE
    :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-20 (*continued*)

The timing data at the end of this chapter shows the difference in the file sizes between the input and output files. As you will see, the input file is 1 MB and the output file is 512 KB, one-half the size of the input file. Not good!

Method 18: while_line_outfile_FD_OUT

This method is the same as Method 17 but here we are redirecting standard output using file descriptor 4. Again, do not use this method, because it picks up only every other line in input file data.

In Method 18 we are attempting to use file descriptor 4 for file output using the `line` command and feeding the `while` loop from the bottom, after the `done` loop terminator. You can see this in Listing 2-21.

```
while_line_outfile_FD_OUT ()
{
# Method 18

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 2-21 while_line_outfile_FD_OUT function

```
# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

# This function processes every other
# line of the $INFILE, so do not use
# this method

while read
do
    line
    :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-21 (*continued*)

For this I just want you to compare timing data for using file descriptors for input as opposed to using a file descriptor for output. Also notice that the output file is one-half the size of the input file.

Method 19: while_line_outfile_FD_IN_AND_OUT

Okay, here we go again. This is the same method that skips every other line of input data, but this time we use file descriptors for both input and output redirection. In our timing shell script, we have the function `verify_files` that verifies that the file sizes match. Because this technique skips every other line, it gives us the following error:

```
ERROR: largefile.random.txt and writefile.out do not match
-rw-r--r--   1 root    system    1024000 Aug 14 17:41 largefile.random.txt
-rw-r--r--   1 root     system       512000 Aug 20 15:05 writefile.out
```

Again, we are interested only in the timing data because it does not work as desired.

This is a combination of Methods 17 and 18, but this time we use file descriptors for both input and output redirection. Listing 2-22 shows how file descriptors are set up, used, and finally closed when we are finished using them.

```
while_line_outfile_FD_IN_AND_OUT ()
{
# Method 19

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


while read
do
    line
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-22 while_line_outfile_FD_IN_AND_OUT function

See how using file descriptors for input *and* output speeds things up? Or does it?

Method 20: while_LINE_line_FD_IN

Here we go again with the `line` command. In this function the `line` command replaces the `read` command; however, we are still going to use file descriptors to gain

access to the $INFILE file as input to our while loop. Please study the function in Listing 2-23.

```
function while_LINE_line_FD_IN
{
# Method 20

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-23 while_LINE_line_FD_IN function

The nice thing about using file descriptors is that standard input is implied. Standard input is there; we do not have to cat the file or use a pipe for data input. We just send the file's data directly into file descriptor 0, stdin. Just don't forget to reset the file descriptor when you are finished using it.

The first exec command redirects input of file descriptor 0 into file descriptor 3. The second exec command redirects our $INFILE file into stdin, file descriptor 0. We process the file using a while loop and then reset the file descriptor 0 back to its default and close file descriptor 3. File descriptors are really not too hard to use after scripting with them a few times. Even though we are using file descriptors to try to speed up the processing, the line command variable assignment will produce slower results than anticipated.

Method 21: while_LINE_line_cmdsub2_FD_IN

This method is just like Method 20 except for the command-substitution technique. We are going to use a large file for our timing tests and hope that we can detect a difference

between the `command` and $(command) command-substitution techniques in overall run time. Please study the function in Listing 2-24.

```
function while_LINE_line_cmdsub2_FD_IN
{
# Method 21

# Zero out the $OUTFILE
>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-24 while_LINE_line_cmdsub2_FD_IN function

The function in Listing 2-24 first redirects stdin, file descriptor 0, to file descriptor 3; however, I could have used any valid file descriptor, such as file descriptor 5. The second step is redirecting the $FILENAME file into stdin, which is file descriptor 0. After the file descriptor redirection we execute the while loop, and on completion file descriptor 3 is redirected back to stdin. The end result is file descriptor 0, which again references stdin. The variable assignment produced by the command substitution has a negative impact on the timing results.

Method 22: while_read_LINE_FD_IN_AND_OUT

Now take a very close look at Listing 2-25. This could be the winner! This method processes the entire file in less than one second. Some of the techniques detailed in the chapter take longer than *eight minutes*! No, really! Study this method and learn how to use it. We will cover the details at the end.

```
function while_read_LINE_FD_IN_AND_OUT
{
# Method 22

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


while read LINE
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-25 while_read_LINE_FD_IN_AND_OUT function

Notice that I highlighted this entire function in bold text. Listing 2-25 combines the best of the best techniques into a single function. Let's start at the top.

The first step is to zero out the `$OUTFILE` using the syntax `>$OUTFILE`. This is equivalent to using `cat /dev/null > $OUTFILE`. I'm just saving a few keystrokes here.

Next we set up the file descriptors to handle all the file input and output. We first associate file descriptor 3 with `stdin`, standard input, and then we redirect input from our `$INFILE` to file descriptor 0, `stdin`. With standard input set up, we move to standard output, `stdout`. This step involves associating file descriptor 4 with `stdout`, file descriptor 1. With this association made, we now redirect standard output to our `$OUTFILE`.

Now we can process the `$INFILE` in a simple `while` loop, as shown here:

```
while read LINE
do
        echo "$LINE"
        :
done
```

It is important to note that if the double quotes are omitted in the `echo "$LINE"` statement, the new lines will not align and the output will look garbled. Again we see our no-op after the `echo` statement, specified by the `:` (colon) character. This is just a placeholder; if you remove the `echo` statement, the loop will still execute without failure, but it will not do anything.

After our loop completes processing the file, we need to restore standard input and standard output, and close file descriptors 3 and 4. This is done with the `exec` statements at the end of the function in Listing 2-25.

Make sure you see how blistering-fast this method of processing a file is at the end of this chapter.

Method 23: while_LINE_line_FD_IN_AND_OUT

How about the `line` command with file descriptors on both the input and output? I think you may be surprised how slow this method of processing a file can be.

Check out the function in Listing 2-26 and we will cover the details at the end.

```
function while_LINE_line_FD_IN_AND_OUT
{
# Method 23

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
```

Listing 2-26 while_LINE_line_FD_IN_AND_OUT function

```
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE='line'
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-26 (*continued*)

First, notice that we are using the back tic `` `command` `` command-substitution technique in Listing 2-26. The next section is the same function with the exception of the `$(command)` command-substitution technique. This is another timing test result that you should study at the end of this chapter.

In this function we associate file descriptor 3 with `stdin`, file descriptor 0. With this association made, we redirect our `$INFILE` to `stdin`, file descriptor 0. Next we associate file descriptor 4 with `stdout`, file descriptor 1. With this new association made, we redirect `stdout`, file descriptor 1, to our `$OUTFILE`.

With the file input and output taken care of with file descriptors, we can now process the `$INFILE`, and send output to the `$OUTFILE` in the `while LINE=`line`` loop. When the file processing completes, we need to restore `stdin` and `stdout` to their defaults, then close file descriptors 3 and 4.

This method is very slow, so do not use it.

Method 24: while_LINE_line_cmdsub2_FD_IN_AND_OUT

The file-processing method in Listing 2-27 is identical to Method 23, shown in Listing 2-26, except for the `$(command)` command-substitution technique used here. Study Listing 2-27 and look for the execution difference, if any, in the command-substitution techniques between Methods 23 and 24 at the end of this chapter.

```
function while_LINE_line_cmdsub2_FD_IN_AND_OUT
{
# Method 24

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=$(line)
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-27 while_LINE_line_cmdsub2_FD_IN_AND_OUT function

That does it for our 24 functions to process a file line-by-line. Now let's time each method and analyze the data.

Timing Each Method

We have created each of the functions for the 24 different methods to parse a file line-by-line. Now we can set up a shell script to time the execution of each function to

see which one is the fastest to process a file. Earlier we wrote the `random_file.Bash` script that creates a user-specified MB file of random alphanumeric characters, with 80 characters per line. This file is called `largefile.random.txt`, which is referenced by the `$OUTFILE` variable.

The file used for our timing test is a 12,800-line, 1 MB file. We needed this large a file to get accurate timing results for each of the 24 methods. Before we start the timing let's look at the timing shell script.

Timing Script

The shell script to time each file is not too difficult to understand. The timing mechanism is the shell's `time` command. The `time` command is followed by the name of the function, shell script, or program whose execution you want to time. The timing data is broken down to the following fields:

```
real    1m30.34s
user    0m35.50s
sys     0m52.13s
```

In the preceding output we have three measurements: `real`, `user`, and `sys`. The `real` time is the total time of execution. The `user` time is the time spent processing at the user/application process level. The `sys` time is the time spent by the system at the system/kernel level. Different UNIX flavors produce slightly different output fields, but the concepts are identical.

The one thing that users get confused about using the `time` command is where the timing data output goes. All of the timing data goes to `stderr`, or standard error, which is file descriptor 2. So the shell script or program will execute with the normal `stdin` and `stdout`, and the timing data will go the `stderr`. Study the shell script in Listing 2-28, and we will go through the script at the end. Then we are going show some timing data for each method.

```
#!/usr/bin/ksh
#
# SCRIPT: 24_ways_to_parse.ksh.ksh
# AUTHOR: Randy Michael
# DATE: 08/15/2007
# REV: 2.5.Q
#
# PURPOSE:  This script shows the different ways of reading
#       a file line-by-line.  Again there is not just one way
#       to read a file line-by-line and some are faster than
#       others and some are more intuitive than others.
#
# REV LIST:
#
#       03/15/2007 - Randy Michael
```

Listing 2-28 24_ways_to_parse.ksh shell script

```
#       Set each of the while loops up as functions and the timing
#       of each function to see which one is the fastest.
#
################
#
#       08/10/2007 - Randy Michael
#       Modified this script to include a total of 24 functions
#       to parse a file line-by-line.
#
#########################################################################
#
#       NOTE: To output the timing to a file use the following syntax:
#
#          24_ways_to_parse.ksh file_to_process  > output_file_name 2>&1
#
#       The actual timing data is sent to standard error, file
#       descriptor (2), and the function name header is sent
#       to standard output, file descriptor (1).
#
#########################################################################
#
# set -n  # Uncomment to check command syntax without any execution
# set -x  # Uncomment to debug this script
#

INFILE="$1"
OUTFILE=writefile.out
TIMEFILE="/tmp/loopfile.out"
>$TIMEFILE
THIS_SCRIPT=$(basename $0)

#####################################
function usage
{
echo "\nUSAGE: $THIS_SCRIPT  file_to_process\n"
echo "OR - To send the output to a file use: "
echo "\n$THIS_SCRIPT  file_to_process  > output_file_name 2>&1 \n"
exit 1
}
#####################################

function verify_files
{
diff $INFILE $OUTFILE >/dev/null 2>&1
if (( $? != 0 ))
then
    echo "ERROR: $INFILE and $OUTFILE do not match"
    ls -l $INFILE $OUTFILE
fi
```

Listing 2-28 (*continued*)

```
}
#######################################

function cat_while_read_LINE
{
# Method 1

# Zero out the $OUTFILE

>$OUTFILE

cat $INFILE | while read LINE
do
        echo "$LINE" >> $OUTFILE
        :
done
}
#######################################

function while_read_LINE_bottom
{
# Method 2

# Zero out the $OUTFILE

>$OUTFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
#######################################

function cat_while_LINE_line
{
# Method 3

# Zero out the $OUTFILE

>$OUTFILE

cat $INFILE | while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :
```

Listing 2-28 (*continued*)

```
done
}
#####################################

function while_LINE_line_bottom
{
# Method 4

# Zero out the $OUTFILE

>$OUTFILE

while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
#####################################

function cat_while_LINE_line_cmdsub2
{
# Method 5

# Zero out the $OUTFILE

>$OUTFILE

cat $INFILE | while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :
done
}
#####################################

function while_LINE_line_bottom_cmdsub2
{
# Method 6

# Zero out the $OUTFILE

>$OUTFILE

while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
```

Listing 2-28 (*continued*)

```
        :

done < $INFILE
}
#####################################

for_LINE_cat_FILE ()
{
# Method 7

# Zero out the $OUTFILE

>$OUTFILE

for LINE in `cat $INFILE`
do
    echo "$LINE" >> $OUTFILE
    :
done
}
#####################################

for_LINE_cat_FILE_cmdsub2 ()
{
# Method 8

# Zero out the $OUTFILE

>$OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE" >> $OUTFILE
    :
done
}
#####################################

while_line_outfile ()
{
# Method 9

# Zero out the $OUTFILE

>$OUTFILE

# This function processes every other
# line of the $INFILE, so do not use
```

Listing 2-28 (*continued*)

```
# this method

while read
do
    line >>$OUTFILE
    :
done < $INFILE
}
#####################################

function while_read_LINE_FD_IN
{
# Method 10

# Zero out the $OUTFILE
>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################

function cat_while_read_LINE_FD_OUT
{
# Method 11

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE
```

Listing 2-28 (*continued*)

```
exec 4<&1
exec 1> $OUTFILE

cat $INFILE | while read LINE
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#####################################

function while_read_LINE_bottom_FD_OUT
{
# Method 12

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#####################################

function while_LINE_line_bottom_FD_OUT
{
# Method 13
```

Listing 2-28 (*continued*)

```
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=`line`
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#####################################

function while_LINE_line_bottom_cmdsub2_FD_OUT
{
# Method 14

# Zero out the $OUTFILE
>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=$(line)
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
```

Listing 2-28 (*continued*)

```
}
#######################################

for_LINE_cat_FILE_FD_OUT ()
{
# Method 15

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


for LINE in `cat $INFILE`
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#######################################

for_LINE_cat_FILE_cmdsub2_FD_OUT ()
{
# Method 16

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

for LINE in $(cat $INFILE)
do
```

Listing 2-28 (*continued*)

```
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#####################################

while_line_outfile_FD_IN ()
{
# Method 17

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# This function processes every other
# line of the $INFILE, so do not use
# this method

while read
do
    line >> $OUTFILE
    :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################

while_line_outfile_FD_OUT ()
{
# Method 18
```

Listing 2-28 (*continued*)

```
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

# This function processes every other
# line of the $INFILE, so do not use
# this method

while read
do
    line
    :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
#####################################

while_line_outfile_FD_IN_AND_OUT ()
{
# Method 19

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE
```

Listing 2-28 (*continued*)

```
while read
do
    line
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################

function while_LINE_line_FD_IN
{
# Method 20

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################
```

Listing 2-28 (*continued*)

```
function while_LINE_line_cmdsub2_FD_IN
{
# Method 21

# Zero out the $OUTFILE
>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :
done

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#######################################

function while_read_LINE_FD_IN_AND_OUT
{
# Method 22

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
```

Listing 2-28 (*continued*)

```
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################
function while_LINE_line_FD_IN_AND_OUT
{
# Method 23

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=`line`
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
```

Listing 2-28 (*continued*)

```
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
#####################################
function while_LINE_line_cmdsub2_FD_IN_AND_OUT
{
# Method 24

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while LINE=$(line)
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-28 (*continued*)

```
#######################################
############ START OF MAIN ############
#######################################

# Test the Input

# Looking for exactly one parameter
(( $# == 1 )) || usage

# Does the file exist as a regular file?
[[ -f $1 ]] || usage

echo "\nStarting File Processing of each Method\n"

echo "Method 1:"
echo "function cat_while_read_LINE"
time cat_while_read_LINE
verify_files
sleep 1
echo "\nMethod 2:"
echo "function while_read_LINE_bottom"
time while_read_LINE_bottom
verify_files
sleep 1
echo "\nMethod 3:"
echo "function cat_while_LINE_line"
time cat_while_LINE_line
verify_files
sleep 1
echo "\nMethod 4:"
echo "function while_LINE_line_bottom"
time while_LINE_line_bottom
verify_files
sleep 1
echo "\nMethod 5:"
echo "function cat_while_LINE_line_cmdsub2"
time cat_while_LINE_line_cmdsub2
verify_files
sleep 1
echo "\nMethod 6:"
echo "function while_LINE_line_botton_cmdsub2"
time while_LINE_line_bottom_cmdsub2
verify_files
sleep 1
echo "\nMethod 7:"
echo "function for_LINE_cat_FILE"
time for_LINE_cat_FILE
verify_files
```

Listing 2-28 (*continued*)

```
sleep 1
echo "\nMethod 8:"
echo "function for_LINE_cat_FILE_cmdsub2"
time for_LINE_cat_FILE_cmdsub2
verify_files
sleep 1
echo "\nMethod 9:"
echo "function while_line_outfile"
time while_line_outfile
verify_files
sleep 1
echo "\nMethod 10:"
echo "function while_read_LINE_FD_IN"
time while_read_LINE_FD_IN
verify_files
sleep 1
echo "\nMethod 11:"
echo "function cat_while_read_LINE_FD_OUT"
time cat_while_read_LINE_FD_OUT
verify_files
sleep 1
echo "\nMethod 12:"
echo "function while_read_LINE_bottom_FD_OUT"
time while_read_LINE_bottom_FD_OUT
verify_files
sleep 1
echo "\nMethod 13:"
echo "function while_LINE_line_bottom_FD_OUT"
time while_LINE_line_bottom_FD_OUT
verify_files
sleep 1
echo "\nMethod 14:"
echo "function while_LINE_line_bottom_cmdsub2_FD_OUT"
time while_LINE_line_bottom_cmdsub2_FD_OUT
verify_files
sleep 1
echo "\nMethod 15:"
echo "function for_LINE_cat_FILE_FD_OUT"
time for_LINE_cat_FILE_FD_OUT
verify_files
sleep 1
echo "\nMethod 16:"
echo "function for_LINE_cat_FILE_cmdsub2_FD_OUT"
time for_LINE_cat_FILE_cmdsub2_FD_OUT
verify_files
sleep 1
echo "\nMethod 17:"
echo "function while_line_outfile_FD_IN"
```

Listing 2-28 (*continued*)

```
time while_line_outfile_FD_IN
verify_files
sleep 1
echo "\nMethod 18:"
echo "function while_line_outfile_FD_OUT"
time while_line_outfile_FD_OUT
verify_files
sleep 1
echo "\nMethod 19:"
echo "function while_line_outfile_FD_IN_AND_OUT"
time while_line_outfile_FD_IN_AND_OUT
verify_files
sleep 1
echo "\nMethod 20:"
echo "function while_LINE_line_FD_IN"
time while_LINE_line_FD_IN
verify_files
sleep 1
echo "\nMethod 21:"
echo "function while_LINE_line_cmdsub2_FD_IN"
time while_LINE_line_cmdsub2_FD_IN
verify_files
sleep 1
echo "\nMethod 22:"
echo "function while_read_LINE_FD_IN_AND_OUT"
time while_read_LINE_FD_IN_AND_OUT
verify_files
sleep 1
echo "\nMethod 23:"
echo "function while_LINE_line_FD_IN_AND_OUT"
time while_LINE_line_FD_IN_AND_OUT
verify_files
sleep 1
echo "\nMethod 24:"
echo "function while_LINE_line_cmdsub2_FD_IN_AND_OUT"
time while_LINE_line_cmdsub2_FD_IN_AND_OUT
verify_files
```

Listing 2-28 (*continued*)

The shell script in Listing 2-28 first defines all the functions that we previously covered in the Method sections. After the functions are defined, we do a little testing of the input. We are expecting exactly one command parameter, and it should be a regular file. Look at the code block in Listing 2-29 to see the file testing.

```
# Test the Input

# Looking for exactly one parameter
(( $# == 1 )) || usage
```

Listing 2-29 Code to test command input

```
# Does the file exist as a regular file?
[[ -f $1 ]] || usage
```

Listing 2-29 (*continued*)

The first test checks to ensure that the number of command parameters, specified by the `$#` operator, is exactly one. Notice that we used the *double parentheses* mathematical test, specified as `(( math test ))`. Additionally, we used a logical OR, specified by `||`, to execute the `usage` function if the number of parameters is not equal to one.

We use the same type of test for the file to ensure that the file exists and the file is a regular file, as opposed to a character or block special file. When we do the test, notice that we use the *double bracket* test for character data, specified by `[[ character test ]]`. This is an important distinction to note. We again use the logical OR to execute the `usage` function if the return code from the test is nonzero.

Now we start the actual timing tests. In doing these tests we execute the Method functions one at a time. The function's internal loop does the file processing, but we redirect each function's output to our `$OUTFILE` file so that we always perform the exact same task of reading the `$INFILE` line-by-line, and writing to the `$OUTFILE`. This allows us to get measurable system activity. As I stated before, the timing measurements produced by the `time` commands go to `stderr`, or file descriptor 2, which will just go to the screen by default. When this shell script executes, there are three things that go to the screen, as you will see in Listing 2-30. You can also send all this output to a file by using the following command syntax:

```
24_ways_to_parse.ksh largefile.random.txt > 24_ways_timing.out 2>&1
```

The preceding command starts with the script name, followed by the file to parse through. The output is redirected to the file `24_ways_timing.out` with `stderr` (file descriptor 2) redirected to `stdout` (file descriptor 1), specified by `2>&1`. Do not forget the ampersand, `&`, before the 1. If the `&` is omitted, a file with the name `1` will be created. This is a common mistake when working with file descriptors. The placement of the `stderr` to `stdout` is important in this case. If the `2>&1` is at the end of the command, you will not get the desired result, which is all of the timing data going to a data file. In some cases the placement of the `2>&1` redirection does not matter, but it does matter here.

Timing Data for Each Method

Now all the hard stuff has been done. We have a 12,800-line 1 MB file of random alphanumeric characters, 80 per line, `largefile.random.txt`, and we have our shell script written, so let's find out which function is the fastest in Listing 2-30. Pay particular attention to the bold text in the timing results in Listing 2-30.

```
Starting File Processing of each Method

Method 1:
function cat_while_read_LINE

real    0m8.31s
```

Listing 2-30 Timing data for each loop method

```
user    0m3.18s
sys    0m8.86s

Method 2:
function while_read_LINE_bottom

real    0m0.61s
user    0m0.41s
sys    0m0.20s

Method 3:
function cat_while_LINE_line

real    0m30.87s
user    0m13.74s
sys    0m20.18s

Method 4:
function while_LINE_line_bottom

real    0m31.24s
user    0m13.57s
sys    0m19.70s

Method 5:
function cat_while_LINE_line_cmdsub2

real    0m30.86s
user    0m13.84s
sys    0m20.20s

Method 6:
function while_LINE_line_botton_cmdsub2

real    0m31.20s
user    0m13.69s
sys    0m19.70s

Method 7:
function for_LINE_cat_FILE

real    0m0.74s
user    0m0.54s
sys    0m0.21s

Method 8:
function for_LINE_cat_FILE_cmdsub2

real    0m0.75s
```

Listing 2-30 (*continued*)

```
user    0m0.50s
sys     0m0.24s

Method 9:
function while_line_outfile

real    4m21.14s
user    0m9.44s
sys     4m8.86s
ERROR: largefile.random.txt and writefile.out do not match
-rw-r--r--   1 root     system      1024000 Aug 14 17:41
largefile.random.txt
-rw-r--r--   1 root     system       512000 Aug 20 14:43 writefile.out

Method 10:
function while_read_LINE_FD_IN

real    0m0.62s
user    0m0.42s
sys     0m0.19s

Method 11:
function cat_while_read_LINE_FD_OUT

real    0m7.95s
user    0m3.10s
sys     0m8.89s

Method 12:
function while_read_LINE_bottom_FD_OUT

real    0m0.30s
user    0m0.29s
sys     0m0.00s

Method 13:
function while_LINE_line_bottom_FD_OUT

real    8m33.44s
user    0m14.17s
sys     8m15.83s

Method 14:
function while_LINE_line_bottom_cmdsub2_FD_OUT

real    8m28.52s
user    0m13.97s
sys     8m11.70s
```

Listing 2-30 (*continued*)

```
Method 15:
function for_LINE_cat_FILE_FD_OUT

real    0m0.47s
user    0m0.38s
sys     0m0.06s

Method 16:
function for_LINE_cat_FILE_cmdsub2_FD_OUT

real    0m0.45s
user    0m0.38s
sys     0m0.05s

Method 17:
function while_line_outfile_FD_IN

real    4m21.52s
user    0m9.54s
sys     4m9.39s
ERROR: largefile.random.txt and writefile.out do not match
-rw-r--r--   1 root     system      1024000 Aug 14 17:41
largefile.random.txt
-rw-r--r--   1 root     system       512000 Aug 20 15:05 writefile.out

Method 18:
function while_line_outfile_FD_OUT

real    4m16.12s
user    0m9.33s
sys     4m4.43s
ERROR: largefile.random.txt and writefile.out do not match
-rw-r--r--   1 root    system    1024000 Aug 14 17:41 largefile.random.txt
-rw-r--r--   1 root     system       512000 Aug 20 15:09 writefile.out

Method 19:
function while_line_outfile_FD_IN_AND_OUT

real    4m16.67s
user    0m9.34s
sys     4m4.93s
ERROR: largefile.random.txt and writefile.out do not match
-rw-r--r--   1 root    system    1024000 Aug 14 17:41 largefile.random.txt
-rw-r--r--   1 root     system       512000 Aug 20 15:13 writefile.out

Method 20:
function while_LINE_line_FD_IN
```

Listing 2-30 (*continued*)

```
real    8m33.41s
user    0m14.41s
sys     8m16.23s

Method 21:
function while_LINE_line_cmdsub2_FD_IN

real    8m35.62s
user    0m14.46s
sys     8m17.71s

Method 22:
function while_read_LINE_FD_IN_AND_OUT

real    0m0.31s
user    0m0.29s
sys     0m0.00s

Method 23:
function while_LINE_line_FD_IN_AND_OUT

real    8m27.93s
user    0m14.03s
sys     8m11.04s

Method 24:
function while_LINE_line_cmdsub2_FD_IN_AND_OUT

real    8m27.55s
user    0m14.04s
sys     8m10.56s
```

Listing 2-30 (*continued*)

As you can see, all file-processing loops are not created equal. Two of the methods are tied for first place. Methods 12 and 22 produce the same `real` execution times at 0.30 and 0.31 seconds to process a 12,800-line 1 MB file. Method 16 came in second at 0.45 seconds. The remaining methods range from almost less than 1 second to more than 8 minutes. The sorted timing output for the real time is shown in Listing 2-31.

```
real    0m0.30s  Method 12:
real    0m0.31s  Method 22:
real    0m0.45s  Method 16:
real    0m0.47s  Method 15:
```

Listing 2-31 Sorted timing data by method

```
real    0m0.61s  Method 2:
real    0m0.62s  Method 10:
real    0m0.74s  Method 7:
real    0m0.75s  Method 8:
real    0m30.86s Method 5:
real    0m30.87s Method 3:
real    0m31.20s Method 6:
real    0m31.24s Method 4:
real    0m7.95s  Method 11:
real    0m8.31s  Method 1:
real    4m16.12s Method 18: *FAILS*
real    4m16.67s Method 19: *FAILS*
real    4m21.14s Method 9:  *FAILS*
real    4m21.52s Method 17: *FAILS*
real    8m27.55s Method 24:
real    8m27.93s Method 23:
real    8m28.52s Method 14:
real    8m33.41s Method 20:
real    8m33.44s Method 13:
real    8m35.62s Method 21:
```

Listing 2-31 (*continued*)

Notice that the first eight methods all process this 1 MB text file in *less than one second*. Then notice that the last six methods all take longer than *eight minutes*! Now I hope you see why it is very important *how* we process files. The percentage difference between the fastest method and the slowest method is a whopping 177,773.333 percent!

Let's take a look at the code for the top four techniques. The order of appearance is Methods 12, 22, 16, 15, and 2. For the sake of argument, let's just say that Methods 12 and 22 are tied for first place. Listing 2-32 shows Method 12.

```
function while_read_LINE_bottom_FD_OUT
{
# Method 12

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
```

Listing 2-32 Method 12 — tied for first place

```
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-32 (*continued*)

The method in Listing 2-32 is tied for first place. This method uses my favorite input redirection for files by redirecting input at the bottom of the loop, after the `done` loop terminator. This method does use a file descriptor for redirecting standard output, `stdout`, to file descriptor 1.

The input redirection using `done < $INFILE` greatly speeds up any loop that requires file input. The nice thing about this method of input redirection is that it is intuitive to use for beginners to shell scripting. I was actually surprised that this method tied, actually won by 10 ms, using file descriptors for both input and output files, as shown in Listing 2-33.

```
function while_read_LINE_FD_IN_AND_OUT
{
# Method 22

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


while read LINE
```

Listing 2-33 Method 22 — tied for first place

```
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 2-33 (*continued*)

I tend not to use this method when I write shell scripts because it can be difficult to maintain through the code life cycle. If a user is not familiar with using file descriptors, then a script using this method is extremely hard to understand. The method in Listing 2-32 produces the same timing results, and it is much easier to understand. Listing 2-34 shows the second-place loop method.

```
for_LINE_cat_FILE_cmdsub2_FD_OUT ()
{
# Method 16

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE"
    :
```

Listing 2-34 Method 16 — second place in timing tests

```
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-34 (*continued*)

The method shown in Listing 2-34 is another surprise: a `for` loop using command substitution with file descriptor file output redirection. We try this same type of `for` loop in Listing 2-35, only changing the command-substitution method.

```
for_LINE_cat_FILE_FD_OUT ()
{
# Method 15

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


for LINE in `cat $INFILE`
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 2-35 Method 15 — third place in timing tests

As shown in Listing 2-36, the only difference between Methods 15 and 16 is the technique used for command substitution.

```
Method 15:
function for_LINE_cat_FILE_FD_OUT

real    0m0.47s
user    0m0.38s
sys     0m0.06s

Method 16:
function for_LINE_cat_FILE_cmdsub2_FD_OUT

real    0m0.45s
user    0m0.38s
sys     0m0.05s
```

Listing 2-36 Timing difference between Methods 15 and 16

The timing results indicate 10 ms in system time, or system/kernel time between the command-substitution methods, for a total of 20 ms in real execution time. The method in Listing 2-37 is the fastest method to process a file line-by-line that does not use file descriptors.

```
function while_read_LINE_bottom
{
# Method 2

# Zero out the $OUTFILE

>$OUTFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 2-37 The fastest method not using file descriptors

I use this technique in almost every shell script that does file parsing simply because of the ease of maintaining the shell script throughout the life cycle. Remember, it is not *if* someone will come behind you and need to edit the script sometime in the future, but *when* someone comes behind you to edit your *most excellent script*. They must be able to understand what you did without having to either hack through your code, or just give up and resort to rewriting the entire script.

Timing Command-Substitution Methods

We also want to take a look at the difference in timing when we used the two different methods of command substitution using `` `command` `` versus `$(command)`. See Listing 2-38, in which Method 4 uses the back tic command-substitution method and Method 5 uses the dollar parentheses method of command substitution.

```
function while_LINE_line_bottom
{
# Method 4

# Zero out the $OUTFILE

>$OUTFILE

while LINE=`line`
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
#####################################

function cat_while_LINE_line_cmdsub2
{
# Method 5

# Zero out the $OUTFILE

>$OUTFILE

cat $INFILE | while LINE=$(line)
do
        echo "$LINE" >> $OUTFILE
        :
done
}
```

Listing 2-38 Command-substitution methods

The timing data for these two methods is shown in Listing 2-39.

```
Method 4:
function while_LINE_line_bottom

real    0m31.24s
```

Listing 2-39 Command-substitution timing difference

```
user    0m13.57s
sys    0m19.70s

Method 5:
function cat_while_LINE_line_cmdsub2

real    0m30.86s
user    0m13.84s
sys    0m20.20s
```

Listing 2-39 (*continued*)

In Method 4 the command-substitution technique uses back tics, `` `command` ``, which are located in the top-left corner of a standard keyboard. The command-substitution technique used in Method 5 is the dollar parentheses technique, `$(command)`. Both command-substitution methods give the same end result, but one method is slightly faster than the other in *real* time. From the timing of each method in Listing 2-39, the `$(command)` method won the *real time* race by only 0.38 seconds. But, look at both the *user* and *sys* times! The back tic method uses fewer system resources. However, this difference in timing is so small that it is really not an issue.

What about Using Command Input Instead of File Input?

I get this a lot. We do not always want to redirect command output to a file, and then process the file. That extra step takes up both system CPU cycles and disk I/O time. Of course, we can run the command and pipe the output to a `while read` loop. The problem with a pipe is the 2,048-character limit of ''system temporary files'' that the pipe uses.

The technique shown in Listing 2-40 is a nice little trick to save both CPU cycles and disk I/Os, and to get around the pipe's 2,048-character limit.

```
while read LINE
do
    echo "$LINE"

done <  <(command)
```

Listing 2-40 Using command output in a loop

Now, I know this looks a bit odd. I got this trick from one of my co-workers, Brian Beers. What we are doing here is input redirection from the bottom of the loop, after the `done` loop terminator, specified by the `done <` notation. The `<(command)` notation executes the command and points the command's output into the bottom of the loop.

NOTE **The space between the two < < in < < `(command)` is required!**

Summary

This chapter covered the various techniques for parsing a file line-by-line that I have seen over the years. You may have seen even more oddball ways to process a file. The two points that I wanted to make in this chapter are these: first, there are many ways to handle any task on a UNIX platform, and second, some techniques that are used to process a file waste a lot of CPU time. Most of the wasted time is spent in unnecessary variable assignments and continuously opening and closing the same file over and over. Using a pipe also has a negative impact on the loop timing, and adds the limitation of the 2,048-character length that the pipe has.

On a small file this is not a big deal, but for large parsing jobs a large delta in timing can have a huge impact both on the machine resources and on the time involved.

Lab Assignments

1. Evaluate the following function:

```
while_true_read_echo_line ()
{
while true
do

   read LINE
   echo "$LINE" > $OUTFILE
   :
done < $INFILE
}
```

   Does it work?

   If it works, how long does it take to process a 1 MB file?

   If it works, by what percentage can you improve the timing by using file descriptors for

   - Input file?
   - Output file?
   - Both input and output files?

2. Write a shell script that will display every line in the `/etc/hosts` file that is not commented out with a # (hash mark), using command, not file, input redirection.

CHAPTER 3

Automated Event Notification

To solve problems proactively, early warning is essential. In this chapter we are going to look at some techniques of getting the word out by automating the notification when a system event occurs. When we write monitoring shell scripts and there is a failure, success, or request, we need a method of getting a message to the right people. There are really three main strategies of notification in shell scripts. The first is to send an email directly to the user. We can also send an alphanumeric page by email to the user for immediate notification to a cell phone or pager. The third is to send a text page by dialing a modem to the service provider. We are mainly going to look at the first two methods, but we will also list some good software products that will send text pages by dialing the modem and transferring the message to the cellular/pager provider.

In some shops email is so restricted that you have to use a little trick or two to get around some of the restrictions. We will cover some of these situations, too.

Basics of Automating Event Notification

In a shell script there are times when you want to send an automated notification. As an example, if you are monitoring filesystems and your script finds that one of the filesystems has exceeded the maximum threshold, then most likely you want to be informed of this situation. I always like an email notification when the backups complete every night — not just when there is a backup error, but when the backup is successful, too. This way I always know the status of last night's backup every morning just by checking my email. I also know that a major backup problem occurred if no email was sent at all. There are a few ways to do the notification, but the most common is through email to a cell phone, a text pager, or an email account. In the next few sections we are going to look at the techniques to get the message out, even if only one server has mail access.

Using the mail and mailx Commands

The most common notification methods use the **mail** and **mailx** commands. To add a subject to the email, we can add the `-s` switch followed by the subject enclosed in quotes. The basic syntax of both email commands is shown in the following code:

```
mail -s "This is the subject" $MAILOUT_LIST < $MAIL_FILE
```

or

```
cat $MAIL_FILE | mail -s "This is the subject" $MAILOUT_LIST
```

or

```
mailx -s "This is the subject" $MAILOUT_LIST < $MAIL_FILE
```

or

```
cat $MAIL_FILE | mailx -s "This is the subject" $MAILOUT_LIST
```

Notice the use of the `MAILOUT_LIST` and `MAIL_FILE` variables. The `MAILOUT_LIST` variable contains a list of email addresses, or email aliases, to send the message to.

The following examples use a *sendmail alias*, specified by `mail_alias`. The `MAIL_FILE` variable points to a filename that holds the message text to be sent.

```
mail -s "This is the subject" mail_alias > $MAIL_FILE
```

or

```
cat $MAIL_FILE | mail -s "This is the subject" mail_alias
```

or

```
mailx -s "This is the subject" mail_alias > $MAIL_FILE
```

or

```
cat $MAIL_FILE | mailx -s "This is the subject" mail_alias
```

NOTE Not all systems support the `mailx` command, but the systems that do have support use the same syntax as the `mail` command. To be safe when dealing with multiple UNIX platforms, always use the `mail` command.

The `MAIL_FILE` variable points to a filename that holds the message text to be sent. Let's look at each of these individually.

Suppose we are monitoring the filesystems on a machine and the `/var` filesystem has reached 98 percent utilization, which is over the 85-percent threshold for a filesystem to be considered full. The Systems Administrator needs to get a page about this situation

quickly, or we may have a machine crash when /var fills up; the same is true for the root filesystem, /. In the monitoring shell script there is a MAIL_FILE variable defined to point to the filename /tmp/mailfile.out,MAILFILE=/tmp/mailfile.out. Then we create a zero-sized mail-out file using cat /dev/null > $MAIL_FILE. When an error is found, which in our case is when /var has reached 98 percent, a message is appended to the $MAIL_FILE for later mailing. If more errors are found, they are also appended to the file as the shell script processes each task. At the end of the shell script we can test the size of the $MAIL_FILE. If the $MAILFILE has any data in it, the file will have a size greater than 0 bytes. If the file has data, we mail the file. If the file is empty with a 0-byte file size, we do nothing.

To illustrate this idea, let's study the code segment in Listing 3-1.

```
MAIL_FILE=/tmp/mailfile.out
cat /dev/null > $MAIL_FILE
MAIL_LIST="randy@my.domain.com 1234567890@mypage_somebody.net"

check_filesystems   # This function checks the filesystems percentage

if [ -s $MAIL_FILE ]
then
     mail -s "Filesystem Full" $MAIL_LIST > $MAIL_FILE
fi
```

Listing 3-1 Typical mail code segment

In Listing 3-1 we see a code segment that defines the MAIL_FILE and MAIL_LIST variables that we use in the mail command. After the definitions this code segment executes the function that looks for filesystems that are over the threshold. If the threshold is exceeded, a message is appended to the $MAIL_FILE file, as shown in the following code segment:

```
FS=/var
PERCENT=98
THISHOST=$(uname -n)

echo "$THISHOST: $FS is $PERCENT" | tee -a $MAIL_FILE
```

This code segment is from the checkfilesystems function. For my machine, this echo command statement would both display the following message to the screen and append it to the $MAILFILE file:

```
yogi: /var is 98%
```

The hostname is yogi, the filesystem is /var, and the percentage of used space is 98. Notice the **tee** command after the pipe (|) from the echo statement. In this case we want to display the results on the screen and send an email with the same data.

The `tee -a` command does this double duty when you pipe the output to `| tee -a $FILENAME`.

After the `checkfilesystems` function finishes, we test the size of the `$MAILFILE`. If it is greater than 0 bytes in size, we send a mail message using the `mail` command. The following message is sent to the `randy@my.domain.com` and `1234567890@mypage_somebody.net` email addresses:

```
yogi: /var is 98%
```

Setting Up a sendmail Alias

It is far easier to set up and maintain a sendmail alias than to add and delete email addresses by editing a shell script. The first step is to find the `aliases` file. Depending on the UNIX flavor, you will find the `aliases` file in `/etc`, `/etc/mail`, or `/etc/sendmail`. Next, edit the `aliases` file using your favorite text editor. As an example, let's add a new alias called `sasupport`. This new alias will consist of the `randy@my.domain.com` and `1234567890@mypagesomebody.net` email addresses:

```
sa_support: randy@my.domain.com, 1234567890@mypagesomebody.net
```

For the new alias to be recognized, we must run the **newaliases** command. The `newaliases` command forces `sendmail` to reread the `aliases` file. This command also does error checking for you.

This sendmail alias entry for `sasupport` allows us to send an email to everyone in the list by using the `sasupport` sendmail alias, as follows:

```
mailx -s "This is the subject" sasupport < $MAIL_FILE
```

Remember to put a comma (`,`) between each email address in the `aliases` file.

Problems with Outbound Mail

Before we hard-code the `mail` command into your shell script we need to do a little test to see if we can get the email to the destination without error. To test the functionality, add the `-v` switch to the `mail` or `mailx` command, as shown in Listing 3-2.

```
# echo "Testing: /var is 98%" > /tmp/mailfile.out

# mail -v -s "Filesystem Full" randy@my.domain.com > /tmp/mailfile.out

AND

# mail -v -s "Filesystem Full" 1234567890@mypage_somebody.net \
  > /tmp/mailfile.out
```

Listing 3-2 Testing the mail service using mail -v

With the -v switch added to the mail command, all the details of the delivery are displayed on the user's terminal. From the delivery details we can see any errors that happen until the file is considered ''sent'' by the local host. If the message is not delivered to the target email address, then further investigation is needed. Listing 3-3 shows an example of using the –v, verbose, mail switch.

```
randy@yogi... Connecting to [127.0.0.1] via relay...
220 booboo ESMTP Sendmail 8.14.1/8.14.1; Wed, 5 Dec 2007 08:27:05 -0500
>>> EHLO booboo
250-booboo Hello localhost.localdomain [127.0.0.1], pleased to meet you
250-ENHANCEDSTATUSCODES
250-PIPELINING
250-8BITMIME
250-SIZE
250-DSN
250-ETRN
250-AUTH DIGEST-MD5 CRAM-MD5
250-DELIVERBY
250 HELP
>>> MAIL From:>root@booboo> SIZE=1692 AUTH=root@booboo
250 2.1.0 >root@booboo>... Sender ok
>>> RCPT To:>randy@yogi>
>>> DATA
250 2.1.5 >randy@yogi>... Recipient ok
 354 Enter mail, end with "." on a line by itself
>>> .
250 2.0.0 lB5DR5av009324 Message accepted for delivery
randy@yogi... Sent (lB5DR5av009324 Message accepted for delivery)
Closing connection to [127.0.0.1]
>>> QUIT
221 2.0.0 booboo closing connection
```

Listing 3-3 Example of verbose mail mode using the –v switch

As you can see, using mail–v gives a lot of detail for troubleshooting a failed connection to the mail server. A few troubleshooting tips are included here. The first step is to ensure sendmail is running by executing the following command:

```
[yogi]@/etc/mail# ps ax | grep sendmail
  5168      - A     2:37 sendmail: accepting connections
 14810  pts/0 A     0:00 grep sendmail
[root:yogi]@/etc/mail#
```

If you do not see sendmail running, it needs to be started. See the Systems Administrator, if that person is not you.

If sendmail is running, you may need to add your location's mail gateway if you have a centralized email server. To configure this, locate the sendmail.cf file in the

/etc, /etc/mail, or /etc/sendmail directory, depending on your UNIX flavor. The sendmail.cf file is a very complex file full of rules. We just want to search for the DS field, which specifies the smart relay host. If the DS field is not set, add your mail gateway server name. For example, we have one called mailgw defined in our /etc/hosts file, so I add the following entry to the sendmail.cf file:

```
DSmailgw
```

or

```
DSmailgw.my_company_domain.com
```

Notice we may need the fully qualified name of the mail server. Do not add a space between the DS and mailgw. You can also use an IP address.

Now we need to have sendmail reread the configuration file sendmail.cf. To do this we need to find the sendmail process ID and run a kill -HUP process_id. Don't worry; this command just causes a reread of the sendmail.cf file. In AIX, if sendmail is under control of the Systems Resource Controller (SRC), you can use refresh -s sendmail to have sendmail reread the configuration file. You can check by running lssrc -s sendmail.

```
[root:yogi]@/etc/mail# ps ax | grep sendmail
  5168      - A     2:37 sendmail: accepting connections
 14810  pts/0 A     0:00 grep sendmail
[root:yogi]@/etc/mail# kill -HUP 5168
[root:yogi]@/etc/mail#
```

After completing this step, try sending another email. Remember to add the -v switch to the mail command.

If the email still does not get to the destination, we can try one more thing. Let's ensure that the hosts have a fully qualified hostname in the /etc/hosts file, unless you are using DNS. A fully qualified hostname includes the domain part of the network name. Here is an example:

```
yogi.mycompany_domain.com
```

If you use a /etc/hosts file, add an alias using the fully qualified hostname. Be sure to check the mail gateway, or smart relay server, as well as the machines where the script is executing.

If you still cannot send an email, see the Systems Administrator and Network Administrator. The next two sections look at some alternative techniques.

Creating a "Bounce" Account with a .forward File

I worked at one shop where only one UNIX machine in the network, other than the mail server, was allowed to send email outside of the LAN. This presented a problem for all of the other machines to get the message out when a script detected an error.

The solution we used was to create a user account on the UNIX machine that could send email outbound. Then we locked down this user account so no one could log in remotely. Let's say we create a user account called `bounce`. In the `/home/bounce` directory we create a file called `/home/bounce/.forward`. Then in the `.forward` file we add the email address to which we want to forward all mail. You can add as many email addresses to this file as you want, but be aware that every single email will be forwarded to *each* address listed in the `.forward` file.

On this single machine that has outside LAN mailing capability we added the user `bounce` to the system. Then in the `/home/bounce` directory we created a file called `.forward` that has the following entries:

```
randy@my.domain.com
1234567890@mypage_somebody.net
```

This `.forward` file will forward all mail received by the `bounce` user to the `randy@my.domain.com` and `1234567890@mypagesomebody.net` email addresses. This way I have an email to my desktop, and I am also notified on my cell phone by text page. On all the other machines we have two options. The first option is to edit all the shell scripts that send email notification and change the `$MAIL_LIST` variable to

```
MAIL_LIST="bounce@dino."
```

This entry assumes that the `dino` host is in the same domain, specified by the period that follows the hostname **dino** (`dino.`).

As we saw earlier, an easier way is to create some entries in the `aliases` file for sendmail. The `aliases` file is usually located in `/etc/aliases`, but you may find it in `/etc/mail/aliases` or `/etc/sendmail/aliases` on some operating systems. The format of defining an alias is a name, username, or tag, followed by one or more email addresses. The following is an example of an `aliases` file:

```
admin:      bounce@dino.,randy,brad,cindy,jon,pepe
```

This `aliases` file entry creates a new alias called `admin` that automatically sends email to the `bounce` account on `dino` and also to `randy`, `brad`, `cindy`, `jon`, and `pepe`.

Before these changes will take effect, we need to run the `newaliases` command. The `sendmail -bi` command works, too.

Using the sendmail Command to Send Outbound Mail

In another shop where I worked, I could not send outbound mail from any user named `root`. The *from* field had to be a valid email address that is recognized by the mail server, and `root` is not valid. To get around this little problem, I changed the command that I used from `mail` to `sendmail` or `mailx`. The **sendmail** command enables us to add the `-f` switch to indicate a valid internal email address for the *from* field. The `mailx` command supports the same functionality using the `-r` switch. The `sendmail` command is in `/usr/sbin/sendmail` on AIX, HP-UX, Linux, and OpenBSD, but on SunOS the location changed to `/usr/lib/sendmail`. Look at the function in Listing 3-4, and we will cover the details at the end.

```
function send_notification
{
if [ -s $MAIL_FILE -a  "$MAILOUT" = "TRUE" ];
then
        case $(uname) in
        AIX|HP-UX|Linux|OpenBSD) SENDMAIL="/usr/sbin/sendmail"
                        ;;
        SunOS)          SENDMAIL="/usr/lib/sendmail"
                        ;;
        esac

        echo "\nSending email notification"
        $SENDMAIL -f randy@$THISHOST $MAIL_LIST > $MAIL_FILE
fi
}
```

Listing 3-4 send_notification function

Notice in Listing 3-4 that we added another variable, `MAILOUT`. This variable is used to turn on/off the email notifications. If the `$MAILOUT` variable points to `TRUE`, and the `$MAIL_FILE` file is not empty, then the email is sent. If the `$MAILOUT` variable does not equal the string `TRUE`, the email is disabled. This is just another way to control the email notifications.

In the `case` statement we use the output of the **uname** command to set the correct command path for the `sendmail` command on the UNIX platform. For AIX, HP-UX, Linux, and OpenBSD the `sendmail` command path is `/usr/sbin`. On SunOS the `sendmail` path is `/usr/lib`. We assign the correct path to the `SENDMAIL` variable, and we use this variable as the command to send the mail. Once the command is defined, we issue the command, as shown here:

```
$SENDMAIL -f randy@$THISHOST $MAIL_LIST > $MAIL_FILE
```

We issue the `sendmail` command using the `-f` switch and follow the switch by a valid email account name, which is `randy@$THISHOST`. Remember that we defined the `THISHOST` variable to the local machine's hostname. The *from* address is followed by the list of email addresses, and the message file is used by redirecting input into the `sendmail` command. We can also use the following syntax:

```
cat $MAIL_FILE | $SENDMAIL -f randy@$THISHOST $MAIL_LIST
```

Either `sendmail` statement will send the mail, assuming the mail server and firewall allow outgoing mail.

We can do the exact same thing using `mailx -r randy@$THISHOST` command syntax:

```
cat $MAIL_FILE | mailx -r randy@$THISHOST $MAIL_LIST
```

The `mailx` command is located in `/usr/bin`. If you want a subject heading, add the `-s` switch followed by the subject text enclosed in double quotes.

Dial-Out Modem Software

Many good products are on the market, both freeware and commercial, that handle large amounts of paging better than any shell script could ever do. They also have the ability to dial the modem and send the message to the provider. A list of such products is shown in Table 3-1.

Table 3-1 shows only a sample of the products available for paging in a UNIX environment. There are others for Windows systems. The nice thing about these products is the ability to dial out on a modem. At some level in every shop there is a need to use a phone line for communications instead of the network. This gives you the ability to get the message out even if the network is having a problem.

Table 3-1 Products That Handle High-Volume Paging and Modem Dialing

PRODUCT	DESCRIPTION
Freeware and Shareware Products	
QuickPage	Client/server software used to send messages to alphanumeric pagers.
SMS Client	Command-line utility for UNIX that allows you to send SMS messages to cell phones and pagers.
HylaFAX+	Faxing product for UNIX that allows dial-in, dial-out, fax-in, fax-out, and pager notifications.
Commercial Products	
EtherPage	Enterprise-wide alphanumeric pager software made by iTechTool.
TelAlert	Pager notification and interactive voice response software made by CalAmp.
FirstPAGE	Supports all national paging networks using IXO/TAP; made by Segent.

SNMP Traps

Most large shops use an enterprise-monitoring tool to monitor all of the systems from a central management console. The server software is installed on a single machine called the management station. All of the managed/monitored machines have the client software installed. This client software is an SNMP agent and uses a local MIB to define the *managed objects*, or *management variables*. These managed objects define things such as the filesystems to monitor and the trigger threshold for detecting a full filesystem. When the managed object, which in this case is a full filesystem, exceeds the set threshold, a local SNMP *trap* is generated and the management station captures the trap and performs the predefined action, which may be to send a text page

to the Systems Administrator. To understand what an SNMP trap is, let's review a short explanation of each of the pieces:

- **SNMP (Simple Network Management Protocol)** — SNMP is a protocol used for agent communications. The most common use for the SNMP protocol is client/server system management software.
- **MIB (Management Information Base)** — Each managed machine, or agent, in an SNMP-managed network maintains a local database of information (MIB) defined to the network managed machine. An SNMP-compliant MIB contains information about the property definitions of each of the managed resources.
- **SNMP trap** — When a threshold is exceeded there is an event notification to the management server from an agent-generated event, called a trap. The server management station receives and sets objects in the MIB, and the local machine, or agent, notifies the management station of client-generated events, or traps. All of the communication between the network management server and its agents, or management clients, takes place using SNMP.

The nice thing about using an enterprise management tool is that it utilizes SNMP. With most products you can write your own shell scripts using SNMP traps. The details vary for the specific syntax for each product, but with the software installed you can have your shell scripts perform the same notifications that the enterprise management software produces. Using Tivoli NetView, EcoTools, or BMC Patrol (just to name a few), you have the ability to incorporate SNMP traps into your own shell scripts for event notifications. Please refer to the product documentation for details on creating and using SNMP traps.

Summary

This chapter is intended to give a brief overview of some techniques of getting critical information out to the system-management community. This chapter mainly focused on email and some different techniques for using the mail commands.

The topics discussed here form the basics for notification of system problems. You should be able to extend the list of notification techniques without much effort. If you have an enterprise management solution installed at your shop, study the vendor documentation on using and creating SNMP traps. There are books based entirely on SNMP, and the information is just too long to cover in this book, but it is an important notification method that you need to be familiar with. If you have trouble getting the email solution to work, talk with the Network Manager to find a solution.

In the next chapter we move on to look at creating progress indicators to give our users feedback on long-running processes. The topics include a series of dots as the processing continues, a line that appears to rotate as processing continues, and elapsed time.

Lab Assignments

1. Send the following email message to yourself from your UNIX server:

   `This is a test from` *`hostname`*

   where `hostname` is the UNIX hostname from which the email originates. Use each method, including `mail`, `mailx`, and `sendmail` commands in a shell script.

2. Send the same message using `mailx` and `sendmail` commands, but this time specify a return email address that is not your own. When you receive the email, who is it from?

CHAPTER 4

Progress Indicators Using a Series of Dots, a Rotating Line, or Elapsed Time

Giving your end users feedback that a script or program is not hung is vital on long processing jobs. We sometimes write shell scripts that take a long time to completely execute — for example, system-backup scripts and replicating data using `rsync`. A good way to keep everyone content is to have some kind of progress indicator. Just about anything can be a progress indicator as long as the end user gets the idea that job processing is continuing. In this chapter we are going to examine the following three progress indicators, which are fairly common:

- A series of dots
- A rotating line
- Elapsed time

We see the series-of-dots, rotating-line, and elapsed-time methods for user feedback in many installation programs, backup routines, and other long-running processes. Each of these methods can be started as a separate script, as a function, putting the code in a loop directly, or as a background process. We will cover the most common practices here.

Indicating Progress with a Series of Dots

The simplest form of progress indicator is to print a period to the screen every five seconds to five minutes, depending on the expected processing time. It is simple, clean, and very easy to do. As with every script, we start out with the command syntax. All we want to do is `echo` a dot to the screen while continuing on the same line.

For Korn shell, use

```
echo ".\c"
```

For Bourne and Bash shell, use

```
echo -e ".\c"
```

For the sake of simplicity, we are going to treat both options as **echo**. This `echo` command prints a single dot on the screen, and the backslash `c` (`\c`) specifies a continuation on the same line without a new line or carriage return. To make a series of dots, we will put this single command in a loop with some sleep time between each dot. For example, we will use a `while` loop that loops forever with a 10-second sleep between printing each dot on the screen:

```
while true
do
     echo ".\c"
     sleep 10
done
```

The placement of the `sleep` statement can be important; it just depends on your application. If, for instance, we want to allow time for a backup script to start executing before we monitor the process, we want to put the `sleep` statement at the top of the `while` loop. Then again, if we are trying to monitor a currently running process, we want to verify that the process is running first. In this case, we want the `sleep` statement at the end of the `while` loop. We could also put this `while` loop in the background and save the last background process ID (PID) This way, we can kill the progress indicator when the backup script execution is complete. First, we will just put this `while` loop in the background, or we can create a function with this loop and run the function in the background. Both methods are shown in Listings 4-1 and 4-2, respectively.

```
while true
do
     sleep 60
     echo ".\c"
done &

BG_PID=$!

/usr/local/bin/my_backup.ksh

kill $BG_PID
echo
```

Listing 4-1 Looping in the background

To accomplish the background loop, notice that we just put an ampersand, `&`, after the end of the `while` loop, after `done`. The next line uses the `$!` operator, which saves the PID of the last background process, `BG_PID=$!`. The background loop sleeps at the beginning of the loop, allowing time for the backup script,

/usr/local/bin/my_backup.ksh, to start executing in the foreground before the dots start ticking. When the backup script is complete, we use the **kill** command to stop the dots by killing the background job, specified by `kill $BG_PID`. Notice that we add one more `echo` at the end. This `echo` takes care of the new line/carriage return because we have been continuing on the same line with the dots.

We can accomplish the same task with a function, as shown in Listing 4-2.

```
function dots
{
SEC=$1  # How many seconds between dots?

while true
do
     sleep $SEC
     echo ".\c"
done
}

###################################
#    Beginning of Main
###################################

dots 60 &

BG_PID=$!

/usr/local/bin/my_backup.ksh

kill $BG_PID
echo
```

Listing 4-2 Using a background function

The script and function in Listing 4-2 accomplish the same task but use a background function instead of just putting the `while` loop itself in the background. We still capture the PID of the last background process of the `dots` function, specified by `$!`, so we can `kill` the function when the backup script has completed, as we did in the previous example. We could also put the loop in a separate shell script and run the external script in the background, but this would be overkill for three lines of code.

We are going to come back to the series-of-dots method again in this chapter.

Indicating Progress with a Rotating Line

If a series of dots is too boring, we could use a rotating line as a progress indicator. To rotate the line, we will again use the `echo` command, but this time we need a little more cursor control. This method requires that we display, in a series, the forward slash

(/), and then a hyphen (-), followed by a backslash (\), and then a pipe (|), and then repeat the process. For this character series to appear seamless, we need to backspace over the last character and erase it, or overwrite it with the new character that makes the line appear to rotate. We will use a `case` statement inside a `while` loop, as shown in Listing 4-3.

```
function rotate
{
# PURPOSE: This function is used to give the end user
# some feedback that "something" is running.  It gives
# a line rotating in a circle. This function is started
# as a background process. Assign its PID to a variable
# using
#       rotate &      # To start
#       ROTATE_PID=$! # Get the PID of the last
#                     # background job
#
#       At the end of execution just break out by
#       killing the $ROTATE_PID process. We also need
#       to do a quick "cleanup" of the leftover line of
#       rotate output.
#
#       FROM THE SCRIPT:
#             kill -9 $ROTATE_PID
#             echo "\b\b   "

INTERVAL=1  # Sleep time between rotation intervals
RCOUNT="0"  # For each RCOUNT the line rotates 1/8
            # cycle

while :        # Loop forever...until this function is killed
do
     (( RCOUNT = RCOUNT + 1 ))   # Increment the RCOUNT

     case $RCOUNT in
           1) echo '-'"\b\c"
              sleep $INTERVAL
              ;;
           2) echo '\\'"\b\c"
              sleep $INTERVAL
              ;;
           3) echo "|\b\c"
              sleep $INTERVAL
              ;;
           4) echo "/\b\c"
              sleep $INTERVAL
              ;;
```

Listing 4-3 Rotate function

```
            *)   RCOUNT="0"   # Reset the RCOUNT to "0", zero.
                 ;;
     esac
done
} # End of Function - rotate
```

Listing 4-3 (*continued*)

NOTE **If you are executing this code in Bash shell, you will need to enable the backslash `echo` operators by adding the `-e` switch, as shown here:**

```
echo -e "-""\b\c"

echo -e '\\'"\b\c"
```

In the function in Listing 4-3, we first define an interval to sleep between updates. If we do not have some sleep time, the load on the system will be noticeable just doing I/O to our tty terminal device doing the `echo` statement updates. We just want to give the end user some feedback, not load down the system. We will use a one-second interval between screen updates. Next we start an infinite `while` loop and use the `RCOUNT` variable to control which part of the rotating line is displayed during the interval. Notice that each time we `echo` a piece of the rotating line, we also back up the cursor with `\b` and continue on the same line with `\c`; both are needed. This way the next loop iteration will overwrite the previous character with a new character, and then we again back up the cursor and continue on the same line. This series of characters gives the appearance of a rotating line.

We use this function just like the previous example using the `dots` function in Listing 4-4. We start the function in the background, save the PID of the background function using the `$!` operator, then start our time-consuming task. When complete, we `kill` the background `rotate` function. We could also just put the `while` loop in the background without using a function. In either case, when the rotating line is killed, we need to clean up the last characters on the screen. To do the cleanup we just back up the cursor and overwrite the last character with a blank space (see Listing 4-4).

```
#####################################
#   Beginning of Main
#####################################

rotate &

ROTATE_PID=$!

/usr/local/bin/my_time_consuming_task.ksh
```

Listing 4-4 Example of rotate function in a shell script

```
kill -9 $ROTATE_PID

# Cleanup...

echo "\b\b  "

# End of Example
```

Listing 4-4 (*continued*)

These scripts work well and execute cleanly, but do not forget to give some sleep time on each loop iteration. Now we have shown the series-of-dots and rotating-line methods. Another method that is very useful is elapsed time.

Indicating Progress with Elapsed Time

For this method, we need to do a little math. This is not difficult math, so if math is not your top subject, don't worry. We will use the shell variable `SECONDS` to let the system keep up with the time. We just need to calculate the hours, minutes, and seconds, and then display the data in a readable manner.

In this chapter, we will use the `ECHO` variable where we need to use the `echo` command. We define the correct usage for the `echo` command to enable the backslash operators based on the executing shell. If the executing shell is Bash, we add the `-e` switch to the `echo` command.

The math we need is simple division and remainder calculations. To do math, we use our math operator `$(( math statement ))`. To do simple division, in an `echo` statement, use the following syntax:

```
$ECHO "Elapsed time: $(( $SECONDS / 60 )) minutes"
```

This statement will divide the value of the `SECONDS` shell variable by 60 (calculating minutes) and display the result followed by the word ''minutes.'' The problem here is that we can lose up to 59 seconds in the timing. To calculate the seconds left over, we use the remainder operator `%` just like we use the forward slash (`/`) for division. The next statement will calculate both the minutes and seconds:

```
$ECHO "Elapsed time: $(( $SECONDS / 60 )) minutes\
$(( $SECONDS % 60 )) seconds"
```

The backslash (\) continues the previous command statement on the next line. To calculate hours, we just take this procedure one more level. The `elapsed_time` function will show the entire elapsed time calculation process (see Listing 4-5).

```
elapsed_time ()
{
SEC=$1

(( SEC < 60 )) && $ECHO "[Elapsed time: \
$SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && $ECHO \
"[Elapsed time: $(( SEC / 60 )) min $(( SEC % 60 )) \
 sec]\c"

(( SEC > 3600 )) && $ECHO "[Elapsed time: \
$(( SEC / 3600 )) hr $(( (SEC % 3600) / 60 )) min \
$(( (SEC % 3600) % 60 )) sec]\c"
}
```

Listing 4-5 elapsed_time function

Notice in Listing 4-5 that we need to test the value of `$SEC`, which is passed to the function as argument `$1`. The three tests required include less than 60 seconds, between 60 and 3600 seconds (1 minute to 1 hour), and more than 3600 seconds (over 1 hour). These tests are to ensure we display the correct number of hours, minutes, and seconds. The specific tests are shown here:

```
(( SEC < 60 )) && $ECHO "[Elapsed

(( SEC >= 60 && SEC < 3600 )) && $ECHO "[Elapsed

(( SEC > 3600 )) && $ECHO "[Elapsed
```

The calculation for `SECONDS` greater than 3600 goes like this: To calculate hours, we divide the `$SECONDS` value by 3600 (the number of seconds in one hour). Then we use the remainder calculation to get the minutes. Then we use the remainder of the minutes to calculate the seconds. The use of the `elapsed_time` function is shown in the `timing_test_function.Bash` script shown in Listing 4-6.

```
#!/bin/Bash
# SCRIPT: timing_test_function.Bash
# AUTHOR: Randy Michael
#
#
```

Listing 4-6 Shell script listing for timing_test_function.Bash

```
######## DEFINE VARIABLES HERE #############

# Ready script for ksh or Bash
ECHO=echo
[[ $(basename $SHELL) = Bash ]] && ECHO="echo -e"
######## DEFINE FUNCTIONS HERE #############

elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && $ECHO "[Elapsed time: $SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && $ECHO "[Elapsed time:
$(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && $ECHO "[Elapsed time: \
$(( SEC / 3600 )) hr $(( (SEC % 3600) / 60 )) min\ $((
(SEC % 3600) % 60 )) sec]\c"
}

###### BEGINNING OF MAIN

SECONDS=15
elapsed_time $SECONDS
$ECHO
SECONDS=60
elapsed_time $SECONDS
$ECHO
SECONDS=3844
elapsed_time $SECONDS
$ECHO
```

Listing 4-6 (*continued*)

This quick little script in Listing 4-6 shows how you can arbitrarily set the `SECONDS` shell variable to anything you want, and it keeps on ticking from that new value. The script is shown in action in Listing 4-7.

```
[Elapsed time: 15 seconds]
[Elapsed time: 1 min 0 sec]
[Elapsed time: 1 hr 4 min 4 sec]
```

Listing 4-7 Elapsed time shell script in action

Now let's put together some of the pieces.

Combining Feedback Methods

One of my favorite methods of user feedback for long-running process and log files is to combine the series-of-dots and elapsed-time methods. Now that we have the `elapsed_time` function, this task is pretty simple. The method in Listing 4-8 is from the `rsync_daily_copy.ksh` script in Chapter 7, ''Using rsync to Efficiently Replicate Data.'' Let's look at some example code in Listing 4-8.

```
#
# While the rsync processes are executing this
# loop will place a . (dot) every 60 seconds
# as feedback to the end user that the background
# rsync copy processes are still executing. When
# the remaining rsync sessions are less than the
# total number of sessions (normally 36) this loop
# will give feedback as to the number of remaining
# rsync session, as well as the elapsed time of
# the procesing, every 5 minutes.

######## DEFIND VARIABLES HERE ############

# Set the default echo command usage
ECHO="echo"

# Test the $SHELL for Bash and set Bash echo usage
[[ $(basename $SHELL) = Bash ]] && ECHO="echo -e"

SECONDS=10
MIN_COUNTER=0
PATTERN="oradata${DAY}_[0-1][0-9]"
RSYNC_CMD="rsync -avz"
TOTAL_SESSIONS=$(ps -ef | grep "$RSYNC_CMD" \
                 | grep "$PATTERN" \
                 | grep -v grep \
                 | awk '{print $2}' | wc -l)

############ BEGINNING OF MAIN #############

# Loop until all rsync processing completes.

until  (( REM_SESSIONS == 0 ))
do
    sleep 60
    $ECHO ".\c"   # Type a dot every minute
```

Listing 4-8 Combining feedback methods

```
    # Query the system for remaining rsync sessions

     REM_SESSIONS=$(ps -ef | grep "$RSYNC_CMD" \
                    | grep "$PATTERN"  \
                    | grep -v grep  \
                    | awk '{print $2}' | wc -l)

    # If the remaining sessions is less than the
    # $TOTAL sessions then give the elapsed time
    # every 5 minutes with an update of the
    # remaining sessions.

    if (( REM_SESSIONS < TOTAL_SESSIONS ))
    then
       # Increment the minute counter
       (( MIN_COUNTER = MIN_COUNTER + 1 ))
       if (( MIN_COUNTER >= 5 ))
       then
          # Hit the 5 minute mark!
          MIN_COUNTER=0
          $ECHO "\n$REM_SESSIONS of $TOTAL_SESSIONS rsync
sessions remaining $(elapsed_time $SECONDS)\c"

        if (( REM_SESSIONS <= $(( TOTAL / 4 ))  ))
           then
              $ECHO "\nRemaining rsync sessions include:\n"
              ps -ef | grep "rsync -avz"  \
                     | grep "$PATTERN" \
                     | grep -v grep
               $ECHO
            fi
         fi
     fi
done
```

Listing 4-8 (*continued*)

This is a code snippet of the feedback process. What we do not see in this code from Chapter 7 are all of the `rsync` sessions that were started in the background. Additionally, the variable assignments are added for clarification. Listing 4-9 shows the `rsync` copy script in action.

```
12 of 36 rsync sessions remaining [Elapsed time: 1 hr 4 min 4 sec].....
10 of 36 rsync sessions remaining [Elapsed time: 1 hr 9 min 14 sec].....
10 of 36 rsync sessions remaining [Elapsed time: 1 hr 14 min 4 sec].....
4 of 36 rsync sessions remaining [Elapsed time: 1 hr 19 min 4 sec].....
```

Listing 4-9 rsync shell script output showing end-user feedback

Remaining `rsync` sessions include the following:

```
root 22899 2786 0 Jul24 tty4 00:2:18 rsync -avz /oradata2_21
root 28872 2786 0 Jul24 tty4 00:2:18 rsync -avz /oradata2_03
root 22765 2786 0 Jul24 tty4 00:2:18 rsync -avz /oradata2_02
root 22733 2786 0 Jul24 tty4 00:2:18 rsync -avz /oradata2_10
```

As you can see from the output in Listing 4-9, when the remaining sessions drops below the total sessions, we give the user an update on the remaining sessions and the elapsed time. Then we print a dot every minute until we count to five minutes, when we update the elapsed time and the number of remaining `rsync` sessions still executing. When the remaining sessions reaches one-fourth the `$TOTAL_SESSIONS`, we display the remaining processes to the end user. This is very useful for long-running processes. End users always wonder ''what's taking so long?!'' Well, let them know.

Other Options to Consider

As with any script, we may be able to improve on the techniques. The series-of-dots method is so simple that I cannot think of any real improvements. The rotating line is a fun little script to play with, and I have accomplished the same result in several different ways. Each method I used produced a noticeable load on the system if the `sleep 1` statement was removed, so that the line rotated as fast as possible. Try to see if you can find a technique that will not produce a noticeable load and does not require a one-second sleep, and using a shell script!

For the `elapsed_time` function we may want to add the ability to expand to days. This task is not very difficult if we expand the three seconds, minutes, and hours calculations with a new `$SEC` test for seconds greater than 86,400 (seconds in 24 hours) and add a days calculation.

Play around with each of these techniques, and always strive to keep your end users informed. A blank or ''frozen'' screen makes people uncomfortable.

Summary

In this chapter we presented three techniques to help keep our script users content. Each technique has its place, and they are all easy to implement within any shell script or function. We covered how to save the PID of the last background job and how to put an entire loop in the background. The background looping can make a script a little easier to follow if you are not yet proficient at creating and using functions. The elapsed time combined with a series of dots and a process listing is really going the extra mile.

Remember, informed users are happy users!

In the next chapter, we are going to work with record files. I have had many requests for this chapter from my application-support staff. I hope you stick around for some interesting techniques.

Lab Assignments

I really hope you paid attention to this chapter, because you will encounter many of these techniques throughout this book. I have a few script tasks that you may be interested in:

1. Write a shell script to start six `sleep` sessions, with each session 5 seconds longer than the previous session. The first sleep interval is 10 seconds. When the `sleep` sessions are less than or equal to half the total, display the remaining `sleep` processes, update the elapsed time, and continue printing dots every second. Repeat the process until all the sleep sessions have completed execution.
2. White a shell script to count down from two hours to zero seconds using the hour, minute, second display format utilizing the shell's `SECOND` variable.

   Extra credit: Repeat task 2, but overwrite the same line of text with the updated values, as opposed to writing a new line for every second.
3. Expand the `elapsed_time` function to calculate days, hours, minutes, and seconds.

PART II

Scripts for Programmers, Testers, and Analysts

CHAPTER 5

Working with Record Files

Every large business that processes its own data works with record files. Record files contain lines of data that are either field delimited, called a *variable-length record file*, or each line of data is the same length and each data field is defined by string length and position, called a *fixed-length record file*. We will look at examples of each record file format type and methods of processing the files quickly and manipulating the data. I added this chapter to this second edition at the request of a co-worker at Coca-Cola Enterprises, Mark Sellers. Mark asked me one day for a quick way to add the name of the record file to the end of every record, or line, in the file. Mark's problem was that when he merged a bunch of record files together in a single file for batch processing, and the batch file had an error with a particular record, he had no idea which record file the record came from. We will look at methods to solve this problem and many others.

What Is a Record File?

A *record file* is an alphanumeric character flat file (text file) that contains one or more lines of data. Each separate line of data is called a *record*. A record is made up of different *fields* that contain the actual data. There are two types of record files:

- **Fixed-length record files** are files with fixed column width with each data field residing within a specific character length and position within the record.
- **Variable-length record files** are files where the individual records may vary in length with the fields delimited (separated) by a character, such as a : (colon), a , (comma), or a | (pipe).

Let's look at an example of both types of record files.

Fixed-Length Record Files

The best way to understand a fixed-length record file is to look at an example. An example record might consist of a Company Branch, Account Number, Name, Total, and Due Date. For this fixed-length record file example we will assume that each record, or line of data, consists of the fields shown in Table 5-1.

Table 5-1 Fixed-Length Record File Definition

CHARACTERS	DATA FIELD
1–6	Branch
7–25	Account Number
26–45	Name
46–70	Total
71–78	Due Date

Using the data in Table 5-1 as a guide, a sample fixed-length record might look like the following:

```
US72271234567890123456789Randal.K.Michael.\
###00000000000000000000000982512312007
```

Now, this looks like a bunch of random data, but it does specify very specific data, as shown in Table 5-2.

This data breaks down to Randal.K.Michael with account number 1234567890123456 789 owes the US7227 company branch $98.25 due on 12/31/2007. Notice that several of the data fields are padded with fill data because the data-string length is shorter than the field-string length. The Name field is left-justified with hash marks (#) padding the extra field data and a period (.) delimiting the different parts of the Name. So, fixed-length record files may need additional parsing for some data fields. Now I just made this example up out of thin air, but I hope you get the idea of a fixed-length record file. Let's move on and look at variable-length record files.

Table 5-2 Fixed-Length Record File Data Fields

FIELD	DATA
Branch	`US7227`
Account Number	`1234567890123456789`
Name	`Randal.K.Michael.###`
`Due Date`	`12312007`

Variable-Length Record Files

In a variable-length record file, the individual records, or lines of data, vary in length and are separated by a field delimiter. For our example, we are going to assume that the : (colon) character is the field delimiter. Again, the best way to learn about variable-length record files is to look at an example.

Instead of worrying about character positions within each record, we only need to know which field the data resides in, and which character we are using as a data field delimiter. This is what we have been doing with `awk` in our scripts when we specify `awk '{print $2}'` to select the second field of input/output. An example variable-length record file definition is shown in Table 5-3.

Table 5-3 Variable-Length Record File Definition

FIELD	DATA FIELD
1	Branch
2	Account Number
3	Name
4	Total
5	Due Date

Using the data in Table 5-3 as a guide, a sample variable-length record might look like the following:

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007
```

As you can see this record is not as long as the fixed-length record. Take a close look at this record and you can see the :, colon, field delimiters that separate each data field. Now let's look at the specific data as shown in Table 5-4.

Table 5-4 Variable-Length Record File Data Fields

FIELD	DATA
Branch	`US7227`
Account Number	`1234567890123456789`
Name	`Randal.K.Michael`
Due Date	`12312007`

Again, this data breaks down to Randal.K.Michael with account number 123456789 0123456789 owes the US7227 company branch $98.25 due on 12/31/2007. Notice that the data fields are not padded with extra characters. Depending on your data, a

variable-length record file is easier to work with, and in most cases faster to process. This data is the same data representation as the fixed-length record file example.

Processing the Record Files

The most important aspect of processing a record file of any size is to select a method of parsing the file line-by-line. Recall from Chapter 2, ''24 Ways to Process a File Line-by-Line,'' that not all file-processing methods are created equal. Depending on the file-processing method, it could take 0.5 seconds or 10 minutes to process the same file. The fastest methods to process a file line by line are shown in Listings 5-1, 5-2, 5-3, and 5-4, and are the methods discussed in detail in Chapter 2.

```
function while_read_LINE_bottom_FD_OUT
{
# Method 12

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read LINE
do
        echo "$LINE"
        :
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-1 Method 12 tied for first place

The method in Listing 5-1 tied for first place in our Chapter 2 timing tests. This method uses my favorite input redirection for files by redirecting input at the bottom of the loop, after the `done` loop terminator. This method does use a file descriptor for redirecting standard output, `stdout`, to file descriptor 4. If you are not up to speed on using file descriptors, please go back and review Chapter 2 for more details. The input redirection using `done < $INFILE` greatly speeds up any loop that requires file

input. The nice thing about this method of input redirection is that it's intuitive for beginners to shell scripting. I was actually surprised that this method tied, actually beat by 10 mS, using file descriptors for both input and output files, as shown in Listing 5-2.

```
function while_read_LINE_FD_IN_AND_OUT
{
# Method 22

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard input with file descriptor 3
# and redirect standard input to $INFILE

exec 3<&0
exec 0< $INFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


while read LINE
do
        echo "$LINE"
        :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-

# Restore standard input and close file
# descriptor 3

exec 0<&3
exec 3>&-
}
```

Listing 5-2 Method 22 tied for first place

I tend not to use this method when I write shell scripts because it can be difficult to maintain through the code life cycle. If a user is not familiar with using file descriptors, a script using this method is extremely hard to understand. The method

in Listing 5-1 produces the same timing results, and it is much easier to understand. Listing 5-3 shows the second-place loop method.

```
for_LINE_cat_FILE_cmdsub2_FD_OUT ()
{
# Method 16

# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

for LINE in $(cat $INFILE)
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-3 Method 16 made second place in timing tests

The method shown in Listing 5-3 is another surprise — a `for` loop using command substitution with file descriptor for output redirection. Listing 5-4 shows the third place method in our timing tests.

```
for_LINE_cat_FILE_FD_OUT ()
{
# Method 15

# Zero out the $OUTFILE

>$OUTFILE
```

Listing 5-4 Method 15 made third place in timing tests

```
# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE


for LINE in `cat $INFILE`
do
    echo "$LINE"
    :
done

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-4 (*continued*)

The only difference between Methods 15 and 16 is the technique used for command substitution, the back tics method `` `command` `` versus the dollar parentheses method `$(command)`. Listing 5-5 shows this timing data.

```
Method 15:
function for_LINE_cat_FILE_FD_OUT
real    0m0.47s
user    0m0.38s
sys     0m0.06s

Method 16:
function for_LINE_cat_FILE_cmdsub2_FD_OUT
real    0m0.45s
user    0m0.38s
sys     0m0.05s
```

Listing 5-5 Timing difference between Methods 15 and 16

The timing results indicate a single mS in system time, or system/kernel time between the command substitution methods, and a total of 2 mS in real execution time. Now let's look at the fastest method to process a file *without* using file descriptors, as shown in Listing 5-6.

```
function while_read_LINE_bottom
{
# Method 2

# Zero out the $OUTFILE

>$OUTFILE

while read LINE
do
        echo "$LINE" >> $OUTFILE
        :

done < $INFILE
}
```

Listing 5-6 The fastest method not using file descriptors

The method in Listing 5-6 is the fastest method to process a file line by line that does *not* use file descriptors. I use this technique in almost every shell script that does file parsing simply because of the ease of maintaining the shell script throughout the life cycle. Remember, it is not *if* someone will come behind you and need to edit the script some time in the future, but *when* someone comes behind you to edit your *most excellent script*, they must be able to understand what you did without having to either hack through your code, or just give up and resort to rewriting the entire script. This is one important reason to put plenty of comments in your shell scripts!

If your goal is absolute speed, use the technique in Listing 5-1. Now let's take a look at some of the things we want to do with record files and individual records.

Tasks for Records and Record Files

Now that we have an idea of the ways to process the record file line by line, we need to look at tasks we can perform on individual records. The most obvious task is to extract each data field from each record and perform some action on that data. The method we use to extract the data depends on the type of record file we are working with. For fixed-length record files, we need to know the placement of each data field within the record. Because we need to select specific characters in a string, the **`cut`** command is the best option. For variable-length record fields, we need to know the field delimiter and which data field represents each value. For this type of record file, we can use **`awk`** or `cut` to select the correct data field.

Tasks on Fixed-Length Record Files

For our examples of parsing record files, we are going to use the method shown in Listing 5-1. The only difference between fixed-length and variable-length records is how we extract the data fields from each record as we process the file line by line. For

the fixed-length record files, we are going to use the `cut` command to select specific groups of characters residing in specific positions and assign these data to variables on each loop iteration.

For our example, we need to refer back to Table 5-1 to determine where each data field resides within the record. Our example specifies characters 1–6 as the `Branch`, characters 7–25 as the `Account` Number, characters 26–45 as the Name, characters 46–70 as the Total, and characters 71–78 as the Due Date field. The data fields are shown again in Table 5-5.

Table 5-5 Fixed-Length Record File Definition

CHARACTERS	DATA FIELD
1–6	Branch
7–25	Account Number
26–45	Name
46–70	Total
71–78	Due Date

With these definitions from Table 5-5, we know how to extract each data field. Check out the code in Listing 5-7, and we will cover the details at the end.

```
function parse_fixed_length_records
{
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read RECORD
do
    # On each loop iteration extract the data fields
    # from the record as we process the record file
    # line by line
    BRANCH=$(echo "$RECORD" | cut -c1-6)
    ACCOUNT=$(echo "$RECORD" | cut -c7-25)
    NAME=$(echo "$RECORD" | cut -c26-45)
    TOTAL=$(echo "$RECORD" | cut -c46-70)
    DUEDATE=$(echo "$RECORD" | cut -c71-78)
```

Listing 5-7 Parsing a fixed-length record file

```
    # Perform some action on the data

    process_data $BRANCH $ACCOUNT $NAME $TOTAL $DATEDUE
    if (( $? != 0 ))
      then
          # Note that $LOGFILE is a global variable
          echo "Record Error: $RECORD" | tee -a $LOGFILE
    fi
done < $INFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-7 (*continued*)

This is the fastest method to process a file line by line. Notice that we feed the file data into the loop after the `done` loop terminator, `done < $INFILE`, and the output is redirected to file descriptor 4.

On each loop iteration, we assign the characters residing in positions 1–6 to the `BRANCH` variable, positions 7–25 are assigned to the `ACCOUNT` variable, positions 26–45 are assigned to the `NAME` variable, the `TOTAL` variable is assigned the characters residing in positions 46–70, and characters 71–78 are assigned to the `DUEDATE` variable. After the variable assignments, we execute some `process_data` function (to be discussed later), passing each set of variable assignments on each loop iteration. This is just an example of how you can extract the data fields from a fixed-length record file and perform some type of processing on that data. Now let's look at variable-length record files.

NOTE **This method works well with record files that contain fields with spaces and comments as long as the variables are double quoted when used.**

Example: `echo "$NAME"`

Tasks on Variable-Length Record Files

The main difference between processing variable-length and fixed-length record files is how we extract the data field from each record in the record file. For fixed-length record files, we had to know which character positions in a record represented each data field. In the variable-length record files, we need to know how many fields of data we have and what data it represents and what the field delimiter character is that separates each data field in the record.

For our example, we have five data fields that are field separated by a : (colon), as follows:

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007
```

To process this record, we can use `awk` or `cut` to select each of the fields and assign them to variables. I tend to use `awk` for this process. Check out Listing 5-8, and we will cover the details at the end.

```
function parse_variable_length_records
{
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read RECORD
do
   # On each loop iteration extract the data fields
   # from the record as we process the record file
   # line by line

   echo $RECORD | awk -F : '{print $1, $2, $3, $4, $5}' \
                | while read BRANCH ACCOUNT NAME TOTAL DATEDUE
   do
       # Perform some action on the data

       process_data $BRANCH $ACCOUNT $NAME $TOTAL $DATEDUE
       if (( $? != 0 ))
       then
             # Note that $LOGFILE is a global variable
             echo "Record Error: $RECORD" | tee -a $LOGFILE
       fi
   done

done < $INFILE

# Restore standard output and close file
```

Listing 5-8 Parsing a variable-length record file

```
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-8 (*continued*)

This is the fastest method to process a file line by line. Notice that we feed the file data into the loop after done, `done < $INFILE`, and the output is redirected to file descriptor 4.

On each loop iteration, we echo each `$RECORD` and pipe this line of data to an `awk` statement where we define the field delimiter as the `:` (colon) character, specified by `awk -F :`. With the field delimiter defined, we just select the first five fields and pipe these values to a `while read` loop where the variable assignments are made.

NOTE The Solaris version of `awk` does not support defining a field delimiter using the `-F :` switch option. For Solaris we must use `nawk` (`new-awk`). Adding the following alias statement in the variable definition section of the shell script will correct this problem:

```
case $(uname) in
SunOS) alias awk=nawk
       ;;
esac
```

The full statement is shown here:

```
echo $RECORD | awk -F : '{print $1, $2, $3, $4, $5}' \
           | while read BRANCH ACCOUNT NAME TOTAL DATEDUE
```

Notice that we continued the command statement on a second line by ending the first line with a backslash, `\`. The first line is the `awk` statement, and the second line contains the variable assignments.

We can accomplish the same task using the `cut` command, but it requires multiple `echo` statements, as shown here:

```
BRANCH=$(echo $RECORD | cut -d : -f1)
ACCOUNT=$(echo $RECORD | cut -d : -f2)
NAME=$(echo $RECORD | cut -d : -f3)
TOTAL=$(echo $RECORD | cut -d : -f4)
DATEDUE=$(echo $RECORD | cut -d : -f5)
```

The `cut` command is not a direct replacement for `awk` and requires multiple system calls compared to `awk`. We can extract more than one field in a variable-length record

file using the `cut` command, but `cut` will also display the field delimiter character if more than one field is extracted. If the field delimiter is a blank space this is not a problem, but the `:`, colon, would require more parsing. See Lab Assignment 3 at the end of this chapter for more details.

After the variable assignments, we execute some `process_data` function (to be discussed later) from within the `while` loop, passing each variable assignment on each loop iteration. This is just an example of how you can extract the data fields from a variable-length record file and perform some type of processing on that data.

NOTE **This method of a loop assigning all of the fields' data to variables at the same time on each loop iteration *does not work* if any of the fields being extracted contain white space. For record files that contain data fields with spaces or comments, the individual field(s) containing white space must be extracted as a single variable assignment one at a time. When using variables with white space the variables must be double quoted.**

Example: `echo "$NAME"`

The Merge Process

If you work with data files for very long, you realize that troubleshooting *batch-processing* errors can be a daunting task. For example, let's say that we have record files coming in every day from each Branch of the company. When we get the record files, we have a process where we append all the record files from all the various Branches into a single file. Then we process the big file every day to do all of the processing in one big batch job. This process of appending the record files into a single file is called a *merge process*. After the merge process takes place, we have all the branch records in a single file. At first look, the only way to tell where an individual record came from is to reference the Branch field. However, this can be time consuming when you are trying to troubleshoot a batch-processing problem. One option is to append the name of the record file to the end of every record in the file. Then after the merge process you can look at the merged record file and see the filename associated with each record in the batch-processing file. This helps to ease the troubleshooting headache to find where the error came from.

So, how do we add the record filename to the end of a record? When my co-worker Mark Sellers came to me with this problem, he had a very slow process where the files were processed line by line, and then an `echo` statement listed each line of record data followed by the filename and appended this data to a ''new'' record, and then to the end of a new record file. This process took many hours to complete. I looked at this code and thought **`sed`** should be able to do this with character substitution, and at the file level as opposed to the record level. I played around with `sed` for a half hour or

so and came up with the following sed statement to add a filename to the end of each record in a file:

```
sed s/$/$(basename $RecordFileName)/g $RecordFileName > ${RecordFileName}
.preprocess
```

This is a simple character substitution sed statement with a twist. The ''substitution'' is to replace the End-of-Line (EOL) with the record filename. The $ (dollar sign) is the regular expression defining EOL. (The ^, caret, is the regular expression defining the Beginning-of-Line.) An important point in this sed statement is where we use $(basename $RecordFileName) in the substitution. If we had omitted the basename part and the filename has a forward slash (/), the sed statement would produce an error. Notice that we redirected output to a new filename specified by the .preprocess filename suffix, but you may just want to do this step during the merge process as you build the batch-processing file. Just remember that substituting EOL with a filename results in the filename being appended to the end of each record in the record file, as shown here.

Fixed-length record:

```
US722712345678901234567 89Randal.K.Michael.###00000000000000000000009825 \
12312007record.dat
```

Variable-length record:

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007:record.dat
```

In this example, our record filename is record.dat, and this name is appended to the end of our fixed-length and variable-length records. Listing 5-9 shows a merge process where we loop through a list of record filenames and, as we append each record file to build the big batch-processing file, we append the record filename to each record. Check out Listing 5-9, and we will cover the details at the end.

```
MERGERECORDFILE=/data/mergerecord.$(date +%m%d%y)
RECORDFILELIST=/data/branch_records.lst

while read RECORDFILENAME junk
do

    sed s/$/$(basename $RECORDFILENAME)/g $RECORDFILENAME >>\
$MERGERECORDFILE

done  < $RECORDFILELIST
```

Listing 5-9 Code for a merge process for fixed-length record files

Listing 5-9 is a merge script for fixed-length record files. We first define a couple of files. The MERGERECORDFILE variable definition specifies the name of the resulting merged record data file. The RECORDFILELIST variable defines the file that contains

a list of record files that must be merged. Notice the use of the `basename` command to strip the directory part of the `$RECORDFILENAME` on each loop iteration. As we feed the `while` loop from the bottom, after `done`, to process the `$RECORDFILELIST` file line by line, we assign a new record file to the `RECORDFILENAME` variable. We use this new value in our `sed` statement that appends the record filename to the end of each record in the file. As the last step, this record file is appended to the end of the `$MERGERECORDFILE` file.

Listing 5-10 is a merge script for variable-length record files. The only difference between this script and Listing 5-9 is that we added the field-delimiter variable, `FD`. We define the field delimiter and then add the field delimiter between the end of the record and the record filename. These modifications are highlighted in bold in Listing 5-10. As with Listing 5-9, we first define a couple of files. The `MERGERECORDFILE` variable definition specifies the name of the resulting merged record data file. The `RECORDFILELIST` variable defines the file that contains a list of record files that must be merged. As we feed the `while` loop from the bottom, after `done`, we execute a `sed` statement that substitutes `EOL` with the name of the record file, `$RECORDFILENAME`. Again, notice the use of the `basename` command to strip out the directory part of the filename, if it exists. This new merged record file, with the name of each source record file appended to the end of each record, is appended to the `$MERGERECORDFILE`.

```
MERGERECORDFILE=/data/mergerecord.$(date +%m%d%y)
RECORDFILELIST=/data/branch_records.lst
FD=:

while read RECORDFILENAME
do

sed s/$/${FD}$(basename $RECORDFILENAME)/g $RECORDFILENAME >>\
$MERGERECORDFILE

done  < $RECORDFILELIST
```

Listing 5-10 Code for a merge process for variable-length record files

Working with Strings

A useful thing to know when working with fixed-length record files is the string length. The length of a string assigned to a variable can be found using the following syntax:

```
echo ${#VAR}
```

For example, if we assign the `VAR` variable the string `1234567890`, the string length should be `10`:

```
VAR=1234567890
echo ${#VAR}
10
```

Sometimes we need the string length for fixed-length records to pad the extra space in a data field that the data does not fill up. As an example, the TOTAL field is defined as characters 46–70, which is 25 characters long. It is unlikely that anyone would ever owe that kind of cash, but that is the data field we have to work with. This field is right-justified and filled with leading zeros as shown here:

```
0000000000000000000009825
```

When we change a record field and the data is not as long as the data field, we need to pad the rest of the data field with something — in this case, zeros. The hard way to pad the data with leading zeros is to check the original data for the string length, then get the string length of the new data and start looping to add the correct number of leading zeros followed by the new data. It is much easier to do this task with the **typeset** command. The -Z switch specifies right justification with leading zeros, which is just what we need here. Our TOTAL variable is 25 characters long. The following typeset command makes this definition for us:

```
typeset -Z25 TOTAL
```

Now we can change the TOTAL data field to a different value and not worry about how many leading zeros to add. For example, let's change the total to 0. (We paid off this bill!)

```
TOTAL=0
echo $TOTAL
0000000000000000000000000
```

The typeset command can do a lot of the work for us. Table 5-6 lists additional typeset options you might find handy.

NOTE **Using + instead of – turns off the typeset definition.**

Table 5-6 Options for the typeset Command

SWITCH	RESULTING TYPESET
-L	Left justify and remove blank spaces
-R	Right justify and to fill with leading blanks
-Zn	Right justify to *n* length and fill with leading zeros if the first non-blank character is a digit
-i	Variable is an integer
-l	Convert uppercase characters to lowercase characters
-u	Convert lowercase characters to uppercase characters
-x	Automatically export this variable

Putting It All Together

Now that we have covered all the pieces in detail, it is time put them together into one shell script. Our task is to merge and process records based on record-format type. For this selection, we are expecting a single command-line argument, `-f` for fixed-length record files or `-v` for variable-length record files.

We have two data record files for each type of record format shown here:

```
branch01_fixed.dat
branch02_fixed.dat
branch01_variable.dat
branch02_variable.dat
```

The record files are shown in Listings 5-11, 5-12, 5-13, and 5-14, respectively.

```
US722712345678901234567 89Randal.K.Michael.###00000000000000000000009825 \
12312007
US722712399228901234567 89James.M.Jones.######00000000000000000000001426 \
12312007
US722715288578901234567 89William.C.Rogers.###00000000000000000000427732 \
12312007
US722712229455301234567 89Robin.M.Kim.########00000000000000000002263320 \
12312007
US722712340668201234567 89Ana.Marie.Larson.###00000000000000000000004741 \
12312007
US722712477834901234567 89Stacy.M.Spry.#######00000000000000000000008847 \
12312007
US722719982334901234567 89Marcus.S.Moore.#####00000000000000000000095248 \
12312007
US722712355832901234567 89Paul.W.Bryant.######00000000000000000000886799 \
12312007
```

Listing 5-11 File listing for branch01_fixed.dat

```
US822812992773000882582 39Andy.C.James.#######00000000000000000000882991 \
12312007
US822812002999388824567 89Shakar.C.Divini.####00000000000000000002211426 \
12312007
US822829903888723344567 89Joe.M.Baker.########00000000000000000000088234 \
12312007
US822812229455300922766 11George.Williams.###00000000000000000000881091 \
2312007
US822812340668201998223 89Larry.C.Guy.########00000000000000000000000882 \
12312007
```

Listing 5-12 File listing for branch02_fixed.dat

```
US8228124778349012343602 1Lacy.C.Cocaran.#####00000000000000000009921556 \
12312007
US8228199823349012342640 1Herman.G.Munster.###00000000000000000000055324 \
12312007
US8228123558329012340217 3LaQuita.H.Dabney.###00000000000000000000882371 \
12312007
```

Listing 5-12 (*continued*)

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007
US7227:1239922890123456789:James.M.Jones:1426:12312007
US7227:1528857890123456789:William.C.Rogers:427732:12312007
US7227:1222945530123456789:Robin.M.Kim:2263320:12312007
US7227:1234066820123456789:Ana.Marie.Larson:4741:12312007
US7227:1247783490123456789:Stacy.M.Spry:8847:12312007
US7227:1998233490123456789:Marcus.S.Moore:95248:12312007
US7227:1235583290123456789:Paul.W.Bryant:886799:12312007
```

Listing 5-13 File listing for branch01_variable.dat

```
US8228:1299277300088258239:Andy.C.James:882991:12312007
US8228:1200299938882456789:Shakar.C.Divini:2211426:12312007
US8228:2990388872334456789:Joe.M.Baker:88234:12312007
US8228:1222945530092276611:George.Williams:88109:12312007
US8228:1234066820199822389:Larry.C.Guy:882:12312007
US8228:1247783490123436021:Lacy.C.Cocaran:9921556:12312007
US8228:1998233490123426401:Herman.G.Munster:55324:12312007
US8228:1235583290123402173:LaQuita.H.Dabney:882371:12312007
```

Listing 5-14 File listing for branch02_variable.dat

An important thing to notice here is that Listings 5-11 and 5-13 represent the same data and Listings 5-12 and 5-14 represent the same data. The only difference is the record format we represent the data in.

In our shell script we are first going to merge the record files together, based on record-file format, and then process the merged data file to produce a post-processing output file. Our task is to change the Due Date from 12/31/2007 to 1/31/2008. Check out the script in Listing 5-15, and we will cover it in more detail at the end.

NOTE **For the `parse_records_files.Bash` script in Listing 5-15 to work, as written, you must create a directory and some files. Specifically, you need to create the directory `/data`. Next, depending on your record-file data type, you need to create the `/data/branch_records_variable.lst` or `/data/branch_records_fixed.lst` file that contains a list of record files to process. Example record files to process are shown in Listings 5-11,**

5-12, 5-13, and 5-14. Otherwise, edit the shell script to reflect your particular environment. Each of these files is on the web site accompanying this book.

```
#!/bin/Bash
#
# SCRIPT: parse_record_files.Bash
# AUTHOR: Randy Michael
# DATE: 12/7/2007
# REV: 1.0
# PURPOSE: This script is used to parse both
# fixed-length and variable-length record files.
# Before we parse the records we first merge the
# files into a single file for batch processing.
#
# set -n # Uncomment to check script syntax
#        # without any execution
# set -x # Uncomment to debug
#
# REV LIST:
#
# Revised by:
# Revision date:
# Revision:
#
#
#
##########################################
# VERIFY INPUT
##########################################

if (( $# != 1 ))
then
    echo -e "\nUSAGE: $(basename $0) -f|-v"
    echo -e "\nWhere -f = fixed-length records"
    echo -e "and   -v = variable-length records\n"
    exit 1
else
    case $1 in
    -f) RECORD_TYPE=fixed
        ;;
    -v) RECORD_TYPE=variable
        ;;
     *) echo -e "\nUSAGE: $(basename $0) -f|-v"
        echo -e "\nWhere -f = fixed-length records"
        echo -e "and   -v = variable-length records\n"
```

Listing 5-15 Shell script listing for parse_record_files.Bash

```
        exit 1
        ;;
    esac
fi

########################################
# DEFINE FILES AND VARIABLES HERE
########################################

DATADIR=/data # This variable defines the directory to use for data

if [ $RECORD_TYPE = fixed ]
then
   MERGERECORDFILE=${DATADIR}/mergedrecords_fixed.$(date +%m%d%y)
   >$MERGERECORDFILE # Zero out the file to start
   RECORDFILELIST=${DATADIR}/branch_records_fixed.lst
   OUTFILE=${DATADIR}/post_processing_fixed_records.dat
   >$OUTFILE  # Zero out the file to start
else
   MERGERECORDFILE=${DATADIR}/mergedrecords_variable.$(date +%m%d%y)
   >$MERGERECORDFILE # Zero out the file to start
   RECORDFILELIST=${DATADIR}/branch_records_variable.lst
   OUTFILE=${DATADIR}/post_processing_variable_records.dat
   >$OUTFILE # Zero out the file to start
fi

# Test for Solaris to alias awk to nawk

case $(uname) in
SunOS) alias awk=nawk
       ;;
esac

FD=:  # This variable defines the field delimiter for fixed-length
records

NEW_DATEDUE=01312008

########################################

function process_fixedlength_data_new_duedate
{
# set -x
# Local positional variables
branch=$1
account=$2
name=$3
total=$4
```

Listing 5-15 (*continued*)

```
datedue=$5
recfile=$6
new_datedue=$7

echo "${branch}${account}${name}${total}${new_datedue}${recfile}" \
      >> $OUTFILE
}

########################################

function process_variablelength_data_new_duedate
{
# set -x
# Local positional variables
branch=$1
account=$2
name=$3
total=$4
datedue=$5
recfile=$6
new_datedue=$7

echo "${branch}${FD}${account}${FD}${name}${FD}${total}\
${FD}${new_datedue}${FD}${recfile}" >> $OUTFILE
}

########################################

function merge_fixed_length_records
{
# set -x
while read RECORDFILENAME
do

    sed s/$/$(basename $RECORDFILENAME 2>/dev/null)/g $RECORDFILENAME\
>> $MERGERECORDFILE

done  < $RECORDFILELIST
}

########################################

function merge_variable_length_records
{
# set -x
while read RECORDFILENAME
do
```

Listing 5-15 (*continued*)

```
sed s/$/${FD}$(basename $RECORDFILENAME 2>/dev/null)/g $RECORDFILENAME\
>> $MERGERECORDFILE

done  < $RECORDFILELIST
}

########################################

function parse_fixed_length_records
{
# set -x
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read RECORD
do
    # On each loop iteration extract the data fields
    # from the record as we process the record file
    # line by line
    BRANCH=$(echo "$RECORD" | cut -c1-6)
    ACCOUNT=$(echo "$RECORD" | cut -c7-25)
    NAME=$(echo "$RECORD" | cut -c26-45)
    TOTAL=$(echo "$RECORD" | cut -c46-70)
    DUEDATE=$(echo "$RECORD" | cut -c71-78)
    RECFILE=$(echo "$RECORD" | cut -c79-)

    # Perform some action on the data

    process_fixedlength_data_new_duedate $BRANCH $ACCOUNT $NAME \
           $TOTAL $DUEDATE $RECFILE $NEW_DATEDUE
    if (( $? != 0 ))
      then
          # Note that $LOGFILE is a global variable
          echo "Record Error: $RECORD" | tee -a $LOGFILE
    fi
done < $MERGERECORDFILE

# Restore standard output and close file
# descriptor 4
```

Listing 5-15 (*continued*)

```
exec 1<&4
exec 4>&-
}

##########################################

function parse_variable_length_records
{
# set -x
# Zero out the $OUTFILE

>$OUTFILE

# Associate standard output with file descriptor 4
# and redirect standard output to $OUTFILE

exec 4<&1
exec 1> $OUTFILE

while read RECORD
do
   # On each loop iteration extract the data fields
   # from the record as we process the record file
   # line by line

   echo $RECORD | awk -F : '{print $1, $2, $3, $4, $5, $6}' \
                | while read BRANCH ACCOUNT NAME TOTAL DATEDUE RECFILE
   do
       # Perform some action on the data

       process_variablelength_data_new_duedate $BRANCH $ACCOUNT $NAME \
               $TOTAL $DATEDUE $RECFILE $NEW_DATEDUE
       if (( $? != 0 ))
       then
           # Note that $LOGFILE is a global variable
           echo "Record Error: $RECORD" | tee -a $LOGFILE
       fi
   done

done < $MERGERECORDFILE

# Restore standard output and close file
# descriptor 4

exec 1<&4
exec 4>&-
}
```

Listing 5-15 (*continued*)

```
##########################################
# BEGINNING OF MAIN
##########################################

case $RECORD_TYPE in
fixed)    merge_fixed_length_records
          parse_fixed_length_records
          ;;
variable) merge_variable_length_records
          parse_variable_length_records
          ;;
esac
```

Listing 5-15 (*continued*)

The first test is to ensure that we have exactly one command-line argument presented to the shell script. In the second test, we use a `case` statement to ensure that the argument presented is either `-f` or `-v`; any other value is a usage error. If we had more command-line options for this shell script, we could use `getopts` to parse the arguments.

Once the input is verified, we define some files and variables. Notice that we use the data we gathered in the last test to set up the file definitions, as shown here:

```
if [ $RECORD_TYPE = fixed ]
then

   MERGERECORDFILE=${DATADIR}/mergedrecords_fixed.$(date +%m%d%y)
   >$MERGERECORDFILE  # Zero out the file to start
   RECORDFILELIST=${DATADIR}/branch_records_fixed.lst
   OUTFILE=${DATADIR}/post_processing_fixed_records.dat
   >$OUTFILE # Zero out the file to start
else

   MERGERECORDFILE=${DATADIR}/mergedrecords_variable.$(date +%m%d%y)
   >$MERGERECORDFILE  # Zero out the file to start
   RECORDFILELIST=${DATADIR}/branch_records_variable.lst
   OUTFILE=${DATADIR}/post_processing_variable_records.dat
   >$OUTFILE # Zero out the file to start
fi
```

Notice how we ''zero out,'' or initialize, the files to zero size, by redirecting NULL data to the file `> $FILENAME`. This is the same as `cat /dev/null > $FILENAME`. We also define the field delimiter and assign the value to the `FD` variable, `FD=:` for this example. If we are working with a variable-length, we will need this information.

Next we define six functions, three for each record format. We have a merge function, a record-file parsing function, and a record-processing function for both types of record formats.

The record files that we need to process, from Listings 5-11, 5-12, 5-13, and 5-14, are defined in the `${DATADIR}/branch_records_fixed.lst` file for fixed-length records, and `$DATADIR/branch_records_variable.lst` file for variable-length records. Examples of these list files are shown here.

BRANCH_RECORDS_FIXED.LST

```
/data/branch01_fixed.dat
/data/branch02_fixed.dat
```

BRANCH_RECORDS_VARIABLE.LST

```
/data/branch01_variable.dat
/data/branch02_variable.dat
```

With all these definitions we are now ready to start processing record files. At `BEGINNING OF MAIN` we use the `RECORD_TYPE`, which was defined on the command line, to decide which set of functions to execute. We take care of this decision-making with the following short `case` statement:

```
case $RECORD_TYPE in
fixed)    merge_fixed_length_records
          parse_fixed_length_records
          ;;
variable) merge_variable_length_records
          parse_variable_length_records
          ;;
esac
```

Let's look at some results. For the first example, we merge and process the fixed-length record files using the following syntax:

```
# parse_record_files.Bash -f
```

The resulting file, `post_processing_fixed_records.dat`, is shown in Listing 5-16.

```
US722712345678901234567 89Randal.K.Michael.###00000000000000000000009825 \
01312008branch01_fixed.dat
US722712399228901234567 89James.M.Jones.######00000000000000000000001426 \
01312008branch01_fixed.dat
US722715288578901234567 89William.C.Rogers.###00000000000000000000427732 \
01312008branch01_fixed.dat
US722712229455301234567 89Robin.M.Kim.########00000000000000000002263320 \
01312008branch01_fixed.dat
US722712340668201234567 89Ana.Marie.Larson.###00000000000000000000004741 \
01312008branch01_fixed.dat
```

Listing 5-16 Data file listing for post_processing_fixed_records.dat

```
US7227124778349012345678 9Stacy.M.Spry.#######00000000000000000000008847 \
01312008branch01_fixed.dat
US7227199823349012345678 9Marcus.S.Moore.#####00000000000000000000095248 \
01312008branch01_fixed.dat
US7227123558329012345678 9Paul.W.Bryant.######00000000000000000000886799 \
01312008branch01_fixed.dat
US8228129927730008825823 9Andy.C.James.#######00000000000000000000882991 \
01312008branch02_fixed.dat
US8228120029993882456789 Shakar.C.Divini.####00000000000000000002211426 \
01312008branch02_fixed.dat
US8228299038887233445678 9Joe.M.Baker.########00000000000000000000088234 \
01312008branch02_fixed.dat
US8228122294553009227661 1George.Williams.###00000000000000000000881090 \
1312008branch02_fixed.dat
US8228123406682019982238 9Larry.C.Guy.########00000000000000000000000882 \
01312008branch02_fixed.dat
US8228124778349012343602 1Lacy.C.Cocaran.#####00000000000000000009921556 \
01312008branch02_fixed.dat
US8228199823349012342640 1Herman.G.Munster.###00000000000000000000055324 \
01312008branch02_fixed.dat
US8228123558329012340217 3LaQuita.H.Dabney.###00000000000000000000882371 \
01312008branch02_fixed.dat
```

Listing 5-16 (*continued*)

To merge and process the variable-length record files, we use the following syntax:

```
# parse_record_files.Bash -v
```

The resulting file, `post_processing_variable_records.dat`, is shown in Listing 5-17.

```
US7227:1234567890123456789:Randal.K.Michael:9825:01312008:branch01_ \
variable.dat
US7227:1239922890123456789:James.M.Jones:1426:01312008: \
branch01_variable.dat
US7227:1528857890123456789:William.C.Rogers:427732:01312008: \
branch01_variable.dat
US7227:1222945530123456789:Robin.M.Kim:2263320:01312008: \
branch01_variable.dat
US7227:1234066820123456789:Ana.Marie.Larson:4741:01312008: \
branch01_variable.dat
US7227:1247783490123456789:Stacy.M.Spry:8847:01312008: \
branch01_variable.dat
US7227:1998233490123456789:Marcus.S.Moore:95248:01312008: \
branch01_variable.dat
```

Listing 5-17 Data file listing for post_processing_variable_records.dat

```
US7227:1235583290123456789:Paul.W.Bryant:886799:01312008: \
branch01_variable.dat
US8228:1299277300088258239:Andy.C.James:882991:01312008: \
branch02_variable.dat
US8228:1200299938882456789:Shakar.C.Divini:2211426:01312008: \
branch02_variable.dat
US8228:2990388872334456789:Joe.M.Baker:88234:01312008: \
branch02_variable.dat
US8228:1222945530092276611:George.Williams:88109:01312008: \
branch02_variable.dat
US8228:1234066820199822389:Larry.C.Guy:882:01312008: \
branch02_variable.dat
US8228:1247783490123436021:Lacy.C.Cocaran:9921556:01312008: \
branch02_variable.dat
US8228:1998233490123426401:Herman.G.Munster:55324:01312008: \
branch02_variable.dat
US8228:1235583290123402173:LaQuita.H.Dabney:882371:01312008: \
branch02_variable.dat
```

Listing 5-17 (*continued*)

By studying the resulting post-processing files in Listings 5-16 and 5-17, you can see that we accomplished all the tasks we set out to accomplish. We merged the files based on record format and added the record filename to the end of each record in the file, and then appended the file to the merged file ready for processing. We then processed the merged file, based on record format, to change the Date Due from 12/31/2007 to 1/31/2008. Study the `parse_record_files.Bash` script in Listing 5-15 in detail. You can pick up a few tips and tricks.

Other Things to Consider

As with any chapter there is not enough room to get to every single point in great detail. If you have record data files you are processing, you may need to do a lot of testing of the data integrity before using the data. So, you may need to add in tests for string length, integers, alphanumeric, date format, currency format, and many others.

You need to really know your data so that when you define variables you can specify the data type with the `typeset` command. For example, to define the variable `VAR` to be an integer, use the following syntax:

```
typeset -i VAR
```

We did not even touch on setting traps, logging errors, methods to cleanup after a failure, and all the other things that go with daily processing of data. If you know your data, you have a much better chance of success in writing your scripts.

As you process the data, you need to ensure you are checking return codes at each and every step. Missing just one return code can make troubleshooting an error a

two-week job, especially if is an intermittent error. Then there is the log file. If you are processing data, you should keep at least a week's worth of log files so that you can go back and look at previous processing runs. It could be that the error you are troubleshooting has been around for a while. You will not know if you are not keeping some of the previous log files. One week of log files is a good starting point. You may be required, by business requirements, to keep logs for 30 days or more.

Summary

Working with record files can be a challenge. To write a good and fast shell script to process record files, we need a good understanding of the data we are processing and the format that the data is in. For fixed-length records, we need to know where in the record each data field resides. For variable-length record files, we need to know how many fields of data we have and what they represent, and which character is used as the field delimiter. With this understanding we can build a comprehensive shell script that will process the data fast and efficiently. We can set up pre-processing and post-processing events, log errors, and send notifications of any issues that arise.

I hope you gained a good understanding of the challenges to processing record files and some techniques to help you succeed. In the next chapter we are going to look at automating FTP file transfers and related tasks.

Lab Assignments

1. Using the `parse_record_files.Bash` script as a guide, write a shell script that will automatically detect the type of record file and process the record file correctly. The key is to check the string-length of the first record in the file. If the record is exactly 83 characters, the file is a fixed-length record file and has the following record definitions:
   a. Characters 1–18 = Account number
   b. Characters 19–29 = Phone number
   c. Characters 30–55 = Name
   d. Characters 56–76 = Address
   e. Characters 77–83 = Balance
2. If the record file has variable-length records, the field delimiter is a : (colon), and there are five fields of data.
   a. Field 1 = Account number
   b. Field 2 = Phone number
   c. Field 3 = Name

d. Field 4 = Address

e. Field 5 = Balance

3. You will have to create some longer record files for this exercise.
4. Rewrite the shell script in Lab Assignment 1 to add functionality to first merge a group of like record files (all fixed-length or all variable-length records). During the merge process your new script will add the record filename to the end of each record before appending the record file to the correct merge file. There are two merge files, one for fixed-length records and one for variable-length records. The last step is to process the merged batch-processing files. Again, the script must recognize the difference between fixed-length and variable-length record files and merge the record files into the correct merge file before processing each file.
5. Evaluate the following code by writing a shell script to incorporate this `while` loop:

```
echo $RECORD | cut -d : -f1, -f2, -f3, -f4, -f5 \
          | while read BRANCH ACCOUNT NAME TOTAL DATEDUE
```

to evaluate this variable-length record:

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007
```

When you `echo` each variable, is the data assigned correctly? Explain your findings.

6. Evaluate the following code by writing a shell script to incorporate this `while` loop:

```
while read BRANCH ACCOUNT NAME TOTAL DATEDUE
do
 echo $BRANCH
 echo $ACCOUNT
 echo $NAME
 echo $TOTAL
 echo $DATEDUE
 done < <(echo "$RECORD" | sed s/':'/' '/g)
```

to evaluate this variable-length record:

```
US7227:1234567890123456789:Randal.K.Michael:9825:12312007
```

When you `echo` each variable, is the data assigned correctly? Explain your findings.

CHAPTER 6

Automated FTP Stuff

In many shops the business relies on nightly, or even hourly, file transfers of data that is to be processed. Due to the importance of this data, the data movement must be automated. The extent of automation in the FTP (and SFTP) world is threefold. We want the ability to move outbound files to another site, move inbound files from a remote location to our local machine, and check a remote site on a regular basis for files that are ready to download. In this chapter we are going to create some shell scripts to handle each of these scenarios.

Most businesses that rely on this type of data movement also require some pre-FTP and post-FTP processing to ready the system for the files before the transfer takes place and to verify the data integrity or file permissions after the transfer. For this pre and post processing we need to build into the shell script the ability to either hard-code the pre- and post-processing events or point to a file that performs these tasks. Now we are up to five pieces of code that we need to create.

Before you settle on a technique to move the data, be sure to also look at remote copy (`rcp`), Secure Copy (`scp`), and `rsync`, which are covered in Chapter 7, ''Using rsync to Efficiently Replicate Data.'' If you need to move a large amount of data, `rsync` is your best option because of its built-in compression and the ability to update changes only, for certain file types. A database file cannot be updated with changes only, of course, but the compression makes `rsync` faster than FTP, remote copy, and Secure Copy.

Okay, the topic of this chapter is FTP and SFTP. Before we go any further let's look at the syntax for the FTP connections.

Syntax

Normally when we `ftp` a file, the remote machine's hostname is included as an argument to the `ftp` command. We are prompted for the password and, if it is entered correctly, we are logged in to the remote machine. We then can then transfer files

between the systems by moving to the local system directory containing files using the `lcd` (local change directory) command, and then move to the remote directory using the `cd` (change directory) command. In either case, we are working with an interactive program. A typical FTP session looks like the output shown in Listing 6-1.

```
[root:yogi]@/scripts# ftp wilma
Connected to wilma.
220 wilma FTP server (SunOS 5.8) ready.
Name (wilma:root): randy
331 Password required for randy.
Password:
230 User randy logged in.
ftp> lcd /scripts/download
250 CWD command successful.
ftp> cd /scripts
250 CWD command successful.
ftp> get auto_ftp_xfer.ksh
200 PORT command successful.
150 ASCII data connection for auto_ftp_xfer.ksh (10.10.10.1,32787)
   (227 bytes).
226 ASCII Transfer complete.
246 bytes received in 0.0229 seconds (10.49 Kbytes/s)
local: auto_ftp_xfer.ksh remote: auto_ftp_xfer.ksh
ftp> bye
221 Goodbye.
[root:yogi]@/scripts/download#
```

Listing 6-1 Typical FTP file download

As you can see in Listing 6-1, the `ftp` command requires interaction with the user to make the transfer of the file from the remote machine to the local machine. How do we automate this interactive process? One option is to use a *here document*. A here document is a coding technique that allows us to place all the required interactive command input between two *labels*. However, a here document will not work for a Secure Shell (`ssh`, `scp`, and `sftp`) login. We will cover this topic later in this chapter. Let's look at an example of coding a simple FTP transfer using this automation technique in Listing 6-2.

```
#!/bin/ksh
#
# SCRIPT: tst_ftp.ksh
# AUTHOR: Randy Michael
# DATE: 6/12/2007
# REV: 1.1.A
# PLATOFRM: Not platform dependent
#
```

Listing 6-2 Simple here document for FTP transfer in a script

```
# PURPOSE: This shell script is a simple demonstration of
#          using a here document in a shell script to automate
#          an FTP file transfer.
#

# Connect to the remote machine and begin a here document.

ftp -i -v -n wilma <<END_FTP

user randy mypassword
binary
lcd /scripts/download
cd /scripts
get auto_ftp_xfer.ksh
bye

END_FTP
```

Listing 6-2 (*continued*)

Notice in Listing 6-2 where the beginning and ending labels are located. The first label, `<<END_FTP`, begins the here document and is located just after the interactive command that requires input, which is the `ftp` command in our case. Next comes all of the input that a user would have to supply to the interactive command. In this example we log in to the remote machine, `wilma`, using the `user randy mypassword` syntax. This `ftp` command specifies that the user is `randy` and the password is `mypassword`. Once the user is logged in, we set up the environment for the transfer by setting the transfer mode to binary, locally changing directory to `/scripts/download`, then changing the directory on the remote machine to `/scripts`. The last step is to `get` the `auto_ftp_xfer.ksh` file. To exit the FTP session, we use `bye`; `quit` also works. The last label, `END_FTP`, ends the here document, and the script exits.

Also notice the `ftp` command switches used in Listing 6-2. The `-i` command switch turns off interactive prompting during multiple file transfers so there is no prompt for the username and password. See the FTP `man` pages for `prompt`, `mget`, `mput`, and `mdelete` subcommands for descriptions of prompting during multiple file transfers. The `-n` switch prevents an automatic login on the initial connection. Otherwise, the `ftp` command searches for a `$HOME/.netrc` entry that describes the login and initialization process for the remote host. See the `user` subcommand in the `man` page for `ftp`. The `-v` switch was added to the `ftp` command to set *verbose* mode, which allows us to see the commands as the FTP sessions execute. The `tst_ftp.ksh` shell script from Listing 6-2 is shown in action in Listing 6-3.

```
[root:yogi]@/scripts# ./tst_ftp.ksh
Connected to wilma.
220 wilma FTP server (SunOS 5.8) ready.
```

Listing 6-3 Simple automated FTP file transfer using a script

```
331 Password required for randy.
230 User randy logged in.
200 Type set to I.
Local directory now /scripts/download
250 CWD command successful.
200 PORT command successful.
150 Binary data connection for auto_ftp_xfer.ksh
   (10.10.10.1,32793) (227 bytes).
226 Binary Transfer complete.
227 bytes received in 0.001092 seconds (203 Kbytes/s)
local: auto_ftp_xfer.ksh remote:
   auto_ftp_xfer.ksh
221 Goodbye.
[root:yogi]@/scripts#
```

Listing 6-3 (*continued*)

Using these techniques, we are going to create shell scripts to tackle some of the common needs of a business that depends on either receiving data from or transferring data to a remote host.

Automating File Transfers and Remote Directory Listings

We have the basic idea of automating an FTP file transfer, but what do we want to accomplish? We really want to be able to do three things: download one or more files with the `get` or `mget` FTP subcommands, upload one or more files with the FTP `put` or `mput` subcommands, and show a directory listing from a remote host. The first two items are standard uses for any FTP script, but getting a remote directory listing has not been explained in any of the documentation of a scripting technique that I have seen.

Additionally, we need to add the ability of pre-event and post-event processing. For example, a pre-FTP event may be getting a directory listing from a remote host. A post-`ftp` event may be changing the ownership and file permissions on a newly downloaded file(s). This last example brings up another point. When you FTP a file that has the execute bit set, the file will be received with the execute bit *un*set. Any time you `ftp` a file, the execution bit is stripped out of the file permissions. However, this is not the case if you use `sftp` (secure FTP).

Let's look at these topics one at a time.

Using FTP for Directory Listings on a Remote Machine

To save a remote directory listing from a remote system to a local file, we use the FTP subcommand `nlist`. The `nlist` subcommand has the following form:

```
nlist [RemoteDirectory][LocalFile]
```

The `nlist` subcommand writes a listing of the contents of the specified remote directory (`RemoteDirectory`) to the specified local file (`LocalFile`). If the `RemoteDirectory` parameter is not specified, the `nlist` subcommand lists the contents of the current remote directory. If the `LocalFile` parameter is not specified or is a `-` (hyphen), the `nlist` subcommand displays the listing on the local terminal.

Let's create a little shell script to test this idea. We can use most of the shell script contents shown in Listing 6-2, but we remove the `get` command and replace it with the `nlist` subcommand. Take a look at Listing 6-4.

```
#!/bin/ksh
#
# SCRIPT: get_remote_dir_listing.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This shell script uses FTP to get a remote directory listing
#          and save this list in a local file.
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
#########################################################################
################### DEFINE VARIABLES HERE ###############################
#########################################################################

RNODE="wilma"
USER="randy"
UPASSWD="mypassword"
LOCALDIR="/scripts/download"
REMOTEDIR="/scripts"
DIRLISTFILE="${LOCALDIR}/${RNODE}.$(basename ${REMOTEDIR}).dirlist.out"
cat /dev/null > $DIRLISTFILE

#########################################################################
###################### BEGINNING OF MAIN ################################
#########################################################################

ftp -i -v -n $RNODE <<END_FTP
user $USER $UPASSWD
nlist $REMOTEDIR $DIRLISTFILE
bye

END_FTP
```

Listing 6-4 get_remote_dir_listing.ksh shell script

There are several things to point out in Listing 6-4. We start out with a variable definition section. In this section we define the remote node, the username and password for the remote node, a local directory, a remote directory, and finally the local file that is to hold the remote directory listing. Notice that we had to create this file. If the local file does not already exist, the remote listing to the local file will fail. To create the file you can use either of the following techniques:

```
cat /dev/null > $DIRLISTFILE
>$DIRLISTFILE
touch $DIRLISTFILE
```

The first two examples create an empty file or will make an existing file empty. The `touch` command will update the time stamp for the file modification for an existing file and will create the file if it does not exist.

At the `BEGINNING OF MAIN` we have our five lines of code that obtain the directory listing from the remote node. We use the same technique as we did in Listing 6-2 except that we use variables for the remote node name, username, and password. Variables are also used for the directory name on the remote machine and for the local filename that holds the directory listing from the remote machine using the FTP subcommand `nlist`.

Notice that the password is hard-coded into this shell script. This is a security nightmare! The file permissions on this shell script should be set to read and execute by the owner only. In a later section in this chapter we will cover a technique for replacing hard-coded passwords with hidden password variables.

Getting One or More Files from a Remote System

Now we get to some file transfers. Basically we are going to combine the shell scripts in Listings 6-3 and 6-4. We are also going to add the functionality to add pre-FTP and post-FTP events. Let's start by looking at the shell script in Listing 6-5, `get_ftp_files.ksh`.

```
#!/bin/ksh
#
# SCRIPT: get_ftp_files.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This shell script uses FTP to get a list of one or more
#          remote files from a remote machine.
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
```

Listing 6-5 get_ftp_files.ksh shell script

```
#########################################################################
################### DEFINE VARIABLES HERE ###########################
#########################################################################

REMOTEFILES=$1

THISSCRIPT=$(basename $0)
RNODE="wilma"
USER="randy"
UPASSWD="mypassword"
LOCALDIR="/scripts/download"
REMOTEDIR="/scripts"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

#########################################################################
################### DEFINE FUNCTIONS HERE ###########################
#########################################################################

pre_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

#########################################################################

post_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}
```

Listing 6-5 (*continued*)

```
#########################################################################

usage ()
{
echo "\nUSAGE: $THISSCRIPT \"One or More Filenames to Download\" \n"
exit 1
}

#########################################################################

usage_error ()
{
echo "\nERROR: This shell script requires a list of one or more
       files to download from the remote site.\n"

usage
}

#########################################################################
#################### BEGINNING OF MAIN ##################################
#########################################################################

# Test to ensure that the file(s) is/are specified in the $1
# command-line argument.

(($# != 1)) && usage_error

pre_event

# Connect to the remote site and begin the here document.

ftp -i -v -n $RNODE <<END_FTP

user $USER $UPASSWD
binary
lcd $LOCALDIR
cd $REMOTEDIR
mget $REMOTEFILES
bye

END_FTP

post_event
```

Listing 6-5 (*continued*)

We made a few changes in Listing 6-5. The two major changes are that we obtain the list of files to download from the `$1` command-line argument, and we set up the correct `echo` command usage. Even though we declare the shell as Korn on the very first line

of the script, many Linux distributions will still execute in Bash shell. I have found this to be true with my Linux Fedora 7 release. If the executing shell is `*/bin/Bash`, the `echo` command requires a `-e` to enable the backslash operators `\n`, `\c`, and so on. We set up the proper `echo` command usage with the following code segment:

```
# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac
```

Moving on, if more than one file is listed on the command line, they must be enclosed in quotes, `"file1 file2 file3 filen"`, so they are interpreted as a single argument in the shell script. A blank space is assumed when separating the filenames in the list.

Notice that the local and remote directories are hard-coded into the shell script. If you want, you can modify this shell script and use `getopts` to parse through some command-line switches. This sounds like a great Lab Assignment!

Because we are now requiring a single argument on the command line, we also need to add a `usage` function to this shell script. We are looking for exactly one command-line argument. If this is not the case, we execute the `usage_error` function, which in turn executes the `usage` function. We could just as easily combine these functions into a single function.

Because we may have more than one filename specified on the command line, we need to use the FTP subcommand `mget`, as opposed to `get`. We have already turned off interactive prompting by adding the `-i` switch to the `ftp` command so there will not be any prompting when using `mget`.

Pre and Post Events

Notice in Listing 6-5 that we added two new functions, `pre_event` and `post_event`. By default, both of these functions contain only the no-op character, `:` (colon). A `:` does nothing but always has a return code of `0`, zero. We are using this as a placeholder to have something in the function.

If you have a desire to perform a task before or after the FTP activity, enter the tasks in the `pre_event` and/or the `post_event` functions. It is a good idea to enter only a filename of an external shell script rather than editing this shell script and trying to debug a function in an already working shell script. An external shell script filename that is executable is all that is needed to execute the pre and post events.

In the external shell script enter everything that needs to be done to set up the environment for the FTP file transfers. Some things that you may want to do include removing the old files from a directory before downloading new files or getting a directory listing of a remote host to see if there is anything to even download. You can make the code as long or as short as needed to accomplish the task at hand.

Script in Action

To see the shell script in Listing 6-5 in action, look at Listing 6-6, where we are transferring the shell script to another host in the network.

```
[root:yogi]@/scripts# ./get_ftp_files.ksh get_ftp_files.ksh
Connected to wilma.
220 wilma FTP server (SunOS 5.8) ready.
331 Password required for randy.
230 User randy logged in.
200 Type set to I.
Local directory now /scripts/download
250 CWD command successful.
200 PORT command successful.
150 Binary data connection for get_ftp_files.ksh (10.10.10.1,32808)
(1567 bytes)
.
226 Binary Transfer complete.
1567 bytes received in 0.001116 seconds (1371 Kbytes/s)
local: get_ftp_files.ksh remote: get_ftp_files.ksh
221 Goodbye.
[root:yogi]@/scripts#
```

Listing 6-6 get_ftp_files.ksh shell script in action

In this example the transfer is taking place between a local AIX machine called `yogi` and the remote SunOS machine called `wilma`.

Uploading One or More Files to a Remote System

Uploading files to another machine is the same as downloading the files except we now use the `put` and `mput` commands. Let's slightly modify the shell script in Listing 6-5 to make it into an upload script. This script modification is shown in Listing 6-7.

```
#!/bin/ksh
#
# SCRIPT: put_ftp_files.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This shell script uses FTP to put a list of one or more
#          local files to a remote machine.
```

Listing 6-7 put_ftp_files.ksh shell script

```
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
########################################################################
################### DEFINE VARIABLES HERE ##############################
########################################################################

LOCALFILES=$1

THISSCRIPT=$(basename $0)
RNODE="wilma"
USER="randy"
UPASSWD="mypassword"
LOCALDIR="/scripts"
REMOTEDIR="/scripts/download"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

########################################################################
################### DEFINE FUNCTIONS HERE ##############################
########################################################################

pre_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

########################################################################

post_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.
```

Listing 6-7 (*continued*)

```
:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

######################################################################

usage ()
{
echo "\nUSAGE: $THISSCRIPT \"One or More Filenames to Download\" \n"
exit 1
}

######################################################################

usage_error ()
{
echo "\nERROR: This shell script requires a list of one or more
       files to download from the remote site.\n"

usage
}

######################################################################
##################### BEGINNING OF MAIN ##############################
######################################################################

# Test to ensure that the file(s) is/are specified in the $1
# command-line argument.

(($# != 1)) && usage_error

pre_event

# Connect to the remote site and begin the here document.

ftp -i -v -n $RNODE <<END_FTP

user $USER $UPASSWD
binary
lcd $LOCALDIR
cd $REMOTEDIR
mput $LOCALFILES
bye

END_FTP

post_event
```

Listing 6-7 (*continued*)

The script in Listing 6-7 uses the same techniques as the `get_ftp_files.ksh` shell script in Listing 6-5. We have changed the `$1` variable assignment to `LOCALFILES` instead of `REMOTEFILES` and changed the FTP transfer mode to `mput` to upload the files to a remote machine. Other than these two changes the scripts are identical.

In all of the shell scripts in this chapter we have a security nightmare with hard-coded passwords. In the next section is a technique that allows us to remove these hard-coded passwords and replace them with hidden password variables. Following the next section we will use this technique to modify each of our shell scripts to utilize hidden password variables.

Replacing Hard-Coded Passwords with Variables

Traditionally, when a password is required in a shell script, it is hard-coded into the script. Using this hard-coded technique presents us with a lot of challenges, ranging from a security nightmare to the inability to change key passwords on a regular basis. The variable technique presented in this section is very easy to implement with only minor changes to *each* shell script.

NOTE It's important to note that each shell script must be changed to properly implement the technique throughout the infrastructure.

The variable-replacement technique is the same thing as sourcing the environment and consists of a single file that contains unique variable assignments for each password required for shell scripts on the system. A sample password file looks like the following:

```
DBORAPW=abc123
DBADMPW=def456
BACKUPW=ghi789
RANDY=mypassword
```

Some of the considerations of implementing this variable-replacement technique include the following:

- The scope of where the variable containing the password can be seen
- The file permission of the password variable file that contains the hard-coded passwords

To limit the scope of the variable, it is extremely important that the variable *not* be exported in the password variable file. If the variable is exported, you will be able to see the password *in plain text* in the process environment of the shell script that is using the password variable. Additionally, with all of these passwords in a single file, the file must be locked down to *read-only* by root, ideally.

The best illustration of this technique is a real example of how it works. In the following code sections, shown in Listings 6-8, 6-9, and 6-10, there is a password file that contains the password variable assignments that has the name `setpwenv.ksh` (notice this file is a shell script!). In the first file, the password variable *is* exported. In the second file, the password variable is *not* exported. Following these two files is a shell

script, `mypwdtest.ksh`, that executes the password environment file, `setpwenv.ksh`, and tests to see if the password is visible in the environment.

NOTE **Test results of using each technique are detailed in the next section of this chapter.**

Example of Detecting Variables in a Script's Environment

We start the examples with a `setpwenv.ksh` file that exports the password variable in Listing 6-8.

```
#!/bin/ksh
#
# SCRIPT: setpwenv.ksh
#
# PURPOSE: This shell script is executed by other shell
#          scripts that need a password contained in
#          a variable
#
#
# This password is NOT exported

# MYPWDTST=bonehead

# This password IS exported

MYPWDTST=bonehead
export MYPWDTST
```

Listing 6-8 Password file with the password variable exported

Notice in Listing 6-8 that the password *is* exported. As you will see, this export of the password variable will cause the password to be visible in plain text in the calling shell script's environment.

The password file in Listing 6-9 shows an example of *not* exporting the password variable.

```
#!/bin/ksh
#
# SCRIPT: setpwenv.ksh
#
# PURPOSE: This shell script is executed by other shell
#          scripts that need a password contained in
#          a variable
#
```

Listing 6-9 Password file showing the variable not exported

```
#
# This password is NOT exported

MYPWDTST=bonehead

# This password IS exported

# MYPWDTST=bonehead
# export MYPWDTST
```

Listing 6-9 (*continued*)

Notice in Listing 6-9 that the password is *not* exported. As you will see, this variable assignment without exporting the password variable will cause the password to *not* be visible in the calling shell script's environment, which is the result that we are looking for.

The shell script shown in Listing 6-10 performs the test of the visibility of the password assigned for each of the password environment files.

```
#!/usr/bin/ksh
#
# SCRIPT: mypwdtest.ksh
#
# PURPOSE: This shell script is used to demonstrate the
#          use of passwords hidden in variables.
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

# Set the BIN directory
BINDIR=/usr/local/bin

# Execute the shell script that contains the password variable
# assignments.

. ${BINDIR}/setpwenv.ksh
```

Listing 6-10 Shell script to demonstrate the scope of a variable

```
echo "\n\nPASS is $MYPWDTST"  # Display the password contained in
                              # the variable
echo "\nSearching for the password in the environment..."
env | grep $MYPWDTST
if (($? == 0))
then
     echo "\nERROR: Password was found in the environment\n\n"
else
     echo "\nSUCCESS: Password was NOT found in the environment\n\n"
fi
```

Listing 6-10 (*continued*)

The shell script shown in Listing 6-10, `mypwdtest.ksh`, tests the environment using each of the `setpwenv.ksh` shell scripts, one with the password environment exported and the second file that does not do the export. You can see the results of the tests here.

Example with the Password Variable Exported

```
PASS is bonehead

Searching for the password in the environment...
MYPWDTST=bonehead

ERROR: Password was found in the environment
```

Notice in the previous example that the password is visible in the shell script's environment. When the password is visible you can run the **env** command while the `mypwdtest.ksh` shell script is executing and see the password in plain text. Therefore, anyone could conceivably get the passwords very easily. Notice in the next output that the password is hidden.

Example with the Password Variable Not Exported

```
PASS is bonehead

Searching for the password in the environment...

SUCCESS: Password was NOT found in the environment
```

NOTE **As you can see, it is extremely important never to export a password variable.**

To implement this variable-password substitution into your shell scripts you only need to add the password to the password environment file using a unique variable name. Then inside the shell script that requires the password you execute the password file, which is `setpwenv.ksh` in our case. After the password file is executed the password variable(s) is/are ready to use.

NOTE **The preceding content uses this technique for passwords; however, this practice can also be utilized for usernames, hostnames, and application variables. The main purpose of this exercise is to have a central point of changing passwords on a regular basis and to eliminate hard-coded passwords in shell scripts.**

Modifying Our FTP Scripts to Use Password Variables

As you saw in the previous section, it is an easy task to modify a shell script to take advantage of hidden password variables. Here we make the two lines of modifications to our `nlist`, `get`, and `put` shell scripts.

The first thing that we need to do is create a password environment file. Let's use a name that is a little more obscure than `setpwenv.ksh`. How about `setlink.ksh`? Also, let's hide the `setlink.ksh` shell script in `/usr/sbin` for a little more security. Next let's set the file permissions to 400, *read-only* by the owner (`root`). Now you may be asking how we can execute a shell script that is read-only. All we need to do is to *dot* the filename, or source the filename. An example of dotting the file is shown here:

```
. /usr/sbin/setlink.ksh
```

The dot just says to execute the filename that follows. Now let's set up the password environment file. This example assumes that the user is `randy`:

```
echo "RANDY=mypassword" >> /usr/sbin/setlink.ksh
chown 400 /usr/sbin/setlink.ksh
```

Now in each of our shell scripts we need to *dot* the `/usr/sbin/setlink.ksh` file and replace the hard-coded password with the password variable defined in the external file, `/usr/sbin/setlink.ksh`, which is `$RANDY` in our case.

Listings 6-11, 6-12, and 6-13 show the modified shell scripts with the hard-coded passwords removed.

```
#!/bin/ksh
#
# SCRIPT: get_remote_dir_listing_pw_var.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This shell script uses FTP to get a remote directory listing
#          and save this list in a local file. This shell script uses
#          remotely defined passwords.
#
```

Listing 6-11 get_remote_dir_listing_pw_var.ksh script

```
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
##########################################################################
################### DEFINE VARIABLES HERE ##########################
##########################################################################

RNODE="wilma"
USER="randy"
LOCALDIR="/scripts/download"
REMOTEDIR="/scripts"
DIRLISTFILE="${LOCALDIR}/${RNODE}.$(basename ${REMOTEDIR}).dirlist.out"
cat /dev/null > $DIRLISTFILE

##########################################################################
#################### BEGINNING OF MAIN ###########################
##########################################################################

# Get a password

. /usr/sbin/setlink.ksh

ftp -i -v -n $RNODE <<END_FTP

user $USER $RANDY
nlist $REMOTEDIR $DIRLISTFILE
bye

END_FTP
```

Listing 6-11 (*continued*)

In Listing 6-11 the only modifications that we made to the original shell script include a script name change, the removal of hard-coded passwords, adding the execution of the `/usr/sbin/setlink.ksh` shell script, and adding the `$RANDY` remotely defined password variable.

```
#!/bin/ksh
#
# SCRIPT: get_ftp_files_pw_var.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
```

Listing 6-12 get_ftp_files_pw_var.ksh shell script

```
# PURPOSE: This shell script uses FTP to get one or more remote
#          files from a remote machine. This shell script uses a
#          remotely defined password variable.
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
######################################################################
################### DEFINE VARIABLES HERE ############################
######################################################################

REMOTEFILES=$1

THISSCRIPT=$(basename $0)
RNODE="wilma"
USER="randy"
LOCALDIR="/scripts/download"
REMOTEDIR="/scripts"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

######################################################################
################### DEFINE FUNCTIONS HERE ############################
######################################################################

pre_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

######################################################################

post_event ()
{
# Add anything that you want to execute in this function. You can
```

Listing 6-12 (*continued*)

```
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

#########################################################################

usage ()
{
echo "\nUSAGE: $THISSCRIPT \"One or More Filenames to Download\" \n"
exit 1
}

#########################################################################

usage_error ()
{
echo "\nERROR: This shell script requires a list of one or more
       files to download from the remote site.\n"

usage
}

#########################################################################
#################### BEGINNING OF MAIN ##################################
#########################################################################

# Test to ensure that the file(s) is/are specified in the $1
# command-line argument.

(($# != 1)) && usage_error

# Get a password

. /usr/sbin/setlink.ksh

pre_event

ftp -i -v -n $RNODE <<END_FTP

user $USER $RANDY
binary
lcd $LOCALDIR
cd $REMOTEDIR
mget $REMOTEFILES
bye
```

Listing 6-12 (*continued*)

```
END_FTP

post_event
```

Listing 6-12 (*continued*)

In Listing 6-12 the only modifications that we made to the original shell script include a script name change, the removal of hard-coded passwords, adding the execution of the `/usr/sbin/setlink.ksh` shell script, and adding the `$RANDY` remotely defined password variable.

```
#!/bin/ksh
#
# SCRIPT: put_ftp_files_pw_var.ksh
# AUTHOR: Randy Michael
# DATE: July 15, 2007
# REV: 1.1.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This shell script uses FTP to put a list of one or more
#          local files to a remote machine. This shell script uses
#          remotely defined password variables
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
#########################################################################
################### DEFINE VARIABLES HERE ###############################
#########################################################################

LOCALFILES=$1

THISSCRIPT=$(basename $0)
RNODE="wilma"
USER="randy"
LOCALDIR="/scripts"
REMOTEDIR="/scripts/download"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
```

Listing 6-13 put_ftp_files_pw_var.ksh shell script

```
*/bin/Bash) alias echo="echo -e"
            ;;
esac

########################################################################
################### DEFINE FUNCTIONS HERE ##############################
########################################################################

pre_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

########################################################################

post_event ()
{
# Add anything that you want to execute in this function. You can
# hard-code the tasks in this function or create an external shell
# script and execute the external function here.

:  # no-op: The colon (:) is a no-op character. It does nothing and
   # always produces a 0, zero, return code.
}

########################################################################

usage ()
{
echo "\nUSAGE: $THISSCRIPT \"One or More Filenames to Download\" \n"
exit 1
}

########################################################################

usage_error ()
{
echo "\nERROR: This shell script requires a list of one or more
       files to download from the remote site.\n"

usage
}
```

Listing 6-13 (*continued*)

```
#########################################################################
#################### BEGINNING OF MAIN ##################################
#########################################################################

# Test to ensure that the file(s) is/are specified in the $1
# command-line argument.

(($# != 1)) && usage_error

# Get a password

. /usr/sbin/setlink.ksh

pre_event

# Connect to the remote site and begin the here document.

ftp -i -v -n $RNODE <<END_FTP

user $USER $RANDY
binary
lcd $LOCALDIR
cd $REMOTEDIR
mput $LOCALFILES
bye

END_FTP

post_event
```

Listing 6-13 (*continued*)

In Listings 6-11, 6-12, and 6-13, the only modifications that we made to the original shell scripts include a script name change, the removal of hard-coded passwords, adding the execution of the `/usr/sbin/setlink.ksh` shell script, and adding the `$RANDY` remotely defined password variable.

What about Encryption?

I'm glad you asked! Most shops are now disabling FTP in favor of secure FTP. If you work for a publicly traded U.S. corporation, your company must comply with the Sarbanes-Oxley (SOX) Act of 2002. To comply with SOX requirements, the CEO and CFO of the corporation must sign off on the validity of the financial statement sent to the Securities and Exchange Commission (SEC) on a yearly basis. This effort also includes making sure there are controls in place to ensure the data integrity. Most non-encrypted communications must be disabled in favor of the Secure Shell alternatives.

For encrypted file transfers, we can use OpenSSH's secure FTP (`sftp`) or Secure Copy (`scp`). Secure FTP does not support the use of here documents, so we have two options. First, set up the encryption key pairs so that we are not required to use a password. Second, create an `expect` script to handle the interaction with `sftp` or `scp`. By far the simplest solution is to create the Secure Shell encryption keys so that a password is not required.

OpenSSH supports RSA and DSA encryption. You can set up one or both sets of keys for a user. Usually an organization uses one or the other, but not both as a company standard.

Creating Encryption Keys

If you want to transfer files between systems, you first must decide on the username who will own the files, and thus the file transfer tasks. The encryption keys are created in the user's `$HOME/.ssh` directory by executing the following command:

```
ssh-keygen -t rsa|dsa
```

where `rsa` or `dsa` represents the encryption key type you want to create. For our example, we are going to use RSA encryption keys. To create the encryption keys, first log in as the user you want to set up the keys for. Then change the directory to this user's `$HOME` directory. Just type **cd** and press Enter. Next **cd** to the `.ssh` subdirectory. If the `$HOME/.ssh` directory exists, the keys may have already been set up. Look for files named `id_rsa.pub` or `id_dsa.pub`. These files contain the public encryption keys for the particular encryption protocol. If you do not see either of these files, you need to set up the keys:

```
ssh-keygen -t rsa
```

Take the defaults for all the prompts and just press Enter when prompted to enter a passphrase. It takes a few seconds to create the encryption keys, and then you are returned to the command prompt. Now you should have a new set of encryption keys in the `$HOME/.ssh` directory.

Setting Up No-Password Secure Shell Access

To set up the no-password Secure Shell access, the user needs an account on both servers as well as a `$HOME` directory. To log in remotely without a password, the user's local public encryption key, located in the `$HOME/.ssh/id_rsa.pub` file, needs to be appended to the end of the remote system's `$HOME/.ssh/authorized_keys` file. The following command will take care of the task for us. This is an example of setting up the `ftpadmin` user for no-password access to the remote machine `booboo`:

```
cat $HOME/.ssh/id_rsa.pub | ssh ftpadmin@booboo \
"cat >> ~ftpuser/.ssh/authorized_keys"
```

If it is the first time this user has used Secure Shell to access the server, the user will be prompted to add a local key; just type **yes**. Next the user is prompted for a password and, if it's correct, the key is appended to the remote `$HOME/.ssh/authorized_keys` file. The next time you log in, you should not need a password.

Now that we have the encryption keys set up for our file transfer ''owner'' created, we only need to get the syntax for Secure Shell file transfers.

Secure FTP and Secure Copy Syntax

The syntax for Secure Copy (`scp`) and secure FTP (`sftp`) is almost identical for transferring files. Study the syntax of the `sftp` versus the `scp` syntax:

```
sftp ${COPYMGR}@${REM_MACHINE}:$REM_FILE $LOC_FILE

scp ${COPYMGR}@${REM_MACHINE}:$REM_FILE $LOC_FILE
```

The only difference is the command we use. Check out Listing 6-14 and we will cover the details at the end.

```
#!/bin/Bash
#
# SCRIPT: sftp-scp-getfile.Bash
# AUTHOR: Randy Michael
# DATE: 11/15/2007
# REV: 1.0
#
# PURPOSE: This is a simple script to show how
# Secure FTP and Secure Copy work with and
# without passwords. This is done by removing
# and adding the remote host's key in the local
# $HOME/.ssh/known_hosts file.
#
####################################
# DEFINE FILES AND VARIABLES HERE
####################################

COPYMGR=ftpadmin
REM_MACHINE=booboo
REM_FILE=/home/ftpadmin/getall.sh
LOC_FILE=$HOME # Use the same filename but
               # store the file in $COPYMGR
               # $HOME directory.

####################################
# BEGINNING OF MAIN
####################################
```

Listing 6-14 sftp-scp-getfile.Bash shell script

```
echo -e "\nSecure FTP Method\n"

sftp ${COPYMGR}@${REM_MACHINE}:$REM_FILE $LOC_FILE

echo -e "\nSecure Copy Method\n"

scp ${COPYMGR}@${REM_MACHINE}:$REM_FILE $LOC_FILE

echo -n
```

Listing 6-14 (*continued*)

In Listing 6-14, we define the `COPYMGR` as the `ftpadmin` user. The remote machine is defined as `booboo`, and the remote file to download is `/home/ftpadmin/getall.sh`. We are just going to store the files in the `ftpadmin` user's `$HOME` directory. Both file transfers are shown in Listing 6-15.

```
[sysadmin@yogi scripts]$ ./sftp-scp-getfile.Bash

Secure FTP Method

Connecting to booboo...
Fetching /home/sysadmin/getall.sh to /home/sysadmin/getall.sh

/home/sysadmin/getall.sh        0%    0     0.0KB/s   --:-- ETA
/home/sysadmin/getall.sh        100%
   666     0.7KB/s   00:00

Secure Copy Method


getall.sh      0     0.0KB/s   --:--      ETA
getall.sh                       100%
   666      0.7KB/s   00:00

[ftpadmin@yogi scripts]$
```

Listing 6-15 sftp-scp-getfile.Bash shell script in action

I really have no preference between these two methods; they both get the job done. Now let's change gears a bit and look at a way to automatically create a script to do the work for us.

Automating FTP with autoexpect and expect Scripts

Expect is a scripting language to automate an interactive program, such as FTP. The idea for an expect script is to send data to an interactive program, then *expect* data back,

and send more data back to the interactive application. The result is fully automated interaction with an interactive program.

Another nice thing about `expect` is the ability to create a complete script automatically, just by interacting with the program manually once, and, of course, not making a mistake. This magic is possible because of the `autoexpect` program. The `autoexpect` program works like the shell's `script` program works: by recording each keystroke you type as well as the reply from the application or shell. Then you press Ctrl + D to save the new `expect` script in the current directory. The default filename is `script.exp`, and this file is overwritten each time you execute `autoexpect` from this same directory. So, it's a good idea to rename the `script.exp` file to something a bit more meaningful and descriptive. You can also specify the resulting `expect` script filename with the `-f filename` switch.

```
# autoexpect
```

saves the resulting `expect` script in the current directory with the filename `script.exp`.

```
# autoexpect -f ftp-ls-getfile.exp
```

saves the resulting `expect` script in the current directory with the filename `ftp-ls-getfile.exp`.

```
# autoexpect -f /scripts/ftp-ls-getfile.exp
```

saves the resulting `expect` script in the `/scripts` directory with the filename `ftp-ls-getfile.exp`.

Now let's create a little expect script to log in to a remote server, list the contents of the login directory, and download the `getall.ksh` file. We are going to use `autoexpect` to create this script. The only thing to remember is that you cannot make a mistake. You cannot even press the Backspace or arrow keys. Every keystroke is recorded, and when we execute the expect script, it will ''replay'' the actions we recorded during the `autoexpect` session. Check out `ftp-ls-getfile.exp` in Listing 6-16 and we will cover the details at the end.

```
#!/usr/local/bin/expect -f
#
# This Expect script was generated by autoexpect on Fri Nov 16
   12:29:38 2007
# Expect and autoexpect were both written by Don Libes, NIST.
#
# Note that autoexpect does not guarantee a working script.  It
# necessarily has to guess about certain things.  Two reasons a
# script might fail are
#
# 1) timing - A surprising number of programs (rn, ksh, zsh, telnet,
```

Listing 6-16 expect script listing ftp-ls-getfile.exp

```
# etc.) and devices discard or ignore keystrokes that arrive "too
# quickly" after prompts.  If you find your new script hanging up at
# one spot, try adding a short sleep just before the previous send.
# Setting "force_conservative" to 1 (see below) makes Expect do this
# automatically - pausing briefly before sending each character.  This
# pacifies every program I know of.  The -c flag makes the script do
# this in the first place.  The -C flag allows you to define a
# character to toggle this mode off and on.

set force_conservative 0  ;# set to 1 to force conservative mode even if
                     ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
             sleep .1
             exp_send -s -- $arg
     }
}

#
# 2) differing output - Some programs produce different output each time
# they run.  The "date" command is an obvious example.  Another is
# ftp, if it produces throughput statistics at the end of a file
# transfer.  If this causes a problem, delete these patterns or replace
# them with wildcards.  An alternative is to use the -p flag (for
# "prompt") which makes Expect only look for the last line of output
# (i.e., the prompt).  The -P flag allows you to define a character to
# toggle this mode off and on.
#
# Read the man page for more info.
#
# -Don

set timeout -1
spawn $env(SHELL)
match_max 100000
expect -exact "\]0;root@yogi:/scripts\[root@yogi scripts\]# "
send -- "ftp booboo\r"
expect -exact "ftp booboo\r
Connected to booboo.\r
220 (vsFTPd 1.2.1)\r
530 Please login with USER and PASS.\r
530 Please login with USER and PASS.\r
KERBEROS_V4 rejected as an authentication type\r
Name (booboo:root): "
send -- "ftpadmin\r"
expect -exact "ftpadmin\r
331 Please specify the password.\r
```

Listing 6-16 (*continued*)

```
Password:"
send -- "abc1234\r"
expect -exact "\r
230 Login successful.\r
Remote system type is UNIX.\r
Using binary mode to transfer files.\r
ftp> "
send -- "ls\r"
expect -exact "ls\r
227 Entering Passive Mode (192,168,37,43,182,234)\r
150 Here comes the directory listing.\r
-rw-r--r--   1 4465    4465      29187 Sep 06 21:52
   Linux_booboo_cronlistings.txt\r
-rwxr-xr-x   1 4465    4465       1238 Sep 06 19:51 cron_capture\r
-rwxr-xr-x   1 4465    4465       1230 Sep 06 20:23 cron_capture-LINUX\r
-rw-r--r--   1 0       0            84 Apr 03  2007 drinfo.sh\r
-rw-rw-r--   1 4465    4465      68535 Sep 07 20:40 get_AIX_sysinfo.log\r
-rw-rw-r--   1 4465    4465        205 Sep 07 15:48 get_dr_info.ksh\r
-rw-rw-r--   1 4465    4465      10933 Sep 07 20:35 get_sysinfo2.log\r
-rw-r--r--   1 0       0           666 Apr 03  2007 getall.sh\r
-rw-r--r--   1 0       0           256 Apr 03  2007 imp.sh\r
-rw-r--r--   1 0       0           323 Apr 03  2007 pb_getnet.sh\r
-rw-r--r--   1 0       0           167 Apr 03  2007 pb_getvg.sh\r
-rw-r--r--   1 0       0           618 Apr 03  2007 putall.sh\r
-rw-r--r--   1 0       0         10240 Sep 07 15:50 scripts.tar\r
-rw-r--r--   1 0       0            32 Apr 03  2007 um.sh\r
226 Directory send OK.\r
ftp> "
send -- "get getall.sh\r"
expect -exact "get getall.sh\r
local: getall.sh remote: getall.sh\r
227 Entering Passive Mode (192,168,37,43,52,152)\r
150 Opening BINARY mode data connection for getall.sh (666 bytes).\r
226 File send OK.\r
666 bytes received in 0.064 seconds (10 Kbytes/s)\r
ftp> "
send -- "bye\r"
expect -exact "bye\r
221 Goodbye.\r
\]root@yogi:/scripts\[root@yogi scripts\]# "
send -- ""
expect eof
```

Listing 6-16 (*continued*)

This is the resulting `expect` script that the `autoexpect` program created. As you can see, `autoexpect` adds a lot of extra stuff. One of the key things I've learned writing `expect` scripts, without using `autoexpect`, is to *not expect too much*. If you look closely at Listing 6-16, you will see `expect -exact "something"\r`. The `-exact` part of

that statement is what will get you sometimes. If a space is in the wrong place, you can have a problem. That's why I say don't expect too much. Most of the time, you want to leave off `-exact` when specifying expected output.

Listing 6-17 shows the shell script in action.

```
[root@yogi scripts\]# ftp-ls-getfile.exp
ftp booboo
Connected to booboo.
220 (vsFTPd 1.2.1)
530 Please login with USER and PASS.
530 Please login with USER and PASS.
KERBEROS_V4 rejected as an authentication type
Name (booboo:root): ftpadmin
ftpadmin
331 Please specify the password.
Password:
230 Login successful.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> ls
227 Entering Passive Mode (192,168,37,43,182,234)
150 Here comes the directory listing.
-rw-r--r--   1 0       0          666 Apr 03  2007 getall.sh
-rw-r--r--   1 0       0          256 Apr 03  2007 imp.sh
-rw-r--r--   1 0       0          323 Apr 03  2007 pb_getnet.sh
-rw-r--r--   1 0       0          167 Apr 03  2007 pb_getvg.sh
-rw-r--r--   1 0       0          618 Apr 03  2007 putall.sh
-rw-r--r--   1 0       0        10240 Sep 07 15:50 scripts.tar
-rw-r--r--   1 0       0           32 Apr 03  2007 um.sh
226 Directory send OK.
ftp> get getall.sh
get getall.sh
local: getall.sh remote: getall.sh
227 Entering Passive Mode (192,168,37,43,52,152)
150 Opening BINARY mode data connection for getall.sh (666 bytes).
226 File send OK.
666 bytes received in 0.064 seconds (10 Kbytes/s)
ftp> bye
bye
221 Goodbye.
[root@yogi scripts\]#
```

Listing 6-17 expect script ftp-ls-getfile.exp in action

Expect is a programming language that you just have to play around with to learn. Chapter 8, Automating Interactive Programs with Expect and Autoexpect,'' goes into `expect` in more detail, but for now, study the `expect man` page (**man expect**).

Other Things to Consider

This set of shell scripts is very useful to a lot of businesses, but you will need to tailor the shell scripts to fit your environment. Some options that you may want to consider are listed in the following sections.

Use Command-Line Switches to Control Execution

By using `getopts` to parse command-line options you can modify these shell scripts to have all of the variables assigned on the command line with switches and switch arguments. This modification can allow you to specify the target host, the local and remote working directories, and the file(s) to act on. We have used `getopts` a lot in this book, so look at some of the other chapters that use `getopts` to parse the command-line switches and try making some modifications as an exercise.

Keep a Log of Activity

It is a very good idea to keep a log of each connection and check the return codes. If you use the `ftp` switch `-v` you will have a detailed account of the connection activity of each transaction. Remember to add a date stamp to each log entry, and also remember to trim the log file periodically so the filesystem does not fill up.

Add a Debug Mode to the Scripts

If a connection fails you could put the script into debug mode by adding a function called `debug`. In this function the first thing to do is to `ping` the remote machine to see if it is reachable. If the machine is not reachable by pinging, attempting to `ftp` to the remote node is useless.

You can also issue the `ftp` command with the debug option turned on, specified by the `-d` switch. For more information on FTP debug mode, see the `man` pages for the `ftp` command (**man ftp**).

Reading a Password into a Shell Script

There may come a time when you write a shell script where you want a user to enter a password. I am not talking about a UNIX login or an FTP session; I am talking about a password that the shell script requires.

Any time you read in a password, you want to suppress echoing the password the user types to the screen. This is a little trick my technical editor, John Kennedy, gave me. The idea is to save the current tty definition, turn off the echo response to the screen, read in the user's password, and finally restore the user's tty device:

```
oldSTTY=$( stty --save )
stty -echo
read -p "Password: " PASSWD; echo
stty $oldSTTY
```

The password the user entered is stored in the variable `PASSWD`.

Summary

This chapter is meant to form a basis for creating larger shell scripts that require the transfer of files between machines. The set of shell scripts presented in this chapter can be modified or made into functions to suit your needs. There are too many variables for the use of FTP to follow each path to its logical end, so in this case you get the building blocks. If you have trouble with a shell script, always try to do the same thing the shell script is doing, except do it on the command line. Usually you can find where the problem is very quickly. If you cannot reach a remote node, try to `ping` the machine. If you cannot `ping` the machine, network connectivity or name resolution is the problem.

In the next chapter we are moving on to replicating data between machines using `rsync`. I hope you found this chapter useful, and I'll see you in the next chapter!

Lab Assignments

1. Use `autoexpect` to create an `expect` script to `ftp` a file to a remote machine. Ensure the new `expect` script works, and then edit the script and remove everything that is not required. This `expect` script should be no more than 10 lines of code.
2. Modify the `put_ftp_files_pw_var.ksh` shell script in Listing 6-13 to use `getopts` to parse command-line switches `-l`, local file, and `-r`, remote file. Both `-l` and `-r` switches require a string value.

The script syntax will be

```
put_ftp_files_pw_var.ksh -l LocalFile -r RemoteFile
```

CHAPTER 7

Using rsync to Efficiently Replicate Data

We use ***rsync*** as a faster option for copy (`cp`), remote copy (`rcp`), secure copy (`scp`), file transfer protocol (`ftp`), and secure FTP (`sftp`). We can use `rsync` to copy local files as well as to copy files between the local machine and a remote machine. However, `rsync` does *not* support copying files between two remote machines. The reason that `rsync` is faster than `cp`, `rcp`, and `scp` is that it uses the `rsync` *remote-update protocol*, which greatly speeds up file transfers when the file already exists on the destination server, for certain file types, and offers the option of compression. The `rsync` remote-update protocol uses an efficient checksum search algorithm that allows `rsync` to transfer only the differences between two sets of files, whether locally or remotely, across a network connection. Adding the `-z` switch to `rsync` compresses the files, which offers even faster file transfers.

NOTE **`rsync` must be installed on both machines to transfer files remotely.**

In this chapter we are going to look at the syntax to transfer files from a local machine to a remote machine, transferring files from a remote machine to the local machine, copying files locally, and using compression. Then we will study a simple, generic shell script to transfer files in archive-compressed mode. The final script is a pretty complicated shell script that I use to move Oracle data from a master database server to two remote Oracle OLTP (online transaction processing) machines that alternate between day 1 data and day 2 data. This will become clear when we study this technique. Let's start with the `rsync` command syntax.

Syntax

We use `rsync` in much the same way that we use `rcp` and `scp`. All three methods require a source and destination file or directory, and there are command-line switches

that allow us to save file permissions, links, ownership, and so on, as well as to copy directory structures recursively. A few examples are the best way to learn how to use `rsync`. Let's start with this simple `rsync` statement:

```
rsync  myscript.Bash  yogi:/scripts/
```

This would transfer the file `myscript.Bash` from the current directory on the local machine to the `/scripts` directory on the `yogi` server. Now, if the `myscript.Bash` file already exists on the server `yogi`, in the `/scripts` directory, the *rsync remote-update protocol* is used to update the file by sending only the differences between the source and destination files:

```
rsync -avz yogi:/scripts/data  /scripts/tmp
```

This `rsync` statement will recursively transfer all the files and directories in the `/scripts/data` directory on the `yogi` machine to the `/scripts/tmp` directory on the local machine. The `-a rsync` switch specifies *archive mode*, which preserves the permissions, ownerships, symbolic links, attributes, and so on, and specifies a recursive copy in the transfer. The `-z rsync` switch specifies compression is to be used in the transfer to reduce the amount of data in the transfer. Note that this example will create a new directory, `/scripts/tmp/data`, on the local machine. The `-v rsync` switch specifies verbose mode. Now check out the next rsync example.

```
rsync -avz yogi:/scripts/data/ /scripts/tmp
```

Notice the trailing slash on the source: `yogi:/scripts/data/`.

This trailing slash changes the behavior of `rsync` to eliminate creating the additional directory on the destination, as the previous example produced: `/scripts/tmp/data`. The trailing slash on the *source* side tells `rsync` to *copy the directory contents*, as opposed to *copy the directory name and all its contents*.

```
rsync -avz /scripts/data /scripts/tmp
rsync -avz /scripts/data/ /scripts/tmp
```

As you can see by these two examples, we can copy files locally as well as remotely. Notice that local file copying does not have a hostname specified by the *hostname:* notation.

Generic rsync Shell Script

A simple, generic shell script for `rsync` consists of only defining some variables to point to the file and/or directory we want to copy, and a one-line `rsync` statement. Check out Listing 7-1 and we will cover the details at the end.

```
#!/bin/Bash
#
# SCRIPT: generic_rsync.Bash
# AUTHOR: Randy Michael
# DATE: 11/18/2007
# REV: 1.0
# PURPOSE: This is a generic shell script to copy files
#          using rsync.
#
# set -n # Uncomment to check script syntax without execution
# set -x # Uncomment to debug this script
#
# REV LIST:
#
#
################################################
# DEFINE FILES AND VARIABLES HERE
################################################

# Define the source and destination files/directories

SOURCE_FL="/scripts/"
DESTIN_FL="booboo:/scripts"

################################################
# BEGINNING OF MAIN
################################################

# Start the rsync copy

rsync -avz "$SOURCE_FL" "$DESTIN_FL"

# End of generic_rsync.Bash
```

Listing 7-1 generic_rsync.Bash script

As you can see, there is not much to this shell script. We define the source and destination files/directories to the `SOURCE_FL` and `DESTIN_FL` variables, respectively. Next we use these variables in our `rsync` statement, as follows:

```
rsync -avz "$SOURCE_FL" "$DESTIN_FL"
```

This `rsync` command will recursively transfer all the files and subdirectories in the local `/scripts/` directory (notice the trailing slash on the source) to the `/scripts` directory on the `booboo` server using compression to reduce the amount of data transferred. Notice the trailing slash avoided creating a second `scripts` directory on the destination: `/scripts/scripts/`.

Now let's look at some example shell scripts to replicate data at the directory structure level and filesystem level, respectively.

Replicating Multiple Directories with rsync

Ever need a technique to replicate one or more directory structures to one or more remote machines? If so, this section is your miracle! Using `rsync` to replicate data is both efficient and reliable to an unbelievable degree when you see how fast the `rsync` remote-update protocol is when files already exist on the target(s). We have already looked at using `rsync` to replicate a single directory structure. The only thing we are adding is a loop to `rsync` multiple directory structures in parallel by starting each `rsync` session in the background, specified by `rsync_command &`. As the `rsync` process progresses, we are also going to monitor each `rsync` session at the process table level as we give the user very detailed feedback. This feedback is crucial to any long-running process or procedure that has user interaction.

For this script we will need a list file to hold the names of each top-level directory structure we want to replicate. We can name this list file `rsync_directory_list.lst` for this example. Because we are going to be looping through this list file, the script will expect one directory listed on each line. An example file, `rsync_directory_list.lst`, is shown in Listing 7-2.

```
# This file is used by the generic_DIR_rsync_copy.Bash
# shell script to define top-level directory structures
# to replicate with rsync to one or more remote servers.
# The script is expecting full pathnames (must begin with
# a forward slash, EX: /directory/path. The may end in a
# forward slash but not required.
#
# Example list:
#
# /data/path01
# /home/myhome
# /scripts
#
/data01
/data02
/data03/
/data04/
/data05
```

Listing 7-2 Example rsync_directory_list.lst file

As we previously studied, to prevent `rsync` from creating an extra directory on the target, we must specify the directory path with a trailing forward slash on the source — for example, `/directory/path/`. Notice in Listing 7-2 that only two entries have the trailing forward slash, `/data03/` and `/data04/`. Not to worry. If the trailing forward slash is missing, we will add it in the script.

For this example shell script there are plenty of comments to follow along, so I think it is best if you study the `generic_DIR_rsync_copy.Bash` shell script in Listing 7-3 in detail and we will study the details at the end.

```
#!/bin/Bash
#
# SCRIPT: generic_DIR_rsync_copy.Bash
# AUTHOR: Randy Michael
# DATE: 1/14/2007
# REV: 1.0
# PLATFORM: Not platform dependent
#
# REQUIRED INSTALLATION: rsync must be
#          installed on the source and
#          all target systems
#
# REQUIRED FILE FOR OPERATION:
#          The file pointed to by the
#          $DIR_LIST_FILE variable refers
#          to the required file listing the
#          top-level directory structures
#          that rsync is to replicate. The
#          DIR_LIST_FILE is defined in the
#          variables declarations section
#          of this shell script
#
# PURPOSE: This shell script is used to replicate
#     directory structures to one or more remote
#     machines using rsync in archive and
#     compressed mode. This script requires
#     a file referenced by the variable
#     DIR_LIST_FILE that lists the top level
#     of each of the local directory structures
#     that we want to replicate to one or more
#     remote machines
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check script syntax
#        # without execution. Remember to put
#        # the comment back into the script or it
#        # will never execute.
#
#######################################
# DEFINE FILES AND VARIABLES HERE
#######################################
```

Listing 7-3 generic_DIR_rsync_copy.Bash shell script

```
# Define the target machines to copy data to.
# To specify more than one host enclose the
# hostnames in double quotes and put at least
# one space between each hostname
#
# EXAMPLE:  MACHINE_LIST="fred yogi booboo"

MACHINE_LIST="fred"

# The DIR_LIST_FILE variable define the shell script
# required file listing the directory structures
# to replicate with rsync.

DIR_LIST_FILE="rsync_directory_list.lst"

# Define the directory containing all of the
# output files this shell script will produce

WORK_DIR=/usr/local/bin

# Define the rsync script log file

LOGFILE="generic_DIR_rsync_copy.log"

# Query the system for the hostname

THIS_HOST=$(hostname)

# Query the system for the UNIX flavor

OS=$(uname)

#######################################
# DEFINE FUNCTIONS HERE
#######################################

elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && echo -e "[Elapsed time: $SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && echo -e "[Elapsed time: \
$(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && echo -e "[Elapsed time: $(( SEC / 3600 )) \
hr $(( (SEC % 3600) / 60 )) min $(( (SEC % 3600) % 60 )) \
sec]\c"
}
```

Listing 7-3 (*continued*)

```
########################################

verify_copy ()
{
# set -x

MYLOGFILE=${WORK_DIR}/verify_rsync_copy.log
>$MYLOGFILE
ERROR=0

# Enclose this loop so we can redirect output to the log file
# with one assignment at the bottom of the function
{
# Put a header for the verification log file

echo -e "\nRsync copy verification starting between $THIS_HOST \
and machine(s) $MACHINE_LIST\n\n" >$MYLOGFILE

for M in $MACHINE_LIST
do
   for DS in $(cat $DIR_LIST_FILE)
   do
       LS_FILES=$(find $DS -type f)
       for FL in $LS_FILES
       do
           LOC_FS=$(ls -l $FL | awk '{print $5}' 2>&1)
           REM_FS=$(ssh $M ls -l $FL | awk '{print $5}' 2>&1)
           echo "Checking File: $FL"
           echo -e "Local $THIS_HOST size:\t$LOC_FS"
           echo -e "Remote $M size:\t$REM_FS"
           if [ "$LOC_FS" -ne "$REM_FS" ]
           then
              echo "ERROR: File size mismatch between $THIS_HOST and $M"
              echo "File is: $FL"
              ERROR=1
           fi
       done
   done
done

if (( ERROR != 0 ))
then
    # Record the failure in the log file

    echo -e "\n\nRSYNC ERROR: $THIS_HOST Rsync copy failed...file\
    size mismatch...\n\n" | tee -a $MYLOGFILE

    echo -e "\nERROR: Rsync copy Failed!"
```

Listing 7-3 (*continued*)

```
    echo -e "\n\nCheck log file: $MYLOGFILE\n\n"
    echo -e "\n...Exiting...\n"

    # Send email notification with file size log

#    mailx -r from_someone@somewhere.??? -s "Rsync copy verification \
#failed $THIS_HOST -- File size mismatch" \
#    somebody@fsf.com < $MYLOGFILE

    sleep 2 # Give a couple of seconds to send the email

    exit 3
else
    echo -e "\nSUCCESS: Rsync copy completed successfully..."
    echo -e "\nAll file sizes match...\n"
fi
} | tee -a $MYLOGFILE

}

########################################
# BEGINNING OF MAIN
########################################

# We enclose the entire MAIN in curly braces
# so that all output of the script is logged
# in the $LOGFILE with a single output
# redirection

{

# Save the last logfile with a .yesterday filename extension

cp -f $LOGFILE ${LOGFILE}.yesterday 2>/dev/null

# Zero out the $LOGFILE to start a new file

>$LOGFILE

# Start all of the rsync copy sessions at once by looping
# through each of the mount points and issuing an rsync
# command in the background, saving the PID of the
# background process, and incrementing a counter.

echo -e "\nStarting a bunch of rsync sessions...$(date)\n"

# Initialize the rsync session counter, TOTAL
# to zero
```

Listing 7-3 (*continued*)

```
TOTAL=0

# Loop through each machine in the $MACHINE_LIST

for M in $MACHINE_LIST
do
   # Loop through all of the directory structures
   # listed in the $DIR_LIST_FILE and start an rsync
   # session in the background for each directory

   for DS in $(cat $DIR_LIST_FILE)
   do
      # Ensure each directory structure has a trailing
      # forward slash to ensure an extra directory is
      # not created on the target

      if ! $(echo "$DS" | grep -q '/$')
      then
           # If the directory structure does not
           # have a trailing forward slash, add it

           DS="${DS}/"
      fi

      # Start a timed rsync session in the background

      time rsync -avz ${DS} ${M}:${DS} 2>&1 &

      # Keep a running total of the number of rsync
      # sessions started
      (( TOTAL = TOTAL + 1 ))
   done
done

# Sleep a 10 seconds before monitoring processes

sleep 10

# Query the process table for the number of rsync sessions
# that continue executing and store that value in the
# REM_SESSIONS variablei

# Create a list of directory structures for an egrep list

EGREP_LIST=    # Initialize to null

while read DS
do
```

Listing 7-3 (*continued*)

```
    if [ -z $EGREP_LIST ]
    then
        EGREP_LIST="$DS"
    else
        EGREP_LIST="|$DS"
    fi
done < $DIR_LIST_FILE

REM_SESSIONS=$(ps x | grep "rsync -avz" | egrep "$EGREP_LIST" \
               | grep -v grep | awk '{print $1}' | wc -l)

# Give some feedback to the end user.

if (( REM_SESSIONS > 0 ))
then
   echo -e "\n$REM_SESSIONS of $TOTAL rsync copy sessions require \
   further updating..."
   echo -e "\nProcessing rsync copies from $THIS_HOST to both \
   $MACHINE_LIST machines"
   echo -e "\nPlease be patient, this process may a very long time...\n"
   echo -e "Rsync is running [Start time: $(date)]\c"
else
   echo -e "\nAll files appear to be in sync...verifying file sizes...\
   Please wait...\n"
fi

# While the rsync processes are executing this loop
# will place a . (dot) every 60 seconds as feedback
# to the end user that the background rsync copy
# processes are still executing. When the remaining
# rsync sessions are less than the total number of
# sessions this loop will give feedback as to the
# number of remaining rsync session, as well as
# the elapsed time of the processing, every 5 minutes

# Set the shell variable SECONDS to 10 to make up for the
# time we slept while the rsync sessions started

SECONDS=10

# Initialize the minute counter to zero minutes

MIN_COUNTER=0

# Loop until all of the rsync sessions have completed locally

until  (( REM_SESSIONS == 0 ))
do
```

Listing 7-3 (*continued*)

```
    sleep 60
    echo -e ".\c"
    REM_SESSIONS=$(ps x | grep "rsync -avz" | egrep "$EGREP_LIST" \
                   | grep -v grep | awk '{print $1}' | wc -l)
    if (( REM_SESSIONS < TOTAL ))
    then
        (( MIN_COUNTER = MIN_COUNTER + 1 ))
        if (( MIN_COUNTER >= $(( TOTAL / 2 )) ))
        then
           MIN_COUNTER=0
           echo -e "\n$REM_SESSIONS of $TOTAL rsync sessions \
           remaining $(elapsed_time $SECONDS)\c"
           if (( REM_SESSIONS <= $(( TOTAL / 4 )) ))
           then
              echo -e "\nRemaining rsync sessions include:\n"
              ps x | grep "rsync -avz" | egrep "$EGREP_LIST" \
                     | grep -v grep
              echo
           fi
        fi
    fi
done

echo -e "\n...Local rsync processing completed on ${THIS_HOST}...$(date)"


echo -e "\n...Checking remote target machine(s): ${MACHINE_LIST}..."

# Just because the local rsync processes have completed does
# not mean that the remote rsync processes have completed
# execution. This loop verifies that all of the remote
# rsync processes completed execution. The end user will
# receive feedback if any of the remote processes are running.

for M in $MACHINE_LIST
do
   for DS in $(cat $DIR_LIST_FILE)
   do
       RPID=$(ssh $M ps x | grep rsync | grep $DS | grep -v grep \
       | awk'{print $1}')
       until [ -z "$RPID" ]
       do
           echo "rsync is processing ${MP} on ${M}...
   sleeping one minute..."
           sleep 60
           RPID=$(ssh $M ps x | grep rsync | grep $DS | grep -v grep \
                | awk '{print $1}')
       done
```

Listing 7-3 (*continued*)

```
   done
done

echo -e "\n...Remote rsync processing completed $(date)\n"

# Verify the copy process

verify_copy

echo -e "\nRsync copy completed $(date)"
echo -e "\nElapsed time: $(elapsed_time $SECONDS)\n"

} 2>&1 | tee -a $LOGFILE
################################################
# END OF SCRIPT
################################################
```

Listing 7-3 (*continued*)

We begin the `generic_DIR_rsync_copy.Bash` shell script in Listing 7-3 by declaring some files and variables. The `MACHINE_LIST` contains one or more remote machines to replicate data to. If more than one target machine is listed, the list must be enclosed in quotes and the hostnames must be separated by at least one blank space — *no commas*! The `WORK_DIR` is the directory where the files this shell script creates will be located. Next we define our directory list file with the variable `DIR_LIST_FILE`. This variable points to our directory list file `rsync_directory_list.lst`. This script assumes this directory list file is located in the same directory as the shell script. The last assignments define the name of the log file, hostname, and the UNIX flavor.

We define two functions in the `generic_DIR_rsync_copy.Bash` shell script in Listing 7-3. The `elapsed_time` function converts seconds into hours, minutes, and seconds, and the `verify_copy` function verifies the `rsync` copy by ensuring the file sizes match locally and remotely. We will come back to the verification process; for now, though, let's start at the `BEGINNING OF MAIN` and look closer at the details.

The first thing we do is to open a curly brace, `{`. There is a closing curly brace at the end of the shell script. We enclosed the entire main body of the shell script so we can log all the activity as the shell script executes with a single output redirection to pipe the output to `tee -a $LOGILE`. An example is shown here:

```
################################################
# BEGINNING OF MAIN
################################################

{

     main body shell script code

} 2>&1 | tee -a $LOGFILE
```

Now any output sent to standard output (stdout) or standard error (stderr) will be displayed on the screen and logged to the $LOGFILE at the same time. This technique saves a lot of >>$LOGFILE output redirections and makes the script a lot cleaner and easier to read.

The next thing to do is to save a copy of the last log file. Ideally, at least a week's worth of log files should be kept to troubleshoot any rsync problems that come up. I will show a set of cron table entries that can be used to keep seven days of log files. This script makes a copy of the log file with a .yesterday filename extension, cp $LOGFILE ${LOGFILE}.yesterday.

Now we are ready to kick off a bunch of rsync sessions in the background. We start by looping through the $MACHINE_LIST, and then start a second nested loop that starts looping through the $DIR_LIST_FILE, as follows:

```
# Loop through each machine in the $MACHINE_LIST

for M in $MACHINE_LIST
do
   # Loop through all of the directory structures
   # listed in the $DIR_LIST_FILE and start an rsync
   # session in the background for each directory

   for DS in $(cat $DIR_LIST_FILE)
   do
```

As we loop through all the directory structures, we next test for a trailing forward slash. If the forward slash is missing, we add it, as shown here:

```
      # Ensure each directory structure has a trailing
      # forward slash to ensure an extra directory is
      # not created on the target

      if ! $(echo "$DS" | grep -q '/$')
      then
           # If the directory structure does not
           # have a trailing forward slash, add it

           DS="${DS}/"
      fi
```

To test for a trailing forward slash, we use the regular expression /$. The dollar sign ($) specifies *ends with*, so this regular expression means *ends with* /. We echo the $DS variable and pipe the output to grep -q '/$'. The -q switch specifies quiet mode, so we are looking for the return code in the if statement. The if is negated with an exclamation point, !, specifying that if the forward slash does not exist, we create it with the DS='${DS}/' variable assignment.

Now we start an rsync session for the directory structure we are currently processing in the loop with the following rsync command:

```
time rsync -avz ${DS} ${M}:${DS} 2>&1 &
```

Notice that we start this rsync session with a time command. This is not the operating system's /usr/bin/time command, but the shell's built-in time command. The shell version of time has a more granular detail in the timing results.

The rsync command is specified with the -a, -v, and -z switches:

- The -a switch copies in archive mode, preserving all file and directory characteristics.
- The -v switch is verbose mode for a more detailed output.
- The -z switch specifies using compression during the copy process.

We use the variable ${DS} to point to the directory structure to replicate, and the ${M} points to the remote target machine. We end the rsync command with 2>&1 &. This sends standard error to standard output, and the final & executes the rsync session in the background. As we start each rsync session, we increment the TOTAL counter so that we can keep track of how many sessions we started.

After all the rsync sessions have started execution in the background, we sleep for 10 seconds to allow time for rsync to make an initial check to see if anything needs to be updated using rsync's remote-update protocol. After 10 seconds, we check the process table for any remaining rsync sessions. To run the ps command, we need a pattern to grep on. We first grep on the rsync command statement, rsync -avz. We also have a list of directory structures we need to grep on to find each rsync session. To do this step, we need to build an egrep command list of the directory structures. The following loop builds the EGREP_LIST variable:

```
EGREP_LIST=   # Initialize to null

while read DS
do
   if [ -z $EGREP_LIST ]
   then
       EGREP_LIST="$DS"
   else
       EGREP_LIST="|$DS"
   fi
done < $DIR_LIST_FILE
```

The EGREP_LIST variable is first initialized to NULL. Next we feed the while loop from the bottom with input redirection after the done loop terminator. The if statement begins by checking if the EGREP_LIST variable is zero length, or NULL. If so, this is the first assignment and we assign the current $DS to EGREP_LIST. For all subsequent assignments, a pipe is added in front of the $DS assignment, |$DS. The result is a pipe-delimited list, as shown here:

```
/data01|/data02|/data03|/data04|/data05
```

Now we can assemble the ps command statement to query the system for remaining rsync sessions. The full ps statement is shown here:

```
REM_SESSIONS=$(ps x | grep "rsync -avz" | egrep "$EGREP_LIST" \
               | grep -v grep | awk '{print $1}' | wc -l)
```

If we find any `rsync` sessions running, we enter a monitoring loop until all the local `rsync` sessions have completed. During the execution we continuously give the user feedback. While the `$REM_SESSIONS` variable is equal to the `$TOTAL` sessions variable, we display a dot on the screen every 60 seconds. When the `$REM_SESSIONS` value drops below the `$TOTAL` value, we start updating the user every 5 minutes, 300 seconds, with the number of remaining sessions and the elapsed time. When the `REM_SESSIONS` reaches one-fourth of the `TOTAL` sessions, we start listing the remaining session residing in the process table. Users are always wondering ''What's taking so long?'' Well, this script answers that question.

The `generic_DIR_rsync_copy.Bash` shell script in Listing 7-3 is shown in action in Listings 7-4 and 7-5. The initial copy can take quite a while to replicate because the files do not yet exist on the target(s). However, after the files are copied the first time, the `rsync` remote-update protocol allows for much faster replication. Listing 7-4 shows a first-time `rsync` copy session.

```
Starting a bunch of rsync sessions...Sun Jan 13 01:45:16 EST 2008

building file list ... done
building file list ... done
./
./
random_file.out0
random_file.out2
building file list ... done
./
building file list ... done
random_file.out4
./
random_file.out6
building file list ... done
./
random_file.out7

5 of 5 rsync copy sessions require further updating...

Processing rsync copies from booboo to both fred machines

Please be patient, this process may a very long time...

Rsync is running [Start time: Sun Jan 13 01:45:26 EST 2008]...
sent 1244739 bytes  received 48 bytes  6334.79 bytes/sec
total size is 261428695  speedup is 210.02
```

Listing 7-4 generic_DIR_rsync_copy.Bash script when files do not exist on target

```
real  3m17.007s
user  0m5.817s
sys  0m0.682s
.random_file.out5
random_file.out3
random_file.out1
.
4 of 5 rsync sessions remaining [Elapsed time: 5 min 10 sec]..
4 of 5 rsync sessions remaining [Elapsed time: 7 min 10 sec]
sent 3153396 bytes  received 70 bytes  7274.43 bytes/sec
total size is 662550995  speedup is 210.10

real  7m13.186s
user  0m14.756s
sys  0m1.658s

sent 3153396 bytes  received 70 bytes  7241.02 bytes/sec
total size is 662550995  speedup is 210.10

real  7m15.980s
user  0m14.737s
sys  0m1.693s

sent 3145092 bytes  received 48 bytes  7028.25 bytes/sec
total size is 661235625  speedup is 210.24

real  7m26.847s
user  0m14.768s
sys  0m1.684s

sent 4316924 bytes  received 70 bytes  9117.20 bytes/sec
total size is 907336545  speedup is 210.18

real  7m53.409s
user  0m20.179s
sys  0m2.270s
.
...Local rsync processing completed on booboo...Sun Jan 13 01:53:26
   EST 2008

...Checking remote target machine(s): fred...

...Remote rsync processing completed Sun Jan 13 01:53:31 EST 2008

Checking File: /data01/random_file.out1
Local booboo size:   446004385
Remote fred size:   446004385
Checking File: /data01/random_file.out0
```

Listing 7-4 (*continued*)

```
Local booboo size:   461332160
Remote fred size:   461332160
Checking File: /data02/random_file.out2
Local booboo size:   401122300
Remote fred size:   401122300
Checking File: /data02/random_file.out3
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data03/random_file.out5
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data03/random_file.out4
Local booboo size:   401122300
Remote fred size:   401122300
Checking File: /data04/random_file.out6
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data05/random_file.out7
Local booboo size:   661235625
Remote fred size:   661235625

SUCCESS: Rsync copy completed successfully...

All file sizes match...


Rsync copy completed Sun Jan 13 01:53:38 EST 2008

Elapsed time: [Elapsed time: 8 min 22 sec]
```

Listing 7-4 (*continued*)

As we can see, it took more than eight minutes to complete the initial `rsync` copy. Listing 7-5 shows an `rsync` replication process after the files exist on the target(s). I know this is a hard log file to read and understand. Because we are starting a bunch of `rsync` sessions in the background and because all the output, both `stderr` and `stdout`, is going to the screen and being logged, we get a lot of output that varies and is fluid as the `rsync` sessions are executing. When the `rsync` copy is running, we see dot files like `.random_file.out5`. These dot files are the `rsync` temporary files used by the `rsync` remote-update protocol and go away when the replication completes. Listing 7-5 shows the same rsync process after the files exist on the target(s).

```
Starting a bunch of rsync sessions...Sun Jan 13 02:08:31 EST 2008

building file list ... done
building file list ... done
```

Listing 7-5 generic_DIR_rsync_copy.Bash script with files existing at target

```
sent 74 bytes  received 20 bytes  37.60 bytes/sec
total size is 261428695  speedup is 2781156.33

real  0m2.148s
user  0m0.014s
sys  0m0.006s
building file list ... done

sent 86 bytes  received 20 bytes  42.40 bytes/sec
total size is 907336545  speedup is 8559778.73

real  0m2.197s
user  0m0.012s
sys  0m0.007s

sent 74 bytes  received 20 bytes  37.60 bytes/sec
total size is 661235625  speedup is 7034421.54

real  0m2.193s
user  0m0.013s
sys  0m0.008s
building file list ... done

sent 86 bytes  received 20 bytes  30.29 bytes/sec
total size is 662550995  speedup is 6250481.08

real  0m2.527s
user  0m0.014s
sys  0m0.008s
building file list ... done

sent 86 bytes  received 20 bytes  30.29 bytes/sec
total size is 923979690  speedup is 8716789.53

real  0m2.568s
user  0m0.013s
sys  0m0.009s

All files appear to be in sync...verifying file sizes...Please wait...


...Local rsync processing completed on booboo...Sun Jan 13 02:08:41
   EST 2008

...Checking remote target machine(s): fred...

...Remote rsync processing completed Sun Jan 13 02:08:45 EST 2008
```

Listing 7-5 (*continued*)

```
Checking File: /data01/random_file.out1
Local booboo size:   446004385
Remote fred size:   446004385
Checking File: /data01/random_file.out0
Local booboo size:   461332160
Remote fred size:   461332160
Checking File: /data02/random_file.out2
Local booboo size:   401122300
Remote fred size:   401122300
Checking File: /data02/random_file.out3
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data03/random_file.out5
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data03/random_file.out4
Local booboo size:   662550995
Remote fred size:   662550995
Checking File: /data04/random_file.out6
Local booboo size:   261428695
Remote fred size:   261428695
Checking File: /data05/random_file.out7
Local booboo size:   661235625
Remote fred size:   661235625

SUCCESS: Rsync copy completed successfully...

All file sizes match...


Rsync copy completed Sun Jan 13 02:08:52 EST 2008

Elapsed time: [Elapsed time: 21 seconds]
```

Listing 7-5 (*continued*)

Wow, what a difference! The `rsync` remote-update protocol found the targets to be in sync with the source files and completed the update in 21 seconds. As you can see, `rsync` is a very nice tool for replicating data. Now let's look at replicating data at the filesystems level.

Replicating Multiple Filesystems with rsync

In this section we are going to create a generic shell script that will replicate one or more filesystems to one or more remote servers. This time we are going to match the filesystems to replicate with a regular expression from the `df` command output. Because we are querying the system for the filesystems to replicate, we do not have to worry about a list file to specify what to replicate.

For this example we are again going to replicate the `/data01` through `/data05` directory structures, but this time they are filesystems, not just directories. The regular expression to match these filesystems is `/data0[1-5]`. For ease of updating, this regular expression is assigned to the `FS_PATTERN` variable. We use this regular expression in the following `df` command statement:

```
# df | grep "$FS_PATTERN" | awk '{print $6}'
/data01
/data02
/data03
/data04
/data05
```

With the filesystems known, we loop through each one and start a bunch of `rsync` sessions in the background, the same way we did in Listing 7-3. Just as the previous shell had a lot of comments describing the steps, the `generic_FS_rsync_copy.Bash` shell script is easy to follow through. Study Listing 7-6 in detail and we will cover it further at the end.

```
#!/bin/Bash
#
# SCRIPT: generic_FS_rsync_copy.Bash
# AUTHOR: Randy Michael
# DATE: 1/14/2008
# REV: 1.2.1
#
# PURPOSE: This script is used to replicate
#
#
# EXIT CODES:
#             0 ==> Normal execution.
#             2 ==> Remote host is not pingable.
#             3 ==> Copy verification failed. One or
#                   more local files are not the same
#                   size as the remote files.
#             4 ==> No machines are defined to copy
#                   data to.
#             5 ==> Exited on a trapped signal.
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check the script's syntax
#        # without any execution. Do not forget to
#        # recomment this line!
#
#########################################
# REVISION LIST:
```

Listing 7-6 generic_FS_rsync_copy.Bash script

```
########################################
#
# IF YOU MODIFY THIS SCRIPT, DOCUMENT THE CHANGE(S)!!!
#
########################################
#
# Revised by:
# Revision Date:
# Revision:
#
#############################################
# DEFINE FILES AND GLOBAL VARIABLES HERE
#############################################

# Define the target machines to copy data to.
# To specify more than one host enclose the
# hostnames in double quotes and put at least
# one space between each hostname
#
# EXAMPLE:  MACHINE_LIST="fred yogi booboo"

MACHINE_LIST="fred"

# The FS_PATTERN variable defines the regular expression
# matching the filesystems we want to replicate with rsync.

FS_PATTERN="/data0[1-5]"

# Add /usr/local/bin to the PATH

export PATH=$PATH:/usr/local/bin

# Define the directory containing all of the
# output files this shell script will produce

WORK_DIR=/usr/local/bin

# Define the rsync script log file

LOGFILE=${WORK_DIR}/generic_FS_rsync_copy.log

# Capture the shell script file name

THIS_SCRIPT=$(basename $0)

# Initialize the background process ID list
# variable to NULL
```

Listing 7-6 (*continued*)

```
BG_PID_LIST=

# Define the file containing a list of files to verify
# the sizes match locally and remotely

LS_FILES=ls_output.dat
>$LS_FILES

# Initialize the TOTAL variable to 0

TOTAL=0

# Query the system for the hostname

THIS_HOST=$(hostname)

# Query the system for the UNIX flavor

THIS_OS=$(uname)

##############################################
# DEFINE FUNCTIONS HERE
##############################################

verify_copy ()
{
# set -x

MYLOGFILE=${WORK_DIR}/verify_rsync_copy_day.log
>$MYLOGFILE
ERROR=0

# Enclose this loop so we can redirect output to the log file
# with one assignment at the bottom of the function

{

# Put a header for the verification log file

echo -e "\nRsync copy verification between $THIS_HOST and machine(s) \
$MACHINE_LIST\n\n" >> $MYLOGFILE

# Loop through each machine in the $MACHINE_LIST

for M in $MACHINE_LIST
do
   # Loop through each filesystem that matches the regular
   # regular expression point to by "$FS_PATTERN". It is
```

Listing 7-6 (*continued*)

```
    # important that this variable is enclosed within double
    # quotes. Also note the column for the mount point is 6;
    # in AIX this should be changed to 7.

    for MP in $(df | grep "$FS_PATTERN" | awk '{print $6}')
    do
        # For each filesystem mount point, $MP, execute a
        # find command to find all files in the filesystem.
        # and store them in the $LS_FILES file. We will use this
        # file list to verify the file sizes on the remote
        # machines match the file sizes on the local machine.

        find $MP -type f > $LS_FILES

        # Loop through the file list

        for FL in $(cat $LS_FILES)
        do
            # Find the local file size
            LOC_FS=$(ls -l $FL | awk '{print $5}' 2>&1)
            # Find the remote file size using a remote shell command
            REM_FS=$(rsh $M ls -l $FL | awk '{print $5}' 2>&1)
            echo "Checking File: $FL"
            echo -e "Local $THIS_HOST size:\t$LOC_FS"
            echo -e "Remote $M size:\t$REM_FS"

            # Ensure the file sizes match
            if [ "$LOC_FS" -ne "$REM_FS" ]
            then
               echo "ERROR: File size mismatch between $THIS_HOST and $M"
               echo "File is: $FL"
               ERROR=1
            fi
        done
    done
done

if (( ERROR != 0 ))
then
    # Record the failure in the log file

    echo -e "\n\nRSYNC ERROR: $THIS_HOST Rsync copy failed...file
    size mismatch...\n\n" | tee -a $MYLOGFILE

    echo -e "\nERROR: Rsync copy Failed!"
    echo -e "\n\nCheck log file: $MYLOGFILE\n\n"
    echo -e "\n...Exiting...\n"
    return 3
```

Listing 7-6 (*continued*)

```
    exit 3
else
    echo -e "\nSUCCESS: Rsync copy completed successfully..."
    echo -e "\nAll file sizes match...\n"
fi
} | 2>&1 tee -a $MYLOGFILE

}

################################################

elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && echo -e "[Elapsed time: $SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && echo -e "[Elapsed time:
   $(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && echo -e "[Elapsed time: $(( SEC / 3600 ))
   hr $(( (SEC % 3600) / 60 )) min $(( (SEC % 3600) % 60 )) sec]\c"
}

################################################
# BEGINNING OF MAIN
################################################

# Enclose the entire main part of the script in
# curly braces so we can redirect all output of
# the shell script with a single redirection
# at the bottom of the script to the $LOGFILE

{

# Save a copy of the last log file

cp -f $LOGFILE ${LOGFILE}.yesterday

echo -e "\n[[ $THIS_SCRIPT started execution $(date) ]]\n"

# Ensure that target machines are defined

if [ -z "$MACHINE_LIST" ]
then
    echo -e "\nERROR: No machines are defined to copy data to..."
    echo "...Unable to continue...Exiting..."
    exit 4
fi
```

Listing 7-6 (*continued*)

```
# Ensure the remote machines are reachable through
# the network by sending 1 ping.

echo -e "Verifying the target machines are pingable...\n"
for M in $MACHINE_LIST
do
    echo "Pinging $M..."
    ping -c1 $M >/dev/null 2>&1
    if (( $? != 0 ))
    then
        echo -e "\nERROR: $M host is not pingable...cannot continue..."
        echo -e "...EXITING...\n"
        exit 2
    else
        echo "Pinging $M succeeded..."
    fi
done

# Start all of the rsync copy sessions at once by looping
# through each of the mount points and issuing an rsync
# command in the background, and incrementing a counter.

echo -e "\nStarting a bunch of rsync sessions...\n"

for M in $MACHINE_LIST
do
   # Loop through each filesystem that matches the regular
   # expression point to by "$FS_PATTERN". It is
   # important that this variable is enclosed within double
   # quotes. Also note the column for the mount point is 6;
   # in AIX this should be changed to 7.

   for MP in $(df | grep "$FS_PATTERN" | awk '{print $6}')
   do
        # Start the rsync session in the background

        time rsync -avz ${MP}/ ${M}:${MP} 2>&1 &

        # Keep a running total of the number of rsync
        # sessions started

        (( TOTAL = TOTAL + 1 ))
   done
done

# Sleep a few seconds before monitoring processes

sleep 10
```

Listing 7-6 (*continued*)

```
# Find the number of rsync sessions that are still running

REM_SESSIONS=$(ps x | grep "rsync -avz" | grep "$FS_PATTERN" \
               | grep -v grep | awk {print $1}'| wc -l)

# Give some feedback to the end user.

if (( REM_SESSIONS > 0 ))
then
   echo -e "\n$REM_SESSIONS of $TOTAL rsync copy sessions require \
   further updating..."
   echo -e "\nProcessing rsync copies from $THIS_HOST to both \
   $MACHINE_LIST machines"
   echo -e "\nPlease be patient, this process may take a very long \
   time...\n"
   echo -e "Rsync is running [Start time: $(date)]\c"
else
   echo -e "\nAll files appear to be in sync...verifying file sizes...\
   Please wait...\n"
fi

# While the rsync processes are executing this loop
# will place a . (dot) every 60 seconds as feedback
# to the end user that the background rsync copy
# processes are still executing. When the remaining
# rsync sessions are less than the total number of
# sessions (normally 36) this loop will give feedback
# as to the number of remaining rsync session, as well
# as the elapsed time of the processing, every 5 minutes..


SECONDS=10
MIN_COUNTER=0

# Loop until all of the local rsync sessions have completed

until  (( REM_SESSIONS == 0 ))
do
    # sleep 60 seconds between loop iterations

    sleep 60

    # Display a dot on the screen every 60 seconds

    echo -e ".\c"

    # Find the number of remaining rsync sessions
```

Listing 7-6 (*continued*)

```
    REM_SESSIONS=$(ps x | grep "rsync -avz" | grep "$FS_PATTERN" \
                   | grep -v grep | '{print $1}'| wc -l)

    # Have any of the sessions completed? If so start giving
    # the user updates every 5 minutes, specifying the number
    # remaining rsync sessions and the elapsed time.

    if (( REM_SESSIONS < TOTAL ))
    then
        # Count every 5 minutes
        (( MIN_COUNTER = MIN_COUNTER + 1 ))

        # 5 minutes timed out yet?
        if (( MIN_COUNTER >= 5 ))
        then
           # Reset the minute counter
           MIN_COUNTER=0

           # Update the user with a new progress report

           echo -e "\n$REM_SESSIONS of $TOTAL rsync
           sessions remaining $(elapsed_time $SECONDS)\c"

           # Have three-fourths of the rsync sessions completed?

           if (( REM_SESSIONS <= $(( TOTAL / 4 )) ))
           then
              # Display the list of remaining rsync sessions
              # that continue to run.

              echo -e "\nRemaining rsync sessions include:\n"
              ps x | grep "rsync -avz" | grep "$FS_PATTERN" \
                     | grep -v grep
              echo
           fi
        fi
    fi
done

echo -e "\n...Local rsync processing completed on $THIS_HOST...$(date)"
echo -e "\n...Checking remote target machines: $MACHINE_LIST..."

# Just because the local rsync processes have completed does
# not mean that the remote rsync processes have completed
# execution. This loop verifies that all of the remote
# rsync processes completed execution. The end user will
# receive feedback if any of the remote processes are running.
```

Listing 7-6 (*continued*)

```
for M in $MACHINE_LIST
do
   # Loop through each matching filesystem

   for MP in $(df | grep "$FS_PATTERN" | awk '{print $7}')
   do
       # Find the remote process Ids.
       RPID=$(rsh $M ps x | grep rsync | grep $MP | grep -v grep \
              | awk '{print $1}')

       # Loop while remote rsync sessions continue to run.
       # NOTE: I have never found remote rsync sessions running
       # after the local sessions have completed. This is just
       # an extra sanity check

       until [ -z "$RPID" ]
       do
           echo "rsync is processing ${MP} on ${M}...
   sleeping one minute..."
           sleep 60
           RPID=$(rsh $M ps x | grep rsync | grep $MP | grep -v grep \
                  | awk '{print $1}')
       done
   done
done\

echo -e "\n...Remote rsync processing completed $(date)\n"

# Verify the copy process

verify_copy

# Check the verify_copy return code

if (( $? != 0 ))
then
    exit 3
fi

echo -e "\nRsync copy completed $(date)"

echo -e "\n[[ $THIS_SCRIPT completed execution $(date) ]]\n"
echo -e "\n[[ Elapsed Time: $(elapsed_time $SECONDS) ]]\n"

} | 2>&1 tee -a $LOGFILE

################################################
# END OF SCRIPT
################################################
```

Listing 7-6 (*continued*)

We begin the `generic_FS_rsync_copy.Bash` shell script in Listing 7-6 by defining some files and variables. The `MACHINE_LIST` is the list of target machines to replicate the data to. More than one machine can be a target. The format this script is expecting is a list of hostnames separated by white space, with the entire list enclosed in double quotes.

The `FS_PATTERN` is where we define the regular expression that defines the filesystems we want to replicate — for our example, `FS_PATTERN="/data0[1-5]"`.

Before we start the `rsync` copy, we `ping` the target machines to verify they are reachable through the network. At this point, we are ready to start the `rsync` copy process. We use the `MACHINE_LIST` variable to loop through all the target machines, and then all the filesystems defined by the regular expression shown here:

```
/data0[1-5]
```

Once all the `rsync` sessions have started, we sleep for 10 seconds to allow each of the sessions to start. After this 10-second interval, we scan the process table to identify how many `rsync` sessions remain executing of the total that started. If all the sessions completed in 10 seconds, all the files are up-to-date and no `rsync` copy will take place. Otherwise, we give the user feedback as to how many sessions require updating, show the start time, and start a loop to monitor all the `rsync` sessions every minute. Until the remaining sessions executing is less than the total sessions started, we just print a dot on the screen every minute as feedback that processing continues. As soon as the remaining sessions drop below the `$TOTAL` sessions, we print the elapsed time every 5 minutes and give an update on how many sessions remain executing. Then, when the remaining session reach one-fourth of the `$TOTAL` sessions, we list the remaining filesystem sessions in addition to the elapsed time and number of remaining sessions. Users always want to know ''What's taking so long?'' Well, this script tells them.

When local `rsync` processing completes execution on the source `rsync` copy server, we check the target machines to verify that all remote `rsync` processing is also complete. I have never found remote `rsync` sessions executing after the local `rsync` sessions have completed execution. This is just an extra sanity check. After we verify that all `rsync` processing has completed both locally and remotely, we verify that the `rsync` copy was successful by comparing the file sizes on the source with the file sizes on the target machines. If the file sizes match, we have a successful `rsync` copy.

The `generic_FS_rsync_copy.Bash` shell script in Listing 7-6 is shown in action in Listings 7-7 and 7-8. The initial copy can take quite a while to replicate because the files do not yet exist on the target(s). However, after the files are copied the first time, the `rsync` remote-update protocol allows for much faster replication. Listing 7-7 shows a first-time `rsync` copy session.

```
[[ generic_FS_rsync_copy.Bash started execution Mon Jan 14 15:22:48
   EST 2008 ]]

Verifying the target machines are pingable...
```

Listing 7-7 generic_FS_rsync_copy.Bash in action performing an initial copy

```
Pinging fred...
Pinging fred succeeded...

Starting a bunch of rsync sessions...

building file list ... building file list ... building file list ...
   building file list ... building file list ... done
done
done
done
done
./
./
./
./
./
random_file.out2
random_file.out4
random_file.out3
random_file.out1
random_file.out5

       5 of 5 rsync copy sessions require further updating...

Processing rsync copies from booboo to both fred machines

Please be patient, this process may take a very long time...

Rsync is running [Start time: Mon Jan 14 15:22:59 EST 2008]...
.....................................wrote 55772241 bytes  read 36 bytes
   25038.60 bytes/sec
total size is 74158800  speedup is 1.33
...wrote 55772241 bytes  read 36 bytes  23070.23 bytes/sec
total size is 74158800  speedup is 1.33
..
       3 of 5 rsync sessions remaining [Elapsed time: 41 min 33 sec]
   wrote 55772241 bytes  read 36 bytes  21961.91 bytes/sec
total size is 74158800  speedup is 1.33
.....
       2 of 5 rsync sessions remaining [Elapsed time: 46 min 36 sec].
   wrote 34076139 bytes  read 36 bytes  11887.73 bytes/sec
total size is 45309952  speedup is 1.33
.wrote 55772241 bytes  read 36 bytes  18737.54 bytes/sec
total size is 74158800  speedup is 1.33
.
...Local rsync processing completed on booboo...Mon Jan 14 16:12:27
   EST 2008
```

Listing 7-7 (*continued*)

```
...Checking remote target machines: fred...

...Remote rsync processing completed Mon Jan 14 16:12:28 EST 2008

Checking File: /data01/random_file.out1
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data02/random_file.out2
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data03/random_file.out3
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data04/random_file.out4
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data05/random_file.out5
Local booboo size:   45309952
Remote fred size:   45309952

SUCCESS: Rsync copy completed successfully...

All file sizes match...


Rsync copy completed Mon Jan 14 16:12:29 EST 2008

[[ generic_FS_rsync_copy.Bash completed execution Mon Jan 14 16:12:29
   EST 2008 ]]


[[ Elapsed Time: [Elapsed time: 49 min 40 sec] ]]
```

Listing 7-7 (*continued*)

As we can see, it took almost an hour to complete the initial `rsync` copy. Listing 7-8 shows an `rsync` replication process after the files exist on the target(s).

```
[[ generic_FS_rsync_copy.Bash started execution Mon Jan 14 16:13:46
   EST 2008 ]]

Verifying the target machines are pingable...

Pinging fred...
Pinging fred succeeded...

Starting a bunch of rsync sessions...
```

Listing 7-8 generic_FS_rsync_copy.Bash in action when files exist on the target

```
building file list ... building file list ... building file list ...
   building file list ... building file list ... done
done
done
done
done
wrote 133 bytes  read 20 bytes  306.00 bytes/sec
total size is 74158800  speedup is 484698.40
wrote 133 bytes  read 20 bytes  306.00 bytes/sec
total size is 74158800  speedup is 484698.40
wrote 133 bytes  read 20 bytes  306.00 bytes/sec
total size is 74158800  speedup is 484698.40
wrote 133 bytes  read 20 bytes  306.00 bytes/sec
total size is 45309952  speedup is 296143.48
wrote 133 bytes  read 20 bytes  306.00 bytes/sec
total size is 74158800  speedup is 484698.40

All files appear to be in sync...verifying file sizes...Please wait...


...Local rsync processing completed on booboo...Mon Jan 14 16:13:56
   EST 2008

...Checking remote target machines: fred...

...Remote rsync processing completed Mon Jan 14 16:13:58 EST 2008

Checking File: /data01/random_file.out1
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data02/random_file.out2
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data03/random_file.out3
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data04/random_file.out4
Local booboo size:   74158800
Remote fred size:   74158800
Checking File: /data05/random_file.out5
Local booboo size:   45309952
Remote fred size:   45309952

SUCCESS: Rsync copy completed successfully...

All file sizes match...
```

Listing 7-8 (*continued*)

```
Rsync copy completed Mon Jan 14 16:13:59 EST 2008

[[ generic_FS_rsync_copy.Bash completed execution Mon Jan 14 16:13:59
   EST 2008 ]]


[[ Elapsed Time: [Elapsed time: 13 seconds] ]]
```

Listing 7-8 (*continued*)

Again, we can see that after the initial data replication, the `rsync` remote-update protocol found all the files to be in sync and completed the verification in 13 seconds. `rsync` is a very nice tool for replicating data.

Replicating an Oracle Database with rsync

Up to this point, we have been able to execute the `rsync` copy immediately when we type in the command and press Enter. In many situations, we must wait for some event to happen — for example, if we have a requirement to stop an application before we start the `rsync` copy process, or, as in this particular example, if we need to wait for the database to be put into read-only mode before we start the `rsync` sessions. This section looks at some techniques to allow different teams to communicate by way of *status files* that indicate when each step is allowed to proceed. Sit back — this is a fun section.

Here is the scenario of the problem we want to solve in this section. We have a master Oracle database on one machine that we want to share with two remote machines, like Oracle RAC allows concurrent access to a single database by multiple servers. The remote machines are used by production accounts to access the database in real time. This is called *online transaction processing* (OLTP). Our task is to refresh the data on multiple OLTP servers every day without interrupting production access to the database. To solve this problem, we came up with a *day 1 data* and *day 2 data* strategy. When we update the data each day, the Oracle DBA Team's script changes a synonym in the database to point to the new current day's data. (We are not covering the DBA scripts here.) Please stick with me; this is not that difficult if you keep following along.

`rsync` was chosen as the data-replication tool because of its stability, relatively low network load, and ability to handle only file changes, on certain file types. This `rsync` copy process is part UNIX Systems Administrator (SA) task, and part Oracle DBA task. However, we are covering only the SA scripts in this book. For this method of copying database files to work, the Oracle database must be put into read-only mode so that no changes are made to the `.dbf` database files until the copy process is complete. To facilitate the communications between the Oracle DBA Team's scripts and the SA Team's scripts, we use flat files to signal when the `rsync` copy can start, then another file to signal that the `rsync` copy process has completed execution, and a third file if the `rsync` copy process fails.

Filesystem Structures

We need to understand the filesystem structures for both the master database server, `gamma`, which contains the master Oracle data, and the OLTP servers, `alpha` and `bravo`, which are used for real-time production-database access. The master database server, `gamma`, has one set of 18 filesystems that contains the entire database. The two OLTP production access servers, `alpha` and `bravo`, have two sets of 18 database filesystems, one set of 18 filesystems for day 1 data, and one set of 18 filesystems for day 2 data. The purpose of the day 1 and day 2 filesystems is to allow for alternating days of fresh data without the need to interrupt production access while the data is refreshed each day. The master database server, `gamma`, processes a fresh set of data each night, which can take as long as 12 or more hours to complete. Upon completion of overnight processing, an Oracle script, which is started each night via a cron table entry, puts the database in read-only mode, then signals, with a file, for the `rsync` process to start. The file, `readytocopy.txt`, contains only the number 1 or 2, indicating the target set of filesystems to copy the master data to. Listings 7-9 and 7-10 show the filesystem layouts on the master database server (`gamma`) and the OLTP servers (`alpha` and `bravo`), respectively.

```
/dev/datadmlv1   102760448  59735296   42%  6  1% /dba/oradata_dm_01
/dev/datadmlv2   102760448  59735288   42%  6  1% /dba/oradata_dm_02
/dev/datadmlv3   102760448  59735280   42%  6  1% /dba/oradata_dm_03
/dev/datadmlv4   102760448  59735272   42%  6  1% /dba/oradata_dm_04
/dev/datadmlv5   102760448  59735256   42%  6  1% /dba/oradata_dm_05
/dev/datadmlv6   102760448  59735240   42%  6  1% /dba/oradata_dm_06
/dev/datadmlv7   102760448  59735432   42%  6  1% /dba/oradata_dm_07
/dev/datadmlv8   102760448  59735240   42%  6  1% /dba/oradata_dm_08
/dev/datadmlv9   102760448  59735272   42%  6  1% /dba/oradata_dm_09
/dev/datadmlv10  102760448  59735240   42%  6  1% /dba/oradata_dm_10
/dev/datadmlv11  102760448  59735280   42%  6  1% /dba/oradata_dm_11
/dev/datadmlv12  102760448  59735264   42%  6  1% /dba/oradata_dm_12
/dev/datadmlv13  102760448  59735248   42%  6  1% /dba/oradata_dm_13
/dev/datadmlv14  102760448  59735264   42%  6  1% /dba/oradata_dm_14
/dev/datadmlv15  102760448  59735200   42%  6  1% /dba/oradata_dm_15
/dev/datadmlv16  102760448  59735224   42%  6  1% /dba/oradata_dm_16
/dev/datadmlv17  102760448  61783272   40%  6  1% /dba/oradata_dm_17
/dev/datadmlv18  102760448  61783256   40%  6  1% /dba/oradata_dm_18
```

Listing 7-9 Master database server filesystem layout

```
/dev/rsync_d1_01   104595456  83075104   21%  6  1% /dba/oradata_d1_01
/dev/rsync_d1_02   104595456  83075104   21%  6  1% /dba/oradata_d1_02
/dev/rsync_d1_03   104595456  83075104   21%  6  1% /dba/oradata_d1_03
```

Listing 7-10 OLTP database server filesystem layout

```
/dev/rsync_d1_04   104595456  83075104   21%  6  1% /dba/oradata_d1_04
/dev/rsync_d1_05   104595456  83075104   21%  6  1% /dba/oradata_d1_05
/dev/rsync_d1_06   104595456  83075104   21%  6  1% /dba/oradata_d1_06
/dev/rsync_d1_07   104595456  83075104   21%  6  1% /dba/oradata_d1_07
/dev/rsync_d1_08   104595456  83075104   21%  6  1% /dba/oradata_d1_08
/dev/rsync_d1_09   104595456  83075104   21%  6  1% /dba/oradata_d1_09
/dev/rsync_d1_10   104595456  83075104   21%  6  1% /dba/oradata_d1_10
/dev/rsync_d1_11   104595456  83075104   21%  6  1% /dba/oradata_d1_11
/dev/rsync_d1_12   104595456  83075104   21%  6  1% /dba/oradata_d1_12
/dev/rsync_d1_13   104595456  83075104   21%  6  1% /dba/oradata_d1_13
/dev/rsync_d1_14   104595456  83075104   21%  6  1% /dba/oradata_d1_14
/dev/rsync_d1_15   104595456  83075104   21%  6  1% /dba/oradata_d1_15
/dev/rsync_d1_16   104595456  83075104   21%  6  1% /dba/oradata_d1_16
/dev/rsync_d1_17   104595456  86060540   18%  6  1% /dba/oradata_d1_17
/dev/rsync_d1_18   104595456  86168976   18%  6  1% /dba/oradata_d1_18
/dev/rsync_d2_01   104595456  83075104   21%  6  1% /dba/oradata_d2_01
/dev/rsync_d2_02   104595456  83075104   21%  6  1% /dba/oradata_d2_02
/dev/rsync_d2_03   104595456  83075104   21%  6  1% /dba/oradata_d2_03
/dev/rsync_d2_04   104595456  83075104   21%  6  1% /dba/oradata_d2_04
/dev/rsync_d2_05   104595456  83075104   21%  6  1% /dba/oradata_d2_05
/dev/rsync_d2_06   104595456  83075104   21%  6  1% /dba/oradata_d2_06
/dev/rsync_d2_07   104595456  83075104   21%  6  1% /dba/oradata_d2_07
/dev/rsync_d2_08   104595456  83075104   21%  6  1% /dba/oradata_d2_08
/dev/rsync_d2_09   104595456  83075104   21%  6  1% /dba/oradata_d2_09
/dev/rsync_d2_10   104595456  83075104   21%  6  1% /dba/oradata_d2_10
/dev/rsync_d2_11   104595456  83075104   21%  6  1% /dba/oradata_d2_11
/dev/rsync_d2_12   104595456  83075104   21%  6  1% /dba/oradata_d2_12
/dev/rsync_d2_13   104595456  83075104   21%  6  1% /dba/oradata_d2_13
/dev/rsync_d2_14   104595456  83075104   21%  6  1% /dba/oradata_d2_14
/dev/rsync_d2_15   104595456  83075104   21%  6  1% /dba/oradata_d2_15
/dev/rsync_d2_16   104595456  83075104   21%  6  1% /dba/oradata_d2_16
/dev/rsync_d2_17   104595456  84099104   20%  6  1% /dba/oradata_d2_17
/dev/rsync_d2_18   104595456  84099104   20%  6  1% /dba/oradata_d2_18
```

Listing 7-10 (*continued*)

Both listings show a `df -k` output of only the database filesystems. As you can see, these are huge filesystems. Daily we are moving 400 GB of data to two servers at the same time, for a total of 800 GB of data transfer.

NOTE **The destination filesystems need the capacity to hold twice the source data. The reason is to ensure that if the file already exists on the destination, the filesystem has enough space to hold the temporary file needed to handle the `rsync` remote-update protocol. If you do not have the disk space available, you can delete the destination files before starting the `rsync` copy process.**

rsync Copy Shell Script

The `rsync` copy process is performed by executing the shell script `rsync_daily_copy.ksh` (shown later in Listing 7-13), which is located in `/usr/local/bin` on the `gamma` Oracle master database server. The `rsync_daily_copy.ksh` shell script is executed via `root` user cron table entries, as shown in Listing 7-11.

```
# Daily rsync copy process
0 2 * * 0 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_sun.log 2>&1
0 2 * * 1 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_mon.log 2>&1
0 2 * * 2 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_tue.log 2>&1
0 2 * * 3 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_wed.log 2>&1
0 2 * * 4 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_thu.log 2>&1
0 2 * * 5 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_fri.log 2>&1
0 2 * * 6 /usr/local/bin/rsync_daily_copy.ksh > \
    /usr/local/bin/daily_rsync_stdout_sat.log 2>&1
```

Listing 7-11 Root cron table to execute rsync_daily_copy.ksh daily

This set of cron table entries in Listing 7-11 starts the `rsync_daily_copy.ksh` shell script executing every day at 2:00 a.m. Notice that the log filename changes every day, so we can keep one week of log files to troubleshoot any problems.

We begin by defining files and variables for this script, as shown In Listing 7-12.

```
##############################################
# DEFINE FILES AND GLOBAL VARIABLES HERE
##############################################

typeset -i DAY
EMAIL_FROM=data_support@gamma
export PATH=$PATH:/usr/local/bin
WORK_DIR=/usr/local/bin
LOGFILE=${WORK_DIR}/rsync_daily_copy.log
SEARCH_DIR=/orabin/apps/oracle/dbadm/general/bin
READYTORUN_FILE=${SEARCH_DIR}/readytocopy.txt
COMPLETE_FILE=${SEARCH_DIR}/copycomplete.txt
RSYNCFAILED_FILE=${SEARCH_DIR}/copyfailed.txt
MAILMESSAGEFILE=${WORK_DIR}/email_message.out
THIS_SCRIPT=$(basename $0)
```

Listing 7-12 File and variable definitions

```
BG_PID_LIST=
TOTAL=0
THIS_HOST=$(hostname)
[[ $THIS_HOST = gamma ]] && MACHINE_LIST="alpha-rsync bravo-rsync"
[[ $THIS_HOST = gamma-dg ]] && MACHINE_LIST="alpha-rsync bravo-rsync"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac
```

Listing 7-12 (*continued*)

In Listing 7-12 we define the following files and global variables:

- `typeset -i DAY` — Typesets the `DAY` variable to be an integer.
- `EMAIL_FROM` — Specifies the ''from'' address for emails.
- `PATH` — Adds `/usr/local/bin` to the PATH.
- `WORK_DIR` — Defines the work directory as `/usr/local/bin`.
- `LOGFILE` — Defines the shell script log file.
- `SEARCH_DIR` — Defines a directory to search for status files.
- `READYTORUN_FILE` — Indicates the file specifying the script can start copying.
- `COMPLETE_FILE` — Indicates the file specifying the copy process has completed.
- `RSYNCFAILED_FILE` — Indicates the file specifying the copy process failed.
- `MAILMESSAGEFILE` — Defines the file that contains the mail message body.

The last step here is to use the hostname of the machine, defined as `THIS_HOST`, to determine the target machines to receive the `rsync` data. Notice that we have two `gamma` machines defined, with the second named `gamma-dg`. This is an Oracle Data Guard server used as a backup in case of primary-database failure. The final task is to verify that the `echo` command executes properly. Many Linux distributions will execute in Bash shell even through we declare a Korn shell on the very first line of the shell script. The following code segment corrects this problem by setting up an alias if `$SHELL` is `*/bin/Bash`:

```
# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.
```

```
case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac
```

The `rsync_daily_copy.ksh` shell script, starting at the `BEGINNING OF MAIN`, checks if any other versions of itself are currently executing. If another instance of the shell script is running, this script kills the previous session, and then sleeps for 60 seconds to allow any running `rsync` sessions to die.

The next step in the `rsync_daily_copy.ksh` shell script is where we monitor the search directory `/orabin/apps/oracle/dbadm/general/bin` for a file named `readytocopy.txt`. This is the file created by the DBA Team's shell script that signals that the Oracle database has been put into read-only mode and the `rsync` copy process can start. The `readytocopy.txt` file contains only one character, `1` or `2`, that specifies the target day's destination filesystems. The number is assigned to the `DAY` variable. In the next step, we verify that the `$DAY` variable is valid.

Before we start the `rsync` copy, we `ping` the target machines to verify that they are reachable through the network. When verified, we send a notification email to all users defined in the mail alias `data_support` that the `rsync` copy process started execution.

At this point we are ready to start the `rsync` copy process. We use the `MACHINE_LIST` variable to loop through all the target machines, and then all the filesystems defined by the regular expression shown here:

```
oradata_dm_[0-2][0-9]
```

Notice that this regular expression supports valid values of `oradata_dm_00` through `oradata_dm_29`. Even though we currently have only 18 filesystems, starting at `oradata_dm_01`, this allows room for growth without modifying the shell script in the near term. For each Oracle filesystem on the master database server, we use a `sed` statement to convert the `dm` to the specified `$DAY`, `d1` or `d2`, to match the OLTP filesystems, as shown here:

```
# This sed statement changes the "m" to $DAY
REM_FL=$(echo $FL | sed s/oradata_dm_/oradata_d${DAY}_/g)
```

As we loop through all the filesystems, we execute an `rsync` session in the background, for a total of 36 sessions, 18 to each target machine. To facilitate the bandwidth to copy 400 GB of data to two servers, we use a private network using a dedicated switch and dedicated NIC adapter/IP address. We define the hostnames for the new private network interfaces as follows:

```
gamma-rsync, alpha-rsync, bravo-rsync
```

Once all the `rsync` sessions have started, we sleep for 10 seconds to allow each of the sessions to start. After this 10-second interval, we scan the process table to identify how many `rsync` sessions remain executing of the total that started. If all the sessions completed in 10 seconds, all the files are up-to-date and no `rsync` copy will take place. Otherwise, we give the user feedback as to how many sessions require updating, show the start time, and start a loop to monitor all the `rsync` sessions every minute. Until

the remaining `rsync` sessions are less than the total sessions started, we just print a dot on the screen every minute as feedback that processing continues. As soon as the remaining `rsync` sessions drop below the total sessions, we print the elapsed time every 5 minutes and give an update on how many sessions remain executing. Then, when the remaining `rsync` sessions reaches one-fourth of the total sessions started, we list the remaining filesystem sessions in addition to the elapsed time, and number of remaining sessions. Users always want to know ''What's taking so long?'' Well, this script tells them.

When local `rsync` processing completes execution on the master database server, we check the target machines to verify that all remote `rsync` processing is also complete. After we verify that all `rsync` processing has completed both locally and remotely, we verify that the `rsync` copy was successful by comparing the file sizes on the source with the file sizes on the target machines. If the file sizes match, we have a successful `rsync` copy.

The last two tasks are to put the signal file named `copycomplete.txt` on the system so that the Oracle DBA Team's script can put the master database back in read-write mode. On the OLTP server's Oracle scripts, rename the database to the specified `$DAY` and swing the synonym to point to the correct `$DAY` OLTP database. When the `rsync` copy portion of the process completes, the script sends an email to notify everyone that the `rsync` copy completed successfully.

Should there be a failure during the `rsync` process, an email stating the exact failure is sent, and an error file named `copyfailed.txt` is placed on the system to let the Oracle DBA Team's script know that the `rsync` process failed. Listing 7-23, shown later in this chapter, shows the `rsync_daily_copy.ksh` shell script in action. For now, study Listing 7-13 and pay particular attention to the boldface type.

```
#!/bin/ksh
#
# SCRIPT: rsync_daily_copy.ksh
# AUTHOR: Randy Michael
# DATE: 11/10/2007
# REV: 3.2.Prod
#
# PURPOSE: This script is used to replicate Oracle .dbf
#      files between the "master" DB server and the two
#      OLTP Oracle servers.  The copy method used is
#      rsync. For this method to work, the Oracle DBA must
#      first put the database tables that reside in the
#      copy filesystems into READ-ONLY mode. Before starting
#      rsync copy sessions, this script searches for a file,
#      defined by the $READYTORUN_FILE variable, that is
#      placed on the system by the Oracle DBA team; when
#      the file is found this script will execute
#      all 36 rsync sessions, 18 to each OLTP server,
#      at the same time, then wait for all sessions to
```

Listing 7-13 rsync_daily_copy.ksh shell script

```
#     complete, both locally and on the remote servers.
#     After the rsync copy sessions complete the copy is
#     verified by matching file sizes between the master
#     copy file and the target copy files. When verified
#     successful this script writes a file to the system,
#     defined by the $COMPLETE_FILE variable, to signal
#     the Oracle DBAs to put the DB back into READ-WRITE
#     mode, copy the metadata over, build the tables and
#     attach the DB on the OLTP side servers. Should a
#     failure occur a file, defined by the $RSYNCFAILED_FILE
#     variable, is written to the system to signal to the
#     Oracle DBA team an rsync copy process failure.
#
#
# EXIT CODES:
#             0 ==> Normal execution.
#             1 ==> The value assigned to DAY is not
#                   an integer 1 or 2.
#             2 ==> Remote host is not pingable.
#             3 ==> Copy verification failed. One or
#                   more local files are not the same
#                   size as the remote files.
#             4 ==> No machines are defined to copy
#                   data to.
#             5 ==> Exited on a trapped signal.
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check the script's syntax
#        # without any execution. Do not forget to
#        # recomment this line!
#
########################################
# REVISION LIST:
########################################
#
# IF YOU MODIFY THIS SCRIPT, DOCUMENT THE CHANGE(S)!!!
#
########################################
#
# Revised by: Randy Michael
# Revision Date: 7/23/2007
# Revision: Changed the script to process
# all 36 mount points at a time.
#
########################################
#
# Revised by:
```

Listing 7-13 (*continued*)

```
# Revision Date:
# Revision:
#
################################################
# DEFINE FILES AND GLOBAL VARIABLES HERE
################################################

typeset -i DAY
EMAIL_FROM=data_support@gamma
export PATH=$PATH:/usr/local/bin
WORK_DIR=/usr/local/bin
LOGFILE=${WORK_DIR}/rsync_daily_copy.log
SEARCH_DIR=/orabin/apps/oracle/dbadm/general/bin
READYTORUN_FILE=${SEARCH_DIR}/readytocopy.txt
COMPLETE_FILE=${SEARCH_DIR}/copycomplete.txt
RSYNCFAILED_FILE=${SEARCH_DIR}/copyfailed.txt
MAILMESSAGEFILE=${WORK_DIR}/email_message.out
THIS_SCRIPT=$(basename $0)
BG_PID_LIST=
TOTAL=0
THIS_HOST=$(hostname)
[[ $THIS_HOST = gamma ]] && MACHINE_LIST="alpha-rsync bravo-rsync"
[[ $THIS_HOST = gamma-dg ]] && MACHINE_LIST="alpha-rsync bravo-rsync"

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

################################################
# DEFINE FUNCTIONS HERE
################################################

usage ()
{
echo "\nUSAGE: $THIS_SCRIPT Day"
echo "\nWhere Day is 1 or 2\n"
}

################################################

cleanup_exit ()
{
```

Listing 7-13 (*continued*)

```
# If this script is executing, then something failed!

[ $1 ] && EXIT_CODE=$1

echo "\n$THIS_SCRIPT is exiting on non-zero exit code: $EXIT_CODE"
echo "\nPerforming cleanup..."
echo "Removing $READYTORUN_FILE"
rm -f $READYTORUN_FILE >/dev/null 2>&1
echo "Removing $COMPLETE_FILE"
rm -f $COMPLETE_FILE >/dev/null 2>&1
echo "\nCreating $RSYNCFAILED_FILE"
echo "\nRsync failed on $THIS_HOST with exit code $EXIT_CODE $(date)\n"\
      | tee -a $RSYNCFAILED_FILE
echo "\nCleanup Complete...Exiting..."
exit $EXIT_CODE
}

##############################################

trap_exit ()
{
echo "\nERROR: EXITING ON A TRAPPED SIGNAL!\n"
echo "\nRSYNC ERROR: $THIS_HOST -- Rsync process exited abnormally \
   on a trapped signal $(date)!" > $MAILMESSAGEFILE

mailx -r "$EMAIL_FROM" -s "SYNC ERROR: $THIS_HOST -- Rsync process \
   exited abnormally on a trapped signal!" \
            data_support < $MAILMESSAGEFILE
sleep 2 # Allow the email to go out
cleanup_exit 5
exit 5
}

##############################################

verify_copy ()
{
#set -x

MYLOGFILE=${WORK_DIR}/verify_rsync_copy_day${DAY}.log
>$MYLOGFILE
ERROR=0

# Enclose this loop so we can redirect output to the log file
# with one assignment at the bottom of the function
{
# Put a header for the verification log file
echo "\nRsync copy verification between $THIS_HOST and machines
```

Listing 7-13 (*continued*)

```
    $MACHINE_LIST\n\n"\
        >$MYLOGFILE


for M in $MACHINE_LIST
do
   for LOC_MP in $(df | grep oradata_dm_[0-2][0-9] | awk '{print $7}')
   do
       LS_FILES=$(find $LOC_MP -type f)
       for FL in $LS_FILES
       do
           LOC_FS=$(ls -l $FL | awk '{print $5}' 2>&1)

           # This sed statement changes the "m" to $DAY
           REM_FL=$(echo $FL | sed s/oradata_dm_/oradata_d${DAY}_/g)

           REM_FS=$(rsh $M ls -l $REM_FL | awk '{print $5}' 2>&1)
           echo "Checking File: $FL"
           echo "Local $THIS_HOST size:\t$LOC_FS"
           echo "Checking Remote File: $REM_FL"
           echo "$M size:\t$REM_FS"
           if [ "$LOC_FS" -ne "$REM_FS" ]
           then
              echo "ERROR: File size mismatch between $THIS_HOST and $M"
              echo "File is: $FL"
              ERROR=1
           fi
       done
   done
done

if (( ERROR != 0 ))
then
    # Record the failure in the log file

    echo "\n\nRSYNC ERROR: $THIS_HOST Rsync copy failed...file \
   size mismatch...\n\n" | tee -a $MYLOGFILE
    # Send email notification with file size log

    mailx -r "$EMAIL_FROM" -s "RSYNC ERROR: $THIS_HOST Rsync \
   copy failed...file size mismatch -- log attached" \
                data_support < $MYLOGFILE

    echo "\nERROR: Rsync copy Failed!"
    echo "\n\nCheck log file: $MYLOGFILE\n\n"
    echo "\n...Exiting...\n"
    cleanup_exit 3
    return 3
```

Listing 7-13 (*continued*)

```
    exit 3
else
    echo "\nSUCCESS: Rsync copy completed successfully..."
    echo "\nAll file sizes match...\n"
fi
} | tee -a $MYLOGFILE

}

########################################

ready_to_run ()
{
# set -x
# This function looks for a file on the system
# defined by the $READYTORUN_FILE variable. The
# presence of this file indicates we are ready
# to run this script. This file will contain a
# number 1 or 2 identifying the day we are
# working with.

if [ -r ${READYTORUN_FILE} ]
then
     cat ${READYTORUN_FILE}
else
     echo "NOT_READY"
fi
}

##############################################

elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && echo "[Elapsed time: $SEC seconds]\c"
(( SEC >= 60  &&  SEC < 3600 )) && echo "[Elapsed time:
   $(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"
(( SEC > 3600 )) && echo "[Elapsed time: $(( SEC / 3600 ))
   hr $(( (SEC % 3600) / 60 )) min $(( (SEC % 3600) % 60 )) sec]\c"
}

##############################################
# BEGINNING OF MAIN
##############################################

# Set a trap

trap 'trap_exit' 1 2 3 5 6 11 14 15 17
```

Listing 7-13 (*continued*)

```
# Save the old log file

cp -f $LOGFILE ${LOGFILE}.yesterday \
      >$LOGFILE

# Enclose the entire main part of the script in
# curly braces so we can redirect all output of
# the shell script with a single redirection
# at the bottom of the script to the $LOGFILE

{
echo "\n[[ $THIS_SCRIPT started execution $(date) ]]\n"

# Ensure that target machines are defined

if [ -z "$MACHINE_LIST" ]
then
    echo "\nERROR: No machines are defined to copy data to..."
    echo "\nRSYNC ERROR: $THIS_HOST has no machines are defined to \
   copy data to..." > $MAILMESSAGEFILE
    mailx -r "$EMAIL_FROM" -s "RSYNC ERROR: $THIS_HOST has no machines \
   defined to copy data to" data_support < $MAILMESSAGEFILE
    echo "...Unable to continue...Exiting..."

    cleanup_exit 4
    exit 4
fi

# Checking for currently running versions of this script

echo "Checking for Currently Running Versions of this Script"

MYPID=$$ # Capture this script's PID

MYOTHERPROCESSES=$(ps -ef | grep $THIS_SCRIPT | grep -v $MYPID \
                  | grep -v grep | awk '{print $2}')

if [[ "$MYOTHERPROCESSES" != "" ]]
then
    echo "\WARNING: Another version of this script is running...\
   Killing it!"
    echo "Killing the following process(es)...$MYOTHERPROCESSES"
    kill -9 $MYOTHERPROCESSES
    echo "\nNOTICE: Sleeping for 1 minute to allow both local \
    and remote rsync sessions to terminate, if they exist...\n"
   sleep 60  # Allow any rsync sessions to stop both locally and remotely
else
```

Listing 7-13 (*continued*)

```
    echo "No other versions running...proceeding"
fi

# Remove the file that indicates the rsync copy
# is mounted and ready to use, if it exists.

rm -f $COMPLETE_FILE >/dev/null 2>&1

# Remove the file that indicates the rsync copy
# failed and exited on a non-zero exit code, if
# it exists.

rm -f $RSYNCFAILED_FILE >/dev/null 2>&1


# Search for the file indicating we are ready to proceed

# Send notification

echo "\nDaily Rsync Copy Process Began on Host $THIS_HOST $(date)" \
   > $MAILMESSAGEFILE
echo "\nStarted looking for $READYTORUN_FILE" >> $MAILMESSAGEFILE

mailx -r "$EMAIL_FROM" -s "Rsync Copy Process Began Looking \
   for Startup File on $THIS_HOST" \
      data_support < $MAILMESSAGEFILE

echo "\nSearching for the file: ${READYTORUN_FILE}"
RUN_STATUS=$(ready_to_run)
until [[ $RUN_STATUS != "NOT_READY" ]]
do
    date
    echo "$READYTORUN_FILE is not present...Sleeping 5 minutes..."
    sleep 300
    RUN_STATUS=$(ready_to_run)
done
date
echo "Found file: $READYTORUN_FILE -- Ready to proceed..."
DAY=$RUN_STATUS


# Test the value assigned to the DAY variable

echo "Testing variable assignment for the DAY variable"

if (( DAY != 1 && DAY != 2 ))
then
    echo "\nRSYNC ERROR: $THIS_HOST -- The value assigned to the DAY \
```

Listing 7-13 (*continued*)

```
    variable" > $MAILMESSAGEFILE
     echo "==> $DAY - is not an integer 1 or 2...Exiting..." \
    >> $MAILMESSAGEFILE
     mailx  -r "$EMAIL_FROM" -s "ERROR: $THIS_HOST -- Value assigned \
    to the DAY variable $DAY is invalid" data_support < $MAILMESSAGEFILE

     usage
     cleanup_exit
     exit 1
fi

# Ensure the remote machines are reachable through
# the network by sending 1 ping.

echo "Verifying the target machines are pingable...\n"
for M in $MACHINE_LIST
do
     echo "Pinging $M..."
     ping -c1 $M >/dev/null 2>&1
     if (( $? != 0 ))
     then
          echo "RSYNC ERROR: $M is not pingable from $THIS_HOST" \
    > $MAILMESSAGEFILE
          echo "The rsync copy process cannot continue...Exiting" \
    >> $MAILMESSAGEFILE
          mailx -r "$EMAIL_FROM" -s "RSYNC ERROR: $M is not pingable \
    from $THIS_HOST" data_support < $MAILMESSAGEFILE

          echo "\nERROR: $M host is not pingable...cannot continue..."
          echo "...EXITING...\n"
          sleep 2
          cleanup_exit 2
          exit 2
     else
          echo "Pinging $M succeeded..."
     fi
done

# Notify start of rsync processing by email

echo "Rsync Copy Process for Day $DAY Starting Execution on \
    $THIS_HOST $(date)" > $MAILMESSAGEFILE
mailx -r "$EMAIL_FROM" -s "Rsync copy process for day $DAY starting \
    on $THIS_HOST" data_support < $MAILMESSAGEFILE

# Start all of the rsync copy sessions at once by looping
# through each of the mount points and issuing an rsync
# command in the background, and incrementing a counter.
```

Listing 7-13 (*continued*)

```
echo "\nStarting a bunch of rsync sessions...\n"

# This script copies from the DM filesystems to the
# Day 1 or Day 2 filesystems on the OLTP servers.

for M in $MACHINE_LIST
do
   for LOC_MP in $(df | grep oradata_dm_[0-2][0-9] | awk '{print $7}')
   do
        # This sed statement changes the "m" to $DAY
        REM_MP=$(echo $LOC_MP | sed s/m/$DAY/g)
        time rsync -avz ${LOC_MP}/ ${M}:${REM_MP} 2>&1 &
        (( TOTAL = TOTAL + 1 ))
   done
done

# Sleep a few seconds before monitoring processes

sleep 10

# Give some feedback to the end user.

REM_SESSIONS=$(ps -ef | grep "rsync -avz" | grep oradata_dm_[0-2][0-9] \
               | grep -v grep | awk '{print $2}' | wc -l)

if (( REM_SESSIONS > 0 ))
then
   echo "\n$REM_SESSIONS of $TOTAL rsync copy sessions \
   require further updating..."
   echo "\nProcessing rsync copies from $THIS_HOST to both \
   $MACHINE_LIST machines"
   echo "\nPlease be patient, this process may take longer than \
   two hours...\n"
   echo "Rsync is running [Start time: $(date)]\c"
else
   echo "\nAll files appear to be in sync...verifying file sizes... \
   Please wait...\n"
fi

# While the rsync processes are executing this loop
# will place a . (dot) every 60 seconds as feedback
# to the end user that the background rsync copy
# processes are still executing. When the remaining
# rsync sessions are less than the total number of
# sessions (normally 36) this loop will give feedback
# as to the number of remaining rsync session, as well
# as the elapsed time of the processing, every 5 minutes.
```

Listing 7-13 (*continued*)

```
SECONDS=10
MIN_COUNTER=0

until  (( REM_SESSIONS == 0 ))
do
    sleep 60
    echo ".\c"
    REM_SESSIONS=$(ps -ef | grep "rsync -avz" \
                  | grep oradata_dm_[0-2][0-9] \
                  | grep -v grep | awk '{print $2}' | wc -l)
    if (( REM_SESSIONS < TOTAL ))
    then
        (( MIN_COUNTER = MIN_COUNTER + 1 ))
        if (( MIN_COUNTER >= 5 ))
        then
           MIN_COUNTER=0
           echo "\n$REM_SESSIONS of $TOTAL rsync sessions \
   remaining $(elapsed_time $SECONDS)\c"
           if (( REM_SESSIONS <= $(( TOTAL / 4 )) ))
           then
              echo "\nRemaining rsync sessions include:\n"
              ps -ef | grep "rsync -avz" | grep oradata_dm_[0-2][0-9] \
                     | grep -v grep
              echo
           fi
        fi
    fi
done

echo "\n...Local rsync processing completed on $THIS_HOST...$(date)"
echo "\n...Checking remote target machines: $MACHINE_LIST..."

# Just because the local rsync processes have completed does
# not mean that the remote rsync processes have completed
# execution. This loop verifies that all of the remote
# rsync processes completed execution. The end user will
# receive feedback if any of the remote processes are running.

for M in $MACHINE_LIST
do
   for LOC_MP in $(df | grep oradata_dm_[0-2][0-9] | awk '{print $7}')
   do
       # This sed statement changes the "m" to $DAY
       REM_MP=$(echo $LOC_MP | sed s/m/$DAY/g)

       RPID=$(rsh $M ps -ef | grep rsync | grep $REM_MP \
              | grep -v grep | awk '{print $2}')

       until [ -z "$RPID" ]
```

Listing 7-13 (*continued*)

```
        do
            echo "rsync is processing ${REM_MP} on ${M}... \
    sleeping one minute..."
            sleep 60
            RPID=$(rsh $M ps -ef | grep rsync | grep $REM_MP \
                 | grep -v grep | awk '{print $2}')
        done
    done
done

echo "\n...Remote rsync processing completed $(date)\n"

# Verify the copy process

verify_copy
if (( $? != 0 ))
then
    exit 3
fi

# Write to the $COMPLETE_FILE to signal the Oracle DBAs
# that the copy has completed

echo "Rsync copy from $THIS_HOST to machines $MACHINE_LIST \
completed successfully $(date)" | tee -a $COMPLETE_FILE

# Remove the ready to run file

rm -f $READYTORUN_FILE >/dev/null 2>&1

# Notify completion by email

echo "Rsync Copy for Day $DAY Completed Successfully Execution \
   on $THIS_HOST $(date)\n" > $MAILMESSAGEFILE
elapsed_time $SECONDS >> $MAILMESSAGEFILE
mailx -r "$EMAIL_FROM" -s "Rsync copy for day $DAY completed \
   successfully on $THIS_HOST" data_support < $MAILMESSAGEFILE

echo "\nRsync copy completed $(date)"

echo "\n[[ $THIS_SCRIPT completed execution $(date) ]]\n"

exit 0

} | tee -a $LOGFILE 2>&1

################################################
# END OF SCRIPT
################################################
```

Listing 7-13 (*continued*)

You are probably thinking that Listing 7-13 is intuitively obvious! But, if not, let's cover a few points in more detail. I know this is a bit complicated in that we have to monitor for the existence of a file, and verify that the file contains valid data. However, this is a simple method of relaying information between two separate shell scripts. Remember, the Oracle DBA Team has a shell script monitoring for the nightly processing to complete. When that processing is complete, the database is put into read-only mode, the metadata is captured, and then the `readytocopy.txt` file is created with the specific target day, 1 or 2.

Let's cover Listing 7-13 in logical execution order starting with `BEGINNING OF MAIN`. The first thing we do is set a trap for exit signals 1, 2, 3, 5, 6, 11, 14, 15, and 17. Remember that we cannot trap `kill -9`. With a trap we can log a failure, send an email, and clean up any leftover files before exiting. After setting the `trap`, we copy the `$LOGFILE` to `${LOGFILE}.yesterday`. This log file is an internal script log file, not to be confused with the log files defined in the cron table earlier.

Now we are ready to start looking for the file that signals that we can start the `rsync` copy process. Listing 7-14 shows this section of script code.

```
# Checking for currently running versions of this script

echo "Checking for Currently Running Versions of this Script"

MYPID=$$  # Capture this script's PID

MYOTHERPROCESSES=$(ps -ef | grep $THIS_SCRIPT | grep -v $MYPID \
                  | grep -v grep | awk '{print $2}')

if [[ "$MYOTHERPROCESSES" != "" ]]
then
    echo "\WARNING: Another version of this script is running... \
   Killing it!"
    echo "Killing the following process(es)...$MYOTHERPROCESSES"
    kill -9 $MYOTHERPROCESSES
    echo "\nNOTICE: Sleeping for 1 minute to allow both local \
   and remote rsync sessions to terminate, if they exist...\n"
    sleep 60  # Allow any rsync sessions to stop both locally and \
remotely else
    echo "No other versions running...proceeding"
fi
```

Listing 7-14 Script code to check for other sessions

We capture the shell script's process ID (PID) using the `$$` shell variable. With this PID we can scan the process table looking for other instances of itself without killing this executing shell script. If we find other script sessions running, we issue a `kill -9` on each of the PIDs. If we need to kill other `rsync` processes, we sleep for 60 second to allow time for the killed sessions to exit.

Next we remove any leftover files indicating the shell script completed or failed, if they exist. At this point, we are starting to look for the `readytocopy.txt` file, so we send a notification email and enter the loop shown in Listing 7-15.

```
echo "\nSearching for the file: ${READYTORUN_FILE}"
RUN_STATUS=$(ready_to_run)
until [[ $RUN_STATUS != "NOT_READY" ]]
do
    date
    echo "$READYTORUN_FILE is not present...Sleeping 5 minutes..."
    sleep 300
    RUN_STATUS=$(ready_to_run)
done
date
echo "Found file: $READYTORUN_FILE -- Ready to proceed..."
DAY=$RUN_STATUS
```

Listing 7-15 Loop to wait for a startup file

Notice in Listing 7-15 that we call a function named `ready_to_run`. This function simply looks for the presence of a file defined by the variable `$READYTORUN_FILE`. The `ready_to_run` function is shown in Listing 7-16.

```
ready_to_run ()
{
# set -x
# This function looks for a file on the system
# defined by the $READYTORUN_FILE variable. The
# presence of this file indicates we are ready
# to run this script. This file will contain a
# number 1 or 2 identifying the day we are
# working with.

if [ -r ${READYTORUN_FILE} ]
then
     cat ${READYTORUN_FILE}
else
     echo "NOT_READY"
fi
}
```

Listing 7-16 ready_to_run function

We use the `-r` test operator to look for a readable file defined by `${READYTORUN_FILE}`. If we find the file, we display back the file contents; otherwise, we just `echo` back `"NOT_READY"`. When we find the startup file, we test to ensure the value is a 1 or

2. If this test passes, we send another email stating that we found the startup file and are starting the `rsync` sessions.

As we loop through the filesystems defined by the regular expression `oradata_dm_[0-2][0-9]`, we use the `DAY` variable to translate the master data filesystems to the corresponding OLTP day 1 or 2 filesystems. This substitution is performed with a `sed` statement and assigned to the `REM_MP` variable, for remote mount point. Using the `LOC_MP` and `REM_MP` variables, we start the `rsync` sessions in the background, and time the execution of each session with the shell `time` command, not the system's `/usr/bin/time` command. The shell's `time` program gives a more granular detail for user, system, and kernel execution times. The last step is to keep a running total of how many `rsync` sessions we start. We need this value as feedback to the end user. This loop to start all the `rsync` sessions is shown in Listing 7-17.

```
for M in $MACHINE_LIST
do
   for LOC_MP in $(df | grep oradata_dm_[0-2][0-9] | awk '{print $7}')
   do
        # This sed statement changes the "m" to $DAY
        REM_MP=$(echo $LOC_MP | sed s/m/$DAY/g)
        time rsync -avz ${LOC_MP}/ ${M}:${REM_MP} 2>&1 &
        (( TOTAL = TOTAL + 1 ))
   done
done
```

Listing 7-17 Loop to start all the rsync sessions

We `sleep` for 10 seconds after this loop in Listing 7-17 to allow time for all the `rsync` sessions to start. After this 10-second wait period, we check the process table to see how many `rsync` sessions remain executing *locally*. Just remember that we will also check the remote machines' process table when all the local `rsync` sessions complete.

Listing 7-18 shows the code segment to check for the remaining local `rsync` sessions.

```
sleep 10

# Give some feedback to the end user.

REM_SESSIONS=$(ps -ef | grep "rsync -avz" | grep oradata_dm_[0-2][0-9] \
               | grep -v grep | awk '{print $2}' | wc -l)

if (( REM_SESSIONS > 0 ))
then
   echo "\n$REM_SESSIONS of $TOTAL rsync copy sessions require \
   further updating..."
   echo "\nProcessing rsync copies from $THIS_HOST to both \
   $MACHINE_LIST machines"
```

Listing 7-18 Code to check for remaining rsync sessions

```
    echo "\nPlease be patient, this process may take longer than \
    two hours...\n"
    echo "Rsync is running [Start time: $(date)]\c"
else
    echo "\nAll files appear to be in sync...verifying file sizes... \
    Please wait...\n"
fi
```

Listing 7-18 (*continued*)

Notice that we give the end user feedback as to the number of sessions that remain executing out of the total number of sessions started. We also let the user know that this could be a long process and give a startup time stamp.

If there are no remaining sessions executing after 10 seconds, all the files are up-to-date and there is nothing to copy. This advanced ability to check the source and target files is what makes `rsync` an excellent choice to replicate data.

While the `rsync` processes are executing, this loop will place a . (dot) every 60 seconds as feedback to the end user that the background `rsync` copy processes are still executing. When the remaining `rsync` sessions are less than the total number of sessions (normally 36 for our example), this loop will give feedback as to the number of remaining `rsync` sessions, as well as the elapsed time of the processing, every 5 minutes. This feedback loop is shown in Listing 7-19.

```
SECONDS=10
MIN_COUNTER=0

until  (( REM_SESSIONS == 0 ))
do
    sleep 60
    echo ".\c"
    REM_SESSIONS=$(ps -ef | grep "rsync -avz" \
                  | grep oradata_dm_[0-2][0-9] \
                  | grep -v grep | awk '{print $2}' | wc -l)
    if (( REM_SESSIONS < TOTAL ))
    then
        (( MIN_COUNTER = MIN_COUNTER + 1 ))
        if (( MIN_COUNTER >= 5 ))
        then
           MIN_COUNTER=0
           echo "\n$REM_SESSIONS of $TOTAL rsync sessions \
   remaining $(elapsed_time $SECONDS)\c"
           if (( REM_SESSIONS <= $(( TOTAL / 4 )) ))
           then
              echo "\nRemaining rsync sessions include:\n"
              ps -ef | grep "rsync -avz" | grep oradata_dm_[0-2][0-9] \
```

Listing 7-19 Loop to monitor remaining rsync sessions

```
                    | grep -v grep
            echo
          fi
        fi
    fi
done
```

Listing 7-19 (*continued*)

Notice that we start this code segment in Listing 7-19 by initializing the shell's `SECONDS` variable to 10 seconds. Remember that 10-second sleep time? We make up for it here. The nice thing about using the shell's `SECONDS` variable is that it increments automatically and we can initialize it to any integer value.

Until the remaining executing `rsync` sessions are 5 sessions or less, we just put a dot on the screen every 60 seconds. Once we reach one-fourth of the total session, we list the remaining session(s) to let the user know the answer to that all-important question, ''What's taking so long?'' This script gives the user that feedback every 5 minutes, and still puts a dot on the screen every 60 seconds.

Just because the local `rsync` processes have completed does not necessarily mean that the remote `rsync` processes have completed execution. This loop verifies that all the remote `rsync` processes completed execution. The end user will receive feedback if any of the remote processes are running. The code is shown Listing 7-20.

```
for M in $MACHINE_LIST
do
   for LOC_MP in $(df | grep oradata_dm_[0-2][0-9] | awk '{print $7}')
   do
       # This sed statement changes the "m" to $DAY
       REM_MP=$(echo $LOC_MP | sed s/m/$DAY/g)

       RPID=$(rsh $M ps -ef | grep rsync | grep $REM_MP \
              | grep -v grep | awk '{print $2}')

       until [ -z "$RPID" ]
       do
           echo "rsync is processing ${REM_MP} on ${M}... \
   sleeping one minute..."
           sleep 60
           RPID=$(rsh $M ps -ef | grep rsync | grep $REM_MP \
                | grep -v grep | awk '{print $2}')
       done
   done
done

echo "\n...Remote rsync processing completed $(date)\n"
```

Listing 7-20 Code segment to verify remote rsync sessions completed

NOTE **Notice that this implementation uses remote shell (`rsh`) to perform the remote process table query. For security reasons you may want to install OpenSSH and set up the encryption key pairs so that this data transfer is encrypted.**

Now that the `rsync` copy process has completed, we are ready to verify the file sizes, both locally and remotely, and to send email notification of the success or failure. Take a look at Listing 7-21 and we will cover the details at the end.

```
verify_copy
if (( $? != 0 ))
then
    exit 3
fi

# Write to the $COMPLETE_FILE to signal the Oracle DBAs
# that the copy has completed

echo "Rsync copy from $THIS_HOST to machines $MACHINE_LIST \
completed successfully $(date)" | tee -a $COMPLETE_FILE

# Remove the ready to run file

rm -f $READYTORUN_FILE >/dev/null 2>&1

# Notify completion by email

echo "Rsync Copy for Day $DAY Completed Successfully Execution \
   on $THIS_HOST $(date)\n" > $MAILMESSAGEFILE
elapsed_time $SECONDS >> $MAILMESSAGEFILE
mailx -r "$EMAIL_FROM" -s "Rsync copy for day $DAY completed \
   successfully on $THIS_HOST" data_support < $MAILMESSAGEFILE

echo "\nRsync copy completed $(date)"

echo "\n[[ $(basename $0) completed execution $(date) ]]\n"

exit 0

} | tee -a $LOGFILE 2>&1
```

Listing 7-21 Final verification and notification code

The first thing we do in this final step of the `rsync_daily_copy.ksh` shell script is to call the shell script's internal function `verify_copy`. This verification function compares the local (master) file size(s) to the remote (OLTP) server(s) file size(s). If the

size of each file matches, we assume that the copy completed successfully. However, because we are working with Oracle database files (`*.dbf`), the size of the file is not likely to change. It is the DBA Team's responsibility to verify the copy process by querying the OLTP databases to ensure they are usable. I tried to do a checksum on the Oracle `*.dbf` files, but it just takes too long. I've never had a problem transferring data with `rsync`; it is a very reliable program. This `verify_copy` function is a bit too long to repeat here, so please study Listing 7-13 for details.

If the copy verification fails (the file sizes do not match), we write a timestamp to the `$RSYNCFAILED_FILE` file, which signals the DBA Team's script that the copy failed, and `exit` the script with a return code of `3`. Otherwise, we create the `$COMPLETE_FILE` that signals the DBA Team's shell script that the copy completed successfully.

Next we remove the `$READYTORUN_FILE` file so that we will not automatically start this script again without the DBA Team creating a new `$READYTORUN_FILE` file.

Before we send the final email notification, we create the body of the mail message by creating a file with the text we want to send. One part of this final message is to calculate the elapsed time by executing the `elapsed_time` function, as shown in Listing 7-22.

```
elapsed_time ()
{
SEC=$1
(( SEC < 60 )) && echo "[Elapsed time: $SEC seconds]\c"
(( SEC >= 60  &&  SEC < 3600 )) && echo "[Elapsed time:
   $(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"
(( SEC > 3600 )) && echo "[Elapsed time: $(( SEC / 3600 ))
   hr $(( (SEC % 3600) / 60 )) min $(( (SEC % 3600) % 60 )) sec]\c"
}
```

Listing 7-22 elapsed_time function

The `elapsed_time` function in Listing 7-22 expects as `ARG1` the number of seconds to convert to a more readable, user-friendly format. Specifically, this function supports feedback in hours, minutes, and seconds. To add ''days'' ability, we need only add a fourth test and calculation. This modification process can be repeated for months, years, and so on.

With the elapsed time added to the mail message, we send the email to all users defined by the `data_support` email alias.

Notice how we end the shell script with an `exit 0` and close the ending brace, which uses the `tee -a $LOGFILE` command to both capture the log data in the `$LOGFILE`, and to display the data on the screen at the same time. The braces around the main body of the scripts allow us to only have this single `$LOGFILE` output redirection.

After all this explanation, I hope you are ready to see the `rsync_daily_copy.ksh` shell script in action. Check out Listing 7-23 to see how the user is continuously updated on the status of this extremely long-running copy process.

```
[[ rsync_daily_copy.ksh started execution Thu Oct 25 02:00:00 EDT 2007 ]]

Checking for Currently Running Versions of this Script
No other versions running...proceeding

Searching for the file: /orabin/apps/oracle/dbadm/general/bin/
   readytocopy.txt
Thu Oct 25 02:00:02 EDT 2007
/orabin/apps/oracle/dbadm/general/bin/readytocopy.txt is not present...
   Sleeping 5 minutes...
Thu Oct 25 02:05:15 EDT 2007
/orabin/apps/oracle/dbadm/general/bin/readytocopy.txt is not present...
   Sleeping 5 minutes...
Thu Oct 25 02:10:18 EDT 2007

...


/orabin/apps/oracle/dbadm/general/bin/readytocopy.txt is not present...
   Sleeping 5 minutes...
Thu Oct 25 10:00:19 EDT 2007
/orabin/apps/oracle/dbadm/general/bin/readytocopy.txt is not present...
   Sleeping 5 minutes...
Thu Oct 25 10:05:19 EDT 2007
/orabin/apps/oracle/dbadm/general/bin/readytocopy.txt is not present...
   Sleeping 5 minutes...
Thu Oct 25 10:10:19 EDT 2007
Found file: /orabin/apps/oracle/dbadm/general/bin/readytocopy.txt --
   Ready to proceed...
Testing variable assignment for the DAY variable
Verifying the target machines are pingable...

Pinging alpha-rsync...
Pinging alpha-rsync succeeded...
Pinging bravo-rsync...
Pinging bravo-rsync succeeded...

Starting a bunch of rsync sessions...

building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ... done
done
done
done
```

Listing 7-23 rsync_daily_copy.ksh shell script in action

```
done
done
done
done
done
done
done
done
done
done
done
done
./
./
./
done
./
./
oradata/
./
./
./
./
./
oradata/
./
./
./
./
done
./
./
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ...
building file list ... building file list ... building file list ... done
done
building file list ... done
done
done
done
done
building file list ... done
building file list ... done
done
done
done
dataset_master_12.dbf
oradata/iddata_master_02.dbf
```

Listing 7-23 (*continued*)

```
dataset_master_08.dbf
dataset_master_15.dbf
dataset_master_16.dbf
dataset_master_13.dbf
dataset_master_14.dbf
dataset_master_03.dbf
dataset_master_07.dbf
oradata/iddata_master_01.dbf
dataset_master_04.dbf
dataset_master_10.dbf
dataset_master_09.dbf
dataset_master_02.dbf
dataset_master_11.dbf
dataset_master_06.dbf
dataset_master_05.dbf
dataset_master_01.dbf
./
./
./
./
./
./
./
./
./
./
oradata/
dataset_master_04.dbf
building file list ... building file list ... oradata/
   iddata_master_01.dbf
done
done
dataset_master_05.dbf
building file list ... building file list ... dataset_master_10.dbf
dataset_master_01.dbf
done
done
building file list ... building file list ... dataset_master_06.dbf
done
dataset_master_14.dbf
done
dataset_master_08.dbf
dataset_master_12.dbf
dataset_master_11.dbf
./
./
./
```

Listing 7-23 (*continued*)

```
dataset_master_09.dbf
./
./
dataset_master_07.dbf
oradata/
dataset_master_16.dbf
dataset_master_03.dbf
oradata/iddata_master_02.dbf
dataset_master_02.dbf
dataset_master_13.dbf
dataset_master_15.dbf

      36 of 36 rsync copy sessions require further updating...

Processing rsync copies from gamma to both alpha-rsync
   bravo-rsync machines

Please be patient, this process may take longer than two hours...

Rsync is running [Start time: Thu Oct 25 10:10:30 EDT 2007]...
   ..............................................................
   ...wrote 1679091467 bytes  read 36 bytes  334647.40 bytes/sec
total size is 21495840768  speedup is 12.80

real  1h23m37.30s
user  22m53.20s
sys   0m12.17s
.wrote 1700381810 bytes  read 36 bytes  336476.80 bytes/sec
total size is 21495840768  speedup is 12.64

real  1h24m12.82s
user  22m54.44s
sys  0m12.25s
wrote 1697703683 bytes  read 36 bytes  335614.60 bytes/sec
total size is 21495840768  speedup is 12.66

real  1h24m17.93s
user  23m2.73s
sys  0m12.34s
wrote 1689385648 bytes  read 36 bytes  333705.81 bytes/sec
total size is 21495840768  speedup is 12.72

real  1h24m21.60s
user  22m58.08s
sys  0m12.27s
.wrote 1725237799 bytes  read 36 bytes  336139.86 bytes/sec
total size is 22020128768  speedup is 12.76
```

Listing 7-23 (*continued*)

```
real  1h25m31.75s
user  23m28.60s
sys  0m12.48s
wrote 1728575265 bytes  read 36 bytes  335939.23 bytes/sec
total size is 22020128768  speedup is 12.74

real  1h25m45.23s
user  23m28.51s
sys  0m12.68s
.wrote 1722668291 bytes  read 36 bytes  334466.23 bytes/sec
total size is 22020128768  speedup is 12.78

real  1h25m49.70s
user  23m28.28s
sys  0m12.60s
wrote 1756094117 bytes  read 36 bytes  340889.87
wrote 1689385648 bytes  read 36 bytes  326041.82 bytes/sec
total size is 21495840768  speedup is 12.72

real  1h26m21.51s
user  22m57.00s
sys  0m12.30s
wrote 1679091467 bytes  read 36 bytes  323867.59 bytes/sec
total size is 21495840768  speedup is 12.80

real  1h26m24.50s
user  22m51.34s
sys  0m12.16s
wrote 1697703683 bytes  read 36 bytes  327079.30 bytes/sec
total size is 21495840768  speedup is 12.66

real  1h26m30.66s
user  22m56.29s
sys  0m12.25s
wrote 1772720217 bytes  read 36 bytes  340416.76 bytes/sec
total size is 22020128768  speedup is 12.42

real  1h26m47.00s
user  23m44.54s
sys  0m12.51s
.wrote 1700381810 bytes  read 36 bytes  326149.77 bytes/sec
total size is 21495840768  speedup is 12.64

real  1h26m52.65s
user  22m59.09s
sys  0m12.40s
wrote 1750600698 bytes  read 36 bytes  335460.52 bytes/sec
total size is 22020128768  speedup is 12.58
```

Listing 7-23 (*continued*)

```
real  1h26m57.61s
user  23m37.81s
sys  0m12.56s
.
      22 of 36 rsync sessions remaining [Elapsed time: 1 hr 27 min 49 sec]
   wrote 1722668291 bytes  read 36 bytes  325985.11 bytes/sec
total size is 22020128768  speedup is 12.78

real  1h28m3.83s
user  23m29.03s
sys  0m12.59s
wrote 1985371235 bytes  read 36 bytes  374916.68 bytes/sec
total size is 22020128768  speedup is 11.90

real  1h28m15.61s
user  25m37.23s
sys  0m12.89s
wrote 1985371235 bytes  read 36 bytes  374916.68 bytes/sec
total size is 22020128768  speedup is 11.90

real  1h28m15.59s
user  25m28.99s
sys  0m12.91s
wrote 1728575265 bytes  read 36 bytes  325808.18 bytes/sec
total size is 22020128768  speedup is 12.74

real  1h28m25.05s
user  23m24.20s
sys  0m12.50s
wrote 1725237799 bytes  read 36 bytes  324201.42 bytes/sec
total size is 22020128768  speedup is 12.76

real  1h28m41.40s
user  23m29.53s
sys  0m12.65s
.wrote 1756094117 bytes  read 36 bytes  328149.89 bytes/sec
total size is 22020128768  speedup is 12.54

real  1h29m10.67s
user  23m41.94s
sys  0m12.56s
wrote 2029784980 bytes  read 36 bytes  377739.84 bytes/sec
total size is 22544416768  speedup is 11.11

real  1h29m32.77s
user  26m1.22s
sys  0m13.06s
wrote 2029784980 bytes  read 36 bytes  377739.84 bytes/sec
```

Listing 7-23 (*continued*)

```
total size is 22544416768  speedup is 11.11

real  1h29m33.07s
user  26m5.36s
sys  0m13.05s
wrote 1772720217 bytes  read 36 bytes  329839.10 bytes/sec
total size is 22020128768  speedup is 12.42

real  1h29m33.75s
user  23m36.80s
sys  0m12.40s
.wrote 1750600698 bytes  read 36 bytes  324335.48 bytes/sec
total size is 22020128768  speedup is 12.58

real  1h29m57.29s
user  23m39.67s
sys  0m12.64s
wrote 1990832602 bytes  read 36 bytes  368093.30 bytes/sec
total size is 22544416768  speedup is 11.32

real  1h30m8.23s
user  26m9.25s
sys  0m13.12s
.wrote 1986846605 bytes  read 36 bytes  362067.73 bytes/sec
total size is 22020128768  speedup is 11.80

real  1h31m27.24s
user  25m38.40s
sys  0m13.08s
wrote 1986846605 bytes  read 36 bytes  361474.87 bytes/sec
total size is 22020128768  speedup is 11.80

real  1h31m36.02s
user  25m40.54s
sys  0m13.05s
.wrote 2024116016 bytes  read 36 bytes  366920.34 bytes/sec
total size is 22544416768  speedup is 11.14

real  1h31m56.00s
user  26m9.30s
sys  0m13.13s
wrote 2024116016 bytes  read 36 bytes  365925.35 bytes/sec
total size is 22544416768  speedup is 11.14

real  1h32m11.50s
user  26m10.12s
sys  0m13.25s
wrote 1990832602 bytes  read 36 bytes  357773.86 bytes/sec
```

Listing 7-23 (*continued*)

```
total size is 22544416768  speedup is 11.32

real  1h32m44.39s
user  26m19.03s
sys  0m13.30s
.
      6 of 36 rsync sessions remaining [Elapsed time: 1 hr 32 min 51 sec]
Remaining rsync sessions include:

    root 13217834 13279464 120 10:10:20      - 15:31 rsync -avz /dba/
   oradata_dm_15/alpha-rsync:/dba/oradata_d1_15
    root 13869244 13893768 120 10:10:20      - 15:15 rsync -avz /dba/
   oradata_dm_15/ bravo-rsync:/dba/oradata_d1_15
    root 14028924 14758450 120 10:10:20      - 39:51 rsync -avz /dba/
   oradata_dm_17/ alpha-rsync:/dba/oradata_d1_17
    root 27713858 14320212 111 10:10:20      - 39:43 rsync -avz /dba/
   oradata_dm_18/ alpha-rsync:/dba/oradata_d1_18
    root 28176732 13754940 102 10:10:20      - 27:42 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708  92 10:10:20      - 27:34 rsync -avz /dba/
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

.....
      6 of 36 rsync sessions remaining [Elapsed time: 1 hr 37 min 54 sec]
Remaining rsync sessions include:

    root 13217834 13279464  93 10:10:20      - 18:24 rsync -avz /dba/
   oradata_dm_15/ alpha-rsync:/dba/oradata_d1_15
    root 13869244 13893768  90 10:10:20      - 18:01 rsync -avz /dba/
   oradata_dm_15/ bravo-rsync:/dba/oradata_d1_15
    root 14028924 14758450 105 10:10:20      - 43:36 rsync -avz /dba/
   oradata_dm_17/ alpha-rsync:/dba/oradata_d1_17
    root 27713858 14320212 120 10:10:20      - 43:25 rsync -avz /dba/
   oradata_dm_18/ alpha-rsync:/dba/oradata_d1_18
    root 28176732 13754940 120 10:10:20      - 31:14 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708  98 10:10:20      - 31:06 rsync -avz /dba/
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

....wrote 7183466709 bytes  read 36 bytes  1163785.62 bytes/sec
total size is 20971552768  speedup is 2.92

real  1h42m52.05s
user  45m59.38s
sys  0m19.95s
wrote 7174332611 bytes  read 36 bytes  1162117.54 bytes/sec
total size is 20971552768  speedup is 2.92
```

Listing 7-23 (*continued*)

```
real  1h42m53.63s
user  45m51.40s
sys  0m20.11s
.
      4 of 36 rsync sessions remaining [Elapsed time: 1 hr 42 min 56 sec]
Remaining rsync sessions include:

    root 13217834 13279464 107 10:10:20      - 21:20 rsync -avz /dba/
   oradata_dm_15/ alpha-rsync:/dba/oradata_d1_15
    root 13869244 13893768  85 10:10:20      - 20:52 rsync -avz /dba/
   oradata_dm_15/ bravo-rsync:/dba/oradata_d1_15
    root 28176732 13754940 115 10:10:20      - 34:51 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708 114 10:10:20      - 34:41 rsync -avz /dba/
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

.....
      4 of 36 rsync sessions remaining [Elapsed time: 1 hr 47 min 58 sec]
Remaining rsync sessions include:

    root 13217834 13279464  99 10:10:20      - 24:34 rsync -avz /dba/
   oradata_dm_15/ alpha-rsync:/dba/oradata_d1_15
    root 13869244 13893768  80 10:10:20      - 24:02 rsync -avz /dba/
   oradata_dm_15/ bravo-rsync:/dba/oradata_d1_15
    root 28176732 13754940  88 10:10:20      - 38:24 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708 117 10:10:20      - 38:16 rsync -avz /dba/
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

wrote 1715967444 bytes  read 36 bytes  263165.10 bytes/sec
total size is 22020128768  speedup is 12.83

real  1h48m40.22s
user  24m47.92s
sys  0m13.87s
.wrote 1715967444 bytes  read 36 bytes  260607.10 bytes/sec
total size is 22020128768  speedup is 12.83

real  1h49m43.92s
user  24m49.36s
sys  0m13.95s
....
      2 of 36 rsync sessions remaining [Elapsed time: 1 hr 53 min 0 sec]
Remaining rsync sessions include:

    root 28176732 13754940  82 10:10:20      - 41:59 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708 120 10:10:20      - 41:50 rsync -avz /dba/
```

Listing 7-23 (*continued*)

```
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

.....
       2 of 36 rsync sessions remaining [Elapsed time: 1 hr 58 min 3 sec]
Remaining rsync sessions include:

    root 28176732 13754940  71 10:10:20      - 45:38 rsync -avz /dba/
   oradata_dm_17/ bravo-rsync:/dba/oradata_d1_17
    root 13873778 19423708 120 10:10:20      - 45:31 rsync -avz /dba/
   oradata_dm_18/ bravo-rsync:/dba/oradata_d1_18

....wrote 7183466709 bytes  read 36 bytes  977010.10 bytes/sec
total size is 20971552768  speedup is 2.92

real  2h2m31.79s
user  47m36.77s
sys  0m21.09s
wrote 7174332611 bytes  read 36 bytes  974839.68 bytes/sec
total size is 20971552768  speedup is 2.92

real  2h2m39.11s
user  47m35.59s
sys  0m21.33s
.
       0 of 36 rsync sessions remaining [Elapsed time: 2 hr 3 min 5 sec]
Remaining rsync sessions include:



...Local rsync processing completed on gamma...Thu Oct 25 12:13:25
   EDT 2007

...Checking remote target machines: alpha-rsync bravo-rsync...

...Remote rsync processing completed Thu Oct 25 12:13:32 EDT 2007

Checking File: /dba/oradata_dm_01/dataset_master_01.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_01/dataset_master_01.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_02/dataset_master_02.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_02/dataset_master_02.dbf
alpha-rsync size:   22544416768
Checking File: /dba/oradata_dm_03/dataset_master_03.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_03/dataset_master_03.dbf
alpha-rsync size:   22544416768
```

Listing 7-23 (*continued*)

```
Checking File: /dba/oradata_dm_04/dataset_master_04.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_04/dataset_master_04.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_05/dataset_master_05.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_05/dataset_master_05.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_06/dataset_master_06.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_06/dataset_master_06.dbf
alpha-rsync size:   22544416768
Checking File: /dba/oradata_dm_07/dataset_master_07.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_07/dataset_master_07.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_08/dataset_master_08.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_08/dataset_master_08.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_09/dataset_master_09.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_09/dataset_master_09.dbf
alpha-rsync size:   21495840768
Checking File: /dba/oradata_dm_10/dataset_master_10.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_10/dataset_master_10.dbf
alpha-rsync size:   21495840768
Checking File: /dba/oradata_dm_11/dataset_master_11.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_11/dataset_master_11.dbf
alpha-rsync size:   21495840768
Checking File: /dba/oradata_dm_12/dataset_master_12.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_12/dataset_master_12.dbf
alpha-rsync size:   21495840768
Checking File: /dba/oradata_dm_13/dataset_master_13.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_13/dataset_master_13.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_14/dataset_master_14.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_14/dataset_master_14.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_15/dataset_master_15.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_15/dataset_master_15.dbf
alpha-rsync size:   22020128768
```

Listing 7-23 (*continued*)

```
Checking File: /dba/oradata_dm_16/dataset_master_16.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_16/dataset_master_16.dbf
alpha-rsync size:   22020128768
Checking File: /dba/oradata_dm_17/oradata/iddata_master_01.dbf
Local gamma size:   20971552768
Checking Remote File: /dba/oradata_d1_17/oradata/iddata_master_01.dbf
alpha-rsync size:   20971552768
Checking File: /dba/oradata_dm_18/oradata/iddata_master_02.dbf
Local gamma size:   20971552768
Checking Remote File: /dba/oradata_d1_18/oradata/iddata_master_02.dbf
alpha-rsync size:   20971552768
Checking File: /dba/oradata_dm_01/dataset_master_01.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_01/dataset_master_01.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_02/dataset_master_02.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_02/dataset_master_02.dbf
bravo-rsync size:   22544416768
Checking File: /dba/oradata_dm_03/dataset_master_03.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_03/dataset_master_03.dbf
bravo-rsync size:   22544416768
Checking File: /dba/oradata_dm_04/dataset_master_04.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_04/dataset_master_04.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_05/dataset_master_05.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_05/dataset_master_05.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_06/dataset_master_06.dbf
Local gamma size:   22544416768
Checking Remote File: /dba/oradata_d1_06/dataset_master_06.dbf
bravo-rsync size:   22544416768
Checking File: /dba/oradata_dm_07/dataset_master_07.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_07/dataset_master_07.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_08/dataset_master_08.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_08/dataset_master_08.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_09/dataset_master_09.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_09/dataset_master_09.dbf
bravo-rsync size:   21495840768
```

Listing 7-23 (*continued*)

```
Checking File: /dba/oradata_dm_10/dataset_master_10.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_10/dataset_master_10.dbf
bravo-rsync size:   21495840768
Checking File: /dba/oradata_dm_11/dataset_master_11.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_11/dataset_master_11.dbf
bravo-rsync size:   21495840768
Checking File: /dba/oradata_dm_12/dataset_master_12.dbf
Local gamma size:   21495840768
Checking Remote File: /dba/oradata_d1_12/dataset_master_12.dbf
bravo-rsync size:   21495840768
Checking File: /dba/oradata_dm_13/dataset_master_13.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_13/dataset_master_13.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_14/dataset_master_14.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_14/dataset_master_14.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_15/dataset_master_15.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_15/dataset_master_15.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_16/dataset_master_16.dbf
Local gamma size:   22020128768
Checking Remote File: /dba/oradata_d1_16/dataset_master_16.dbf
bravo-rsync size:   22020128768
Checking File: /dba/oradata_dm_17/oradata/iddata_master_01.dbf
Local gamma size:   20971552768
Checking Remote File: /dba/oradata_d1_17/oradata/iddata_master_01.dbf
bravo-rsync size:   20971552768
Checking File: /dba/oradata_dm_18/oradata/iddata_master_02.dbf
Local gamma size:   20971552768
Checking Remote File: /dba/oradata_d1_18/oradata/iddata_master_02.dbf
bravo-rsync size:   20971552768

SUCCESS: Rsync copy completed successfully...

All file sizes match...

Rsync copy from gamma to machines alpha-rsync bravo-rsync
completed successfully Thu Oct 25 12:13:40 EDT 2007

Rsync copy completed Thu Oct 25 12:13:40 EDT 2007

[[ rsync_daily_copy.ksh completed execution Thu Oct 25 12:13:40
   EDT 2007 ]]
```

Listing 7-23 (*continued*)

This is an example of a successful `rsync` copy process. You can easily follow the process of checking for other copies of this script executing, monitoring for the startup file, verifying the `DAY` variable, pinging the destination servers, starting the replication process, monitoring the `rsync` processes, and giving the user feedback on the progress of the copy process. After all local `rsync` sessions have completed, we query the OLTP server process tables remotely for any leftover `rsync` sessions. Although very unlikely, I still like to check. The last step verifies the file sizes are equal on each server, and then sends notification to that effect.

Summary

I hope you picked up some tips and tricks in this chapter. As with any scripts we write, there is always room for improvement. Using `rsync` is a smart method to replicate data because the `rsync` checksum search algorithm is so fast and accurate. You have a number of options, including using compression, limiting bandwidth, and using the `rsyncd` protocol to replicate data through specific TCP ports.

To get the most out of `rsync`, you need to study the manual page in detail. You can send the `man` page directly to the printer with the following command:

```
man rsync | lp -d queue_name
```

where `queue_name` is a defined print queue on your system.

We used remote shell (`rsh`) for this data transfer. Depending on the sensitivity of your data, you may want to use Open Secure Shell (OpenSSH) so that the data is encrypted, and set up the encryption keys so that a password is not required. You can download OpenSSH from `www.openssh.org`.

We will use `rsync` again in Chapter 27, ''Using Dirvish with rsync to Create Snapshot-Type Backups.'' Dirvish is a wrapper program around `rsync` that does snapshot-type backups. This is a powerful and efficient backup method, so be sure to check it out.

In the next chapter we will look automating interactive programs with `expect` and using `autoexpect` to easily, and automatically, create an `expect` script to interact with a program.

Lab Assignments

1. Rewrite the shell script in Listing 7-1 so that the source file/directory and destination file/directory are specified on the command line as `ARG1` and `ARG2`, respectively.

   Example: `generic_rsync.Bash yogi:/scripts/ /scripts`

2. Write two shell scripts. Shell script A should do an archive-compressed `rsync` copy of some large directory structure to a remote system. Shell script B should `rsync` a tarred-compressed file of the same directory structure (`somedir.tar.Z`) to the remote machine.

Is it faster to just let `rsync` do the compression, or does the compressed file transfer faster with a higher level of compression? Time each method. NOTE: Do not store the tarred-compressed file in the same directory structure. That would change the results.

CHAPTER 8

Automating Interactive Programs with Expect and Autoexpect

Need a robot to take care of a few tasks for you every day in your environment? If so, Expect just may be your answer. Expect is a programming language that ''talks'' with an interactive program or script that requires user interaction for input. Expect works by *expecting* input, and upon receiving the expected input, the Expect script will *send* a response, just like magic.

To make it easy to create Expect scripts, and to help users learn how to use Expect to interact with a program, the programmers came up with the `autoexpect` command. By typing **autoexpect** and pressing Enter, we can create the script automatically by just interacting with the program, *without making a mistake*, as we normally would, and save the interaction in an Expect script file. When we finish interacting with the program, we simply press Ctrl+D to save the new Expect script. The target command or application can also be supplied as an argument to `autoexpect`, and Expect will *spawn* the process for us. We will get to more details in the coming pages. For now, just relax and let's get started.

Downloading and Installing Expect

Expect requires Tcl to be installed before Expect will work to interact with a program. If you need to install Tcl, you can download the code from `http://www.tcl.tk/software/tcltk/`. The simplest method of installing Tcl and Expect is to use `yum` or `apt` to install the file sets from one of many mirror sites around the world. You can also go to the official Expect web page, `http://expect.nist.gov/`, and download the source code to compile on your system.

I like using `yum` to install packages on my Linux machine. Listing 8-1 shows a typical `yum` installation for Tcl and Expect.

```
[root@localhost scripts]# yum install expect
Loading "installonlyn" plugin
Setting up Install Process
Parsing package install arguments
updates                     100%
|=========================| 1.9 kB    00:00
primary.sqlite.bz2        100%
|=========================| 1.4 MB    00:01
freshrpms                   100%
|=========================| 1.9 kB    00:00
primary.sqlite.bz2        100%
|=========================|  89 kB    00:00
fedora                      100%
|=========================| 2.1 kB    00:00
primary.sqlite.bz2        100%
|=========================| 4.7 MB    00:05
Resolving Dependencies
--> Running transaction check
---> Package expect.i386 0:5.43.0-8 set to be updated
---> Package expect.x86_64 0:5.43.0-8 set to be updated
--> Processing Dependency: libtcl8.4.so()(64bit) for package: expect
--> Processing Dependency: libtcl8.4.so for package: expect
--> Restarting Dependency Resolution with new changes.
--> Running transaction check
---> Package tcl.i386 1:8.4.13-16.fc7 set to be updated
---> Package tcl.x86_64 1:8.4.13-16.fc7 set to be updated
---> Package expect.i386 0:5.43.0-8 set to be updated
---> Package expect.x86_64 0:5.43.0-8 set to be updated

Dependencies Resolved

================================================================================
 Package            Arch       Version          Repository      Size
================================================================================
Installing:
 expect             i386       5.43.0-8         fedora          262 k
 expect             x86_64     5.43.0-8         fedora          263 k
Installing for dependencies:
 tcl                i386       1:8.4.13-16.fc7  fedora          1.8 M
 tcl                x86_64     1:8.4.13-16.fc7  fedora          1.8 M

Transaction Summary
================================================================================
Install      4 Package(s)
Update       0 Package(s)
Remove       0 Package(s)

Total download size: 4.1 M
```

Listing 8-1 Installing Tcl and Expect with yum

```
Is this ok [y/N]: y
Downloading Packages:
(1/4): expect-5.43.0-8.x8 100%
|=========================| 263 kB  00:00
(2/4): expect-5.43.0-8.i3 100%
|=========================| 262 kB  00:00
(3/4): tcl-8.4.13-16.fc7. 100%
|=========================| 1.8 MB  00:02
(4/4): tcl-8.4.13-16.fc7. 100%
|=========================| 1.8 MB  00:02
Running Transaction Test
Finished Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing: tcl                         ######################### [1/4]
  Installing: tcl                         ######################### [2/4]
  Installing: expect                      ######################### [3/4]
  Installing: expect                      ######################### [4/4]

Installed: expect.i386 0:5.43.0-8 expect.x86_64 0:5.43.0-8
Dependency Installed: tcl.i386 1:8.4.13-16.fc7
tcl.x86_64 1:8.4.13-16.fc7
Complete!
```

Listing 8-1 (*continued*)

As you can see in Listing 8-1, `yum` found the Tcl requirement for Expect and installed the required Tcl package before installing Expect. For more information on setting up `yum` or `apt`, see the manual pages, `man yum` and `man apt`, respectively.

The Basics of Talking to an Interactive Script or Program

With Expect and Tcl installed, we can now start *talking* to our interactive programs and scripts.

NOTE **For our discussion, I will refer to the combined installation of Tcl and Expect as *Expect* in this chapter.**

To get started, we need to look at the basic commands that Expect uses to interact with a program or script:

- The `expect` command is used to wait for specific output from a process or program, just as `read` waits for input in a shell script. The `-exact` command switch tells Expect to recognize only the *exact* specified output, including spaces, line feeds, and carriage returns. This is why I like to say that when we program in Expect, *we should not expect too much*. If you are running an Expect script and it hangs on one step, it may be caused by the use of the `-exact` switch.

- We use the `send` command to send a reply to a process or program. This works like `echo` in our shell scripts. You must specify the proper cursor control when talking with an interactive application, using `\r` for carriage return and `\n` for each new line. Carriage returns and line feeds are not automatically implied.
- We use the `spawn` command to start up a process or application, such as the default shell, `ftp`, `telnet`, `ssh`, `rcp`, and so on. The `-noecho` switch suppresses screen output of the spawned command. This is useful when you do not want usernames, passwords, or other output displayed on the screen.
- Then we have the `interact` command, which enables us to program a predefined user interaction point in our Expect scripts. For example, we might want have an Expect script that will log us in to an FTP site and then turn control over to the end user.

Table 8-1 summarizes the most basic Expect commands.

Table 8-1 Expect Commands

COMMAND	ACTION
`spawn`	Starts a process or program
`send`	Sends a reply to a process or program
`expect`	Waits for output from a process or program
`interact`	Allows you in interact with a process or program

I wrote a simple Bash shell script that asks questions, and an Expect script that answers the questions automatically. The `lunch_time.Bash` shell script asks Bob if he wants to go to lunch. The `talk_back.exp` Expect script sends the replies to the Bash script. Listing 8-2 shows the `lunch_time.Bash` shell script.

```
#!/bin/Bash
#
# SCRIPT: lunch_time.Bash
#
# This script is used to test an Expect script
#

echo "Hey Bob, you in?"
read REPLY
echo "Have you eaten yet?"
read REPLY
echo "You want to?"
read REPLY
echo "How about that Italian place?"
read REPLY
echo "Meet you in the lobby"
read REPLY
```

Listing 8-2 Simple Bash script to talk with Expect

As you can see in Listing 8-2, we are not testing any of the replies. Any reply will cause the script to ask the next question. Listing 8-3 shows the `talk_back.exp` Expect script.

```
#!/usr/local/bin/expect -f

# SCRIPT: talk_back.exp

# This is an example Expect script starting up and
# talking to a Bash script.

set timeout -1
spawn $env(SHELL)
expect "\r*"
send -- "./lunch_time.Bash\r"
expect  "lunch_time.Bash\r"
expect "Hey Bob, you in?\r"
send -- "Yes\r"
expect -exact "Yes\r"
expect "Have you eaten yet?\r"
send -- "No\r"
expect "You want to?\r"
send -- "Where at?\r"
expect "How about that Italian place?\r"
send -- "Works for me\r"
expect "Meet you in the lobby\r"
send -- "Groovy man\r"
expect -exact "Groovy man\r"
expect eof
```

Listing 8-3 Simple Expect script that starts and talks to a Bash script

Let's look at the Expect script in Listing 8-3 from the top. As with all scripts, we need to define the interpreter on the very first line. Normally, we need to define the executing shell, but in this case `#!/usr/local/bin/expect` specifies the path to Expect. The same is true for Perl scripts.

NOTE **If you get a *bad interpreter* error, you have defined the wrong path to Expect, or Expect is not installed. Expect resides in `/usr/bin/expect` or `/usr/local/bin/expect`.**

On the first line of code, we disable timeouts by setting the Expect `timeout` variable to `-1`. Next we start the default UNIX shell with the command `spawn $env(SHELL)`. You can also use `spawn` to initiate scripts, programs, `ftp`, `telnet`, and other interactive programs. Next we send to the shell the command `./lunch_time.Bash`, which starts our interactive Bash script. The remaining parts of the `talk_back.exp` Expect script are the interactions with the `lunch_time.Bash` shell script. Notice that we end the Expect script with `expect eof`. This last Expect statement tells Expect the end of file is expected and the script ends. Listing 8-4 shows both scripts interacting.

```
[root@yogi scripts]# ./talk_back.exp     Command-line starting
                                         Expect script
spawn /bin/Bash                          Expect spawning the
                                         default UNIX shell
[root@yogi scripts]# ./lunch_time.Bash   Expect starting Bash
                                         shell script
Hey Bob, you in?                         Question from Bash
                                         script
Yes                                      Expect script reply
Have you eaten yet?                      Question from Bash
                                         script
No                                       Expect script reply
You want to?                             Question from Bash
                                         script
Where at?                                Expect script reply
How about that Italian place?            Question from Bash
                                         script
Works for me                             Expect script reply
Meet you in the lobby                    Question from Bash
                                         script
Groovy man                               Expect script reply
[root@yogi scripts]#                     Command prompt
```

Listing 8-4 Example of an Expect script interacting with a Bash shell script

Listing 8-4 shows the how the interaction takes place between the Expect script and the Bash shell script. On the command line, we started the Expect script `talk_back.exp` located in the current directory. On the next line, Expect spawns a new default shell, which is Bash in this case.

NOTE **We can also spawn the Bash shell script directly with `spawn ./lunch_time.Bash`, instead of first spawning a default shell and using `send "./lunch_time.Bash\r"` to start the Bash shell script.**

Next the Expect script starts the Bash shell script. Had we added the `-noecho` switch to the `spawn` command, this particular output would have been suppressed. Once the Bash script starts asking questions, the Expect script responds. You can see the interaction descriptions on the right side of Listing 8-4.

In this example we had the Expect script start the Bash shell script, but we could just as easily have had the Bash shell script start the Expect script. It just depends on the particular application.

Using autoexpect to Automatically Create an Expect Script

To create an Expect script quickly and automatically, we can use `autoexpect`. `autoexpect` works the same way the **script** command works. We enter **autoexpect** on the command line, and a new script-type session is started that saves all the keystrokes

in a file until the application ends. Or we can press Ctrl+D to end the `autoexpect` session. The new Expect script is saved to the default filename `script.exp`, and it is saved in the current directory. You can also have `autoexpect` spawn the process for you by specifying the name on the command line, as follows:

```
# autoexpect  ftp yogi
```

This command spawns an FTP session to the server `yogi` and starts an `autoexpect` session to save all the keystrokes. Using this technique, let's use `autoexpect` to create the new Expect script, and we will look at the differences in the script `autoexpect` creates and the script in Listing 8-4. Listing 8-5 shows how to create the new Expect script using `autoexpect`.

```
[root@yogi scripts]# autoexpect ./lunch_time.Bash
autoexpect started, file is script.exp   Autoexpect session
                                         started
Hey Bob, you in?                         Bash script question
Yes                                      Command-line reply
Have you eaten yet?                      Bash script question
No                                       Command-line reply
You want to?                             Bash script question
Where at?                                Command-line reply
How about that Italian place?            Bash script question
Works for me                             Command-line reply
Meet you in the lobby                    Bash script question
Groovy man                               Command-line reply
autoexpect done, file is script.exp      Bash scripts ends and
                                         autoexpect saves file
[root@yogi scripts]#                     Command prompt
```

Listing 8-5 Example of using autoexpect

Notice in Listing 8-5 that we specified the interactive program or script on the command line, and then there is the interaction between the Bash script and my typing on the command line to reply. When the Bash script ends, the `autoexpect` session automatically ends and the new Expect script is saved in the file `script.exp` located in the current directory. So, don't forget to rename the file to something meaningful.

Now let's look at the Expect script that `autoexpect` created, as shown in Listing 8-6.

```
#!/usr/local/bin/expect -f
#
# This Expect script was generated by autoexpect on Wed
Dec 26 15:16:05 2007
# Expect and autoexpect were both written by Don Libes, NIST.
#
```

Listing 8-6 Expect script created with autoexpect

```
# Note that autoexpect does not guarantee a working script.  It
# necessarily has to guess about certain things.  Two reasons a script
# might fail are:
#
# 1) timing - A surprising number of programs (rn, ksh, zsh, telnet,
# etc.) and devices discard or ignore keystrokes that arrive "too
# quickly" after prompts.  If you find your new script hanging up at
# one spot, try adding a short sleep just before the previous send.
# Setting "force_conservative" to 1 (see below) makes Expect do this
# automatically - pausing briefly before sending each character.  This
# pacifies every program I know of.  The -c flag makes the script do
# this in the first place.  The -C flag allows you to define a
# character to toggle this mode off and on.

set force_conservative 0  ;# set to 1 to force conservative mode even if
                      ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
            sleep .1
            exp_send -s -- $arg
     }
}

#
# 2) differing output - Some programs produce different output each time
# they run.  The "date" command is an obvious example.  Another is
# ftp, if it produces throughput statistics at the end of a file
# transfer.  If this causes a problem, delete these patterns or replace
# them with wildcards.  An alternative is to use the -p flag (for
# "prompt"), which makes Expect only look for the last line of output
# (i.e., the prompt).  The -P flag allows you to define a character to
# toggle this mode off and on.
#
# Read the man page for more info.
#
# -Don


set timeout -1
spawn ./lunch_time.Bash
match_max 100000
expect -exact "Hey Bob, you in?\r
"
send -- "Yes\r"
expect -exact "Yes\r
Have you eaten yet?\r
"
```

Listing 8-6 (*continued*)

```
send -- "No\r"
expect -exact "No\r
You want to?\r
"
send -- "Where at?\r"
expect -exact "Where at?\r
How about that Italian place?\r
"
send -- "Works for me\r"
expect -exact "Works for me\r
Meet you in the lobby\r
"
send -- "Groovy man\r"
expect eof
```

Listing 8-6 (*continued*)

As shown in Listing 8-6, `autoexpect` adds a lot of text at the top of the Expect script. One thing to notice is the setting for `force_conservative` mode. Many programs and applications will ignore any data that arrives too quickly. This can be a problem and is one cause of an Expect script hanging. If you set `force_conservative` to `1`, Expect will pause briefly before sending each reply. Of course, this can slow down the script's execution time.

We need to remember that `autoexpect` *does not guarantee* the new Expect script will work. There are many commands that use timestamps in output or show transfer statistics, as is the case with `ftp`, and as these values change, the Expect script can fail or hang. If you get this type of output when using `autoexpect`, either delete the data that changes from the Expect script or use wildcards to represent the data. We can also use the `-p` (for prompt) `autoexpect` switch to have Expect look only at the last line of output, which may be the command prompt. You can also add the `-P` switch to specify a character to toggle this mode on and off. For example, use `-P ^P` to specify Control+P as the toggle character.

Speaking of file-transfer statistics, let's take a look at another Expect script created by `autoexpect`. The goal of the `ftp-get-file.exp` Expect script is to `ftp` a file named `random_file.out`, located on the remote server named `yogi` in the `/scripts` directory, to the current directory on the local machine. The username for this file transfer is `prodmgr` and the password on `yogi` is `Abc1234`. Check out how we use `autoexpect` to create the `ftp-get-file.exp` Expect script in Listing 8-7.

```
[root@booboo ~]# autoexpect ftp yogi
autoexpect started, file is script.exp
Connected to yogi (192.168.1.100).
220 yogi FTP server (Version 4.1 Sat Feb 23 00:11:36 CST 2002) ready.
Name (yogi:root): prodmgr
331 Password required for prodmgr.
```

Listing 8-7 Using autoexpect to create the ftp-get-file.exp Expect script

```
Password:
230 User prodmgr logged in.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> cd /scripts
250 CWD command successful.
ftp> get random_file.out
local: random_file.out remote: random_file.out
227 Entering Passive Mode (192,168,1,100,128,45)
150 Opening data connection for random_file.out (2185 bytes).
226 Transfer complete.
2185 bytes received in 0.0149 secs (1.4e+02 Kbytes/sec)
ftp> bye
221 Goodbye.
autoexpect done, file is script.exp
```

Listing 8-7 (*continued*)

We begin the `autoexpect` session by specifying `ftp yogi` on the command line. As you will see in the `ftp-get-file.exp` Expect script, this causes Expect to spawn a new `ftp yogi` process instead of spawning a new default shell, as we did earlier when we just typed **autoexpect** on the command line and pressed Enter, and did not specify the program to interact with on the command line.

Next we supply the username and password to get logged in. Now we change directory to `/scripts`, where the `random_file.out` file resides. The next command is `get random_file.out`, which transfers the file to the local server and current directory. Let's look at the code that `autoexpect` created in Listing 8-8.

```
#!/usr/bin/expect -f
#
# This Expect script was generated by autoexpect on Wed
Dec 26 08:24:28 2007
# Expect and autoexpect were both written by Don Libes, NIST.
#
# Note that autoexpect does not guarantee a working script.  It
# necessarily has to guess about certain things.  Two reasons a script
# might fail are:
#
# 1) timing - A surprising number of programs (rn, ksh, zsh, telnet,
# etc.) and devices discard or ignore keystrokes that arrive "too
# quickly" after prompts.  If you find your new script hanging up at
# one spot, try adding a short sleep just before the previous send.
# Setting "force_conservative" to 1 (see below) makes Expect do this
# automatically - pausing briefly before sending each character.  This
# pacifies every program I know of.  The -c flag makes the script do
# this in the first place.  The -C flag allows you to define a
```

Listing 8-8 Expect script to FTP a file that autoexpect created

```
# character to toggle this mode off and on.

set force_conservative 0  ;# set to 1 to force conservative mode even if
                      ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
            sleep .1
            exp_send -s -- $arg
     }
}

#
# 2) differing output - Some programs produce different output each time
# they run.  The "date" command is an obvious example.  Another is
# ftp, if it produces throughput statistics at the end of a file
# transfer.  If this causes a problem, delete these patterns or replace
# them with wildcards.  An alternative is to use the -p flag (for
# "prompt"), which makes Expect only look for the last line of output
# (i.e., the prompt).  The -P flag allows you to define a character to
# toggle this mode off and on.
#
# Read the man page for more info.
#
# -Don


set timeout -1
spawn ftp yogi
match_max 100000
expect -exact "Connected to yogi (192.168.1.100).\r
220 yogi FTP server (Version 4.1 Sat Feb 23 00:11:36 CST 2002) ready.\r
Name (yogi:root): "
send -- "prodmgr\r"
expect -exact "prodmgr\r
331 Password required for prodmgr.\r
Password:"
send -- "Abc1234\r"
expect -exact "\r
230 User prodmgr logged in.\r
Remote system type is UNIX.\r
Using binary mode to transfer files.\r
ftp> "
send -- "cd /scripts\r"
expect -exact "cd /scripts\r
250 CWD command successful.\r
ftp> "
send -- "get random_file.out"
```

Listing 8-8 (*continued*)

```
expect -exact "random_file.out"
send -- "\r"
expect -exact "\r
local: random_file.out remote: random_file.out\r
227 Entering Passive Mode (192,168,1,100,128,45)\r
150 Opening data connection for random_file.out (2185 bytes).\r
226 Transfer complete.\r
2185 bytes received in 0.0149 secs (1.4e+02 Kbytes/sec)\r
ftp> "
send -- "bye\r"
expect eof
```

Listing 8-8 (*continued*)

How much of the code in Listing 8-8 is *really* needed? As it turns out, not a whole lot. Let's strip out the unneeded code that `autoexpect` created to streamline this Expect script. Check out the new Expect script in Listing 8-9 and we will cover the details at the end.

```
#!/usr/bin/expect -f
#
# SCRIPT: ftp-get-file.exp
#

set force_conservative 0  ;# set to 1 to force conservative mode even if
                      ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send }ignore arg} {
             sleep .1
             exp_send -s -- $arg
     }
}


set timeout -1
spawn ftp yogi
match_max 100000
expect "Name *: "
send -- "prodmgr\r"
expect "Password:"
send -- "Abc1234\r"
expect "ftp>"
send -- "cd /scripts\r"
expect "ftp>"
```

Listing 8-9 New ftp-get-file.exp Expect script

```
send -- "get random_file.out\r"
expect "ftp>"
send -- "bye\r"
expect eof
```

Listing 8-9 (*continued*)

In Listing 8-9 we removed all the ''extra stuff'' and only test for, or *expect*, specific prompts. We use each of these prompts as signal points that the program's interaction requires more input. Notice that `expect -exact` is not used anywhere in the `ftp-get-file.exp` Expect script.

If we initially create an Expect script using `autoexpect` to save the keystrokes, we can easily strip out the extra output and extra send data, thus limiting the recognition to specific prompts and saving us a lot of trouble trying to match varying output. The new `ftp-get-file.exp` Expect script is shown in action in Listing 8-10.

```
[root@booboo ~]# ./ftp-get-file.exp
spawn ftp yogi
Connected to yogi (192.168.1.100).
220 yogi FTP server (Version 4.1 Sat Feb 23 00:11:36 CST 2002) ready.
Name (yogi:root): prodmgr
331 Password required for prodmgr.
Password:
230 User root logged in.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> cd /scripts
250 CWD command successful.
ftp> get random_file.out
local: random_file.out remote: random_file.out
227 Entering Passive Mode (192,168,1,100,128,46)
150 Opening data connection for random_file.out (2185 bytes).
226 Transfer complete.
2185 bytes received in 0.00364 secs (5.9e+02 Kbytes/sec)
ftp> bye
221 Goodbye.
[root@booboo ~]#
```

Listing 8-10 ftp-get-file.exp shell script in action

In Listing 8-10 we have six instances where we must supply input to the `ftp` process. We first `spawn` the new `ftp` session to the server `yogi`. Next we supply the username and password to get logged in. Once we are logged in to the system we change to the `/scripts` directory and execute the `get random_file.out` command to retrieve the remote file. After the transfer we again get the `ftp>` prompt and send `bye` to end the `ftp` session. At each step, notice how we use the specific known prompt as a signal point to provide more input.

Working with Variables

Our little `ftp` Expect script works okay, but what about letting us specify the remote host and file on the command line as arguments to the Expect script? This is easy using the following technique.

The Expect command `set` is used to define variables and assign values. For example, to assign the value `5` to the variable `VAR`, we use the following syntax:

```
set VAR 5
```

To access the variable, we use the same technique as we do in a normal shell script — add a `$` in front of the variable name (`$VAR`).

To define command-line arguments to Expect script variables, we use the following syntax:

```
set VAR [lindex $argv 0]
```

The `set` command defines the variable `VAR` as a pointer to the first command-line argument (`$argv 0`). For our `ftp` shell script, we want to define the first command-line argument as the remote host, `rem_host`. The second command-line argument is assigned to the remote directory that contains the file, `rem_dir`, and the third command-line argument is assigned to the remote file, `rem_file`, variable. In our case we make these definitions using the following declarations:

```
set rem_host [lindex $argv 0]
set rem_dir [lindex $argv 1]
set rem_file [lindex $argv 2]
```

With these new definitions, let's modify our `ftp-get-file.exp` script to allow us to create a more flexible Expect script. Check out the code in Listing 8-11 and we will study the details at the end.

```
#!/usr/local/bin/expect -f
#
# SCRIPT: ftp-get-file-cmd-line.exp
#

set force_conservative 0  ;# set to 1 to force conservative mode even if
                     ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
            sleep .1
exp_send -s -- $arg
     }
}
```

Listing 8-11 ftp-get-file-cmd-line.exp script

```
set rem_host [lindex $argv 0]
set rem_dir [lindex $argv 1]
set rem_file [lindex $argv 2]

set timeout -1
spawn ftp $rem_host
match_max 100000
expect "Name *: "
send -- "prodmgr\r"
expect "Password:"
send -- "Abc1234\r"
expect "ftp>"
send -- "cd $rem_dir \r"
expect "ftp>"
send -- "get $rem_file \r"
expect "ftp>"
send -- "bye\r"
expect eof
```

Listing 8-11 (*continued*)

The only difference between Listings 8-9 and 8-11 is the use of command-line arguments. Instead of hard-coding the script for a single use, we now have a flexible Expect script that lets us specify the remote host, remote directory, and remote file that we want to transfer.

Notice in Listing 8-11 that we use the `set` command to define three variables as command-line arguments: `rem_host`, `rem_dir`, and `rem_file`. With these definitions we now `spawn` the `ftp` session to `$rem_host`, then we `cd` to the `$rem_dir` directory, and then `get` the `$rem_file` file, with every variable defined as command-line arguments. Listing 8-12 shows the `ftp-get-file-cmd-line.exp` Expect script in action.

```
[root@booboo ~]# ./ftp-get-file-cmd-line.exp yogi
/scripts random_file.out
spawn ftp yogi
Connected to yogi (192.168.1.100).
220 yogi FTP server (Version 4.1 Sat Feb 23 00:11:36 CST 2002) ready.
Name (yogi:root): prodmgr
331 Password required for prodmgr.
Password:
230 User root logged in.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> cd /scripts
250 CWD command successful.
ftp> get random_file.out
```

Listing 8-12 ftp-get-file-cmd-line.exp Expect script in action

```
local: random_file.out remote: random_file.out
227 Entering Passive Mode (192,168,1,100,128,46)
150 Opening data connection for random_file.out (2185 bytes).
226 Transfer complete.
2185 bytes received in 0.00352 secs (5.9e+02 Kbytes/sec)
ftp> bye
221 Goodbye.
[root@booboo ~]#
```

Listing 8-12 (*continued*)

Listings 8-10 and 8-12 are identical, and they should be because we are executing the exact same command, but referenced through variable assignments.

The only bad thing about these scripts is the fact that the usernames and passwords are visible in plain text in the script. Therefore, you need to lock down the file permissions to keep others from getting the password. A better solution is to create an environment file in an obscure location that has username and password information, and source, or execute, the environment file at the beginning of the script, and maybe even encrypt the password file and have the Expect script decrypt the password before use. Just remember to never export the username and password script variables or they will be viewable in the process table in plain text.

What about Conditional Tests?

Many times what we are expecting varies. For example, if we `ssh` to a server and the remote host is not listed in the `$HOME/.ssh/known_hosts` file, we are prompted to add the remote host's public key. In this case, we first need to type **yes** for the login to proceed. Other times we get the `Password:` prompt. So, how does Expect handle this type of conditional test? One method is with braces. Let's take a closer look.

Expect's Version of a case Statement

Let's look at two examples of using `ssh` to log in to a remote server. In the first example, the remote server is not in the user's `known_hosts` file, and we get an extra prompt to permanently add the server to the `ssh` configuration. The second example shows an `ssh` login to a known host. Listing 8-13 shows an `ssh` session to an unknown host.

```
[root@yogi ~]# ssh prodmgr@wilma
The authenticity of host 'wilma (192.168.1.104)' can't be established.
RSA key fingerprint is de:2f:e1:42:96:68:fe:4c:4f:2a:25:97:0a:22:46:e4.
Are you sure you want to continue connecting (yes/no)? yes
Warning:Permanently added 'wilma,192.168.1.104' (RSA)
to the list of known hosts.
```

Listing 8-13 SSH login to an unknown host

```
prodmgr@wilma's password:
Last unsuccessful login: Thu Nov 29 10:53:04 EST 2007 on ssh from yogi
Last login: Mon Dec 24 17:36:50 EST 2007 on /dev/pts/0 from fred
You are logging on to wilma

$
```

Listing 8-13 (*continued*)

Notice in Listing 8-13 that `ssh` does not recognize the host `wilma` as a known host because the public key for `wilma` is not in the local `$HOME/.ssh/known_hosts` file. So, `ssh` prompts us to add the key for `wilma` into the `$HOME/.ssh/known_hosts` file and we respond with `yes`, as shown here:

```
Are you sure you want to continue connecting (yes/no)? yes
```

With a positive reply we are prompted for the `prodmgr` password and we get logged in. In Listing 8-14 notice that we are prompted for only the `prodmgr` password this time.

```
[root@yogi ~]# ssh prodmgr@wilma
prodmgr@wilma's password:
Last unsuccessful login: Thu Nov 29 10:53:04 EST 2007 on ssh from yogi
Last login: Thu Dec 27 13:44:11 EST 2007 on /dev/pts/0 from yogi
You are logging on to wilma

$
```

Listing 8-14 SSH login to a known host

In Listing 8-14 the host `wilma` is known, so `ssh` does not prompt us to add the key; we just get the `Password:` prompt. With Expect, we use the syntax shown in Listing 8-15 to perform a conditional test.

```
expect {
        "*re you sure you want to continue connecting*"
            {
                send "yes\n"
                expect {
                        "*assword*"
                            {
                                send "Abc1234\n"
                            }
                       }
            }
```

Listing 8-15 Example syntax for an Expect conditional test

```
        "*assword*"
            {
                send "Abc1234\n"
            }
        }
```

Listing 8-15 (*continued*)

Listing 8-15 illustrates Expect's version of a `case` statement. The first `expect` has two possible expected responses:

```
"*re you sure you want to continue connecting*"
```

or

```
"*assword*"
```

Notice that we are using wildcards because different versions of SSH and UNIX flavors produce varied responses. Sometimes the `A` and the `P` are capitalized and sometimes not. Sometimes there is extra text that we do not care about, so we use wildcards to match the data we are not sure about because it can vary.

If the reply is `*re you sure you want to continue connecting*`, we respond with `yes`, and then we expect the `Password:` prompt, and we respond with the password. Otherwise, we get only the `"*assword*"` prompt and we respond with the password. This is like a `case` statement in a shell script.

Let's look at the Expect script in Listing 8-16 to see how to do this. The `etc-hosts-copy.exp` Expect script is used to copy the master `/etc/hosts` file, located on the server `yogi`, to a remote machine. Follow through the script and pay attention to the bold text and the comments throughout Listing 8-16.

```
#!/usr/local/bin/expect -f
#
# SCRIPT: etc-hosts-copy.exp

# Set the timeout to 3 seconds
set timeout 3

# Assign the first command line argument to the
# "host" variable
set rem_host [lindex $argv 0]

# Spawn an ssh session to $host as the prodmgr user
spawn /usr/bin/ssh -l prodmgr ${rem_host}

# When we ssh to a remote server we can have two
# possible responses, 1) "*re you sure you want to continue
```

Listing 8-16 etc-hosts-copy.exp Expect script

```
# connecting*", which we must reply to with "yes", and
# 2) Password: prompt. This next expect statement
# will perform the correct action based on the
# response.

expect {
        "*re you sure you want to continue connecting*"
            {
                send "yes\n"
                expect {
                        "*assword*"
                            {
                                send "Abc1234\n"
                            }
                       }
            }
        "*assword*"
            {
                send "Abc1234\n"
            }
       }

# Sleep for 1 second before proceeding

sleep 1

# Set the command-line prompt for the prodmgr user
# to the hash mark, #

send "PS1\=\"\# \"\n "

# Now we know what to expect as a command-line prompt

expect "^#*"

# Copy the master /etc/hosts file from yogi
# to this machine.

# First su to root

send "su - \n"
expect "*assword:*"
send "ABCD1234\n"
sleep 1

# Set the command-line prompt for the root user
# to the hash mark, #
send "PS1\=\"\# \"\n "
```

Listing 8-16 (*continued*)

```
# Now we know what the command-line prompt is for
# the root user
expect "^#*"

# Save the current version of the /etc/hosts file
send "cp /etc/hosts /etc/hosts$$\n"
expect {
        "*re you sure you want to continue connecting*"
            {
                send "yes\n"
                expect {
                        "*assword*"
                            {
                                send "Abc1234\n"
                            }
                       }
            }
        "*assword*"
            {
                send "Abc1234\n"
            }
        "^#*"             {
                send "\n"
            }
       }

# Copy the master /etc/hosts file from yogi to
# this server.
send "rcp yogi:/etc/hosts /etc/hosts \n"
expect "^#*"

# Logout from $host
send  "exit\n"
expect eof
```

Listing 8-16 (*continued*)

We start out Listing 8-16 by setting the timeout to three seconds. We do not want to wait too long if a host is not reachable. Then we assign the first command-line argument, `$argv 0`, to the variable `rem_host`. Next we `spawn` the `ssh` session to the remote `$rem_host` as the `prodmgr` user. At this point we are expecting two possible replies:

```
"*re you sure you want to continue connecting*"
```

or

```
"*assword*"
```

Depending on the reply, we either respond with `yes` and wait for the `Password:` prompt, or we have the `Password:` prompt and we respond with the `prodmgr`'s password. At this point, by either path, we should be logged in to the remote host.

At this point we have no clue what the command-line prompt is. It could be anything, so let's set the prompt to the hash mark, `#`, as shown here:

```
send "PS1\=\"\# \"\n "
```

Now we know what to expect as a command-line prompt, so we can just expect a line that begins with the hash mark, `^#`, as shown here:

```
expect "^#*"
```

To copy the `/etc/hosts` file, we need root authority, and in my shop you cannot log in remotely to any server as `root`. You have to be on the system console to log in directly as `root`, so we have to `su` to `root`, as follows:

```
send "su - \n"
expect "*assword:*"
send "ABCD1234\n"
sleep 1
```

As you can see, the password is in plain text, so be sure to lock down the file permissions on this Expect script to keep from revealing the passwords.

After we `su` to `root`, we need to set the prompt to something we know, so let's set the command-line prompt to the hash mark, as we did for the `prodmgr` user.

Now that we have `root` authority on the remote machine, we can make a backup copy of the current `/etc/hosts` file with the current process ID, specified by the shell's `$$` variable, as a suffix, and then remote-copy the master `/etc/hosts` file located on the server `yogi` to the remote server:

```
# Save the current version of the /etc/hosts file
send "cp /etc/hosts /etc/hosts$$\n"

# Copy the master /etc/hosts file from yogi to
# this server.
send "rcp yogi:/etc/hosts /etc/hosts \n"
expect {
        "*re you sure you want to continue connecting*"
            {
                send "yes\n"
                expect {
                        "*assword*"
                            {
                                send "Abc1234\n"
                            }
                    }
            }
```

```
        "*assword*"
            {
                send "Abc1234\n"
            }
        "^#*"               {
                send "\n"
            }
    }
```

Notice that even though we are using remote copy (`rcp`) to copy the master `/etc/hosts` file, some UNIX flavors will execute secure copy (`scp`) instead. We added another Expect `case` statement to test for a secure shell login. Otherwise, we get the PS1 prompt we specified. With the tasks complete, we `exit`. Listing 8-17 shows the `etc-hosts-copy.exp` script in action.

```
[root@yogi scripts]# ./etc-hosts-copy.exp booboo
spawn /usr/bin/ssh -l prodmgr booboo
prodmgr@booboo's password:
You are logging on to booboo


Stats: Linux booboo 2.4.22-1.2199.nptl #1 Wed Aug 4
12:21:48 EDT 2004 i686 i686 i386 GNU/Linux


PS1="# "
 [prodmgr@booboo ~]$ PS1="# "
#  su -
Password:
[root@booboo ~]# PS1="# "
#  cp /etc/hosts /etc/hosts$$
# rcp li01s:/etc/hosts /etc/hosts
exit
[root@yogi scripts]#
```

Listing 8-17 etc-hosts-copy.exp Expect script in action

Notice that the system suppresses echoing the password on the terminal. A good way to use this Expect script is to create a short shell script with a `while read` loop that reads a list of hostnames. As we read each hostname, we execute the `etc-hosts-copy.exp` Expect script to copy the master `/etc/hosts` file to each remote machine in the list, as shown here:

```
while read SERVER
do
       ./etc-hosts-copy.exp $SERVER

done < ./host-update.lst
```

This `while` loop reads the `host-update.lst` file line-by-line and on each loop iteration executes the `etc-hosts-copy.exp` Expect script using the current `$SERVER` as the remote host.

Expect's Version of an if...then...else Loop

Expect also provides `if...then...else` and other basic control structures. Just like Expect's version of a `case` statement, the `if...then...else` structure uses curly braces, as shown here in an Expect code segment:

```
set TOTAL 5
if ( $TOTAL < 10 ) {
    puts ''TOTAL is less than 10''
} else {
    puts "TOTAL greater than or equal to 10"
}
```

We assign the variable `TOTAL` the value `5`. If the `$TOTAL` variable's value is less than `10` we use the `puts` command, like we use `echo` in a shell script, to output user data to the terminal. In our case, this code segment will return the following:

```
TOTAL is less than 10
```

Let's expand this `if...then...else` statement to add in an `elseif` to extend our test of the `$TOTAL` value, as shown in Listing 8-18.

```
#!/usr/local/bin/expect -f

set TOTAL 1
if { $TOTAL < 10 } {
     puts "\nTOTAL is less than 10\n"
} elseif { $TOTAL > 10 } {
     puts "\nTOTAL greater than 10\n"
} else {
     puts "\nTOTAL is equal to 10\n"
}
```

Listing 8-18 if-then-else-test.exp Expect script

Other than the use of the curly braces, this `if...then...else` works the same way it does in a shell script.

NOTE **The opening brace *must* appear on the same line as the `if`, `elseif`, and `else` statements.**

Notice that we added new lines before and after the text we output with the `puts` command. This is the same technique we use with the `echo` command.

Expect's Version of a while Loop

Expect uses similar syntax for a `while` loop as our shell scripts use. But again, we are using braces to contain the expression. Carrying over the previous example of testing the value of the variable `TOTAL`, this time using a `COUNT` variable, we will add an incremental counter as we have the `COUNT` variable count from 0 to 10, as shown in Listing 8-19.

```
#!/usr/local/bin/expect -f

set COUNT 0
while { $COUNT <= 10 } {
    puts "\nCOUNT is currently at $COUNT"
    set COUNT [ expr $COUNT + 1 ]
}
puts ""
```

Listing 8-19 while_test.exp Expect script

In Listing 8-19 we initialize the variable `COUNT` to `0`. Then we start a `while` loop that continues while `$COUNT` is less than or equal to `10`. On each loop iteration we use the `puts` command to display the current value of `$COUNT` and increment the `COUNT` by adding `1`, until `$COUNT` is greater than `10`. The output of this `while` loop is shown in Listing 8-20.

```
[root@yogi scripts]# ./while_test.exp

COUNT is currently at 0

COUNT is currently at 1

COUNT is currently at 2

COUNT is currently at 3

COUNT is currently at 4

COUNT is currently at 5

COUNT is currently at 6

COUNT is currently at 7
```

Listing 8-20 while_test.exp Expect script in action

```
COUNT is currently at 8

COUNT is currently at 9

COUNT is currently at 10

[root@yogi scripts]#
```

Listing 8-20 (*continued*)

Notice in Listing 8-20 there is a new line after the line `COUNT is currently at 10`, and before the ending command prompt, `[root@yogi scripts]#`. This last new line is the result of the last `puts ""` at the end of the `while_test.exp` Expect script in Listing 8-19, which adds the final new line before exiting when the count reaches 10.

Expect's Version of a for Loop

The `for` loop in Expect works a little differently from a `for` loop in a shell script. An Expect `for` loop requires three fields to be specified with the following syntax:

```
for initial_value  conditional_exression incremental_step {

      Do something here
}
```

As an example, let's use an Expect `for` loop to count from 0 to 10, as shown in Listing 8-21.

```
#!/usr/local/bin/expect -f

for {set COUNT 0} {$COUNT <= 10} {incr COUNT} {

    puts "\nCOUNT is currently at $COUNT"
}
puts ""
```

Listing 8-21 for_text.exp Expect script

This `for` loop begins by assigning the variable `COUNT` an initial value of `0`. The second part of the `for` statement is the conditional expression that determines when to exit the loop. The last part of the `for` loop statement defines how we increment or decrement the `COUNT` variable on each loop iteration. Notice that we introduced a new Expect operator, `incr`. The `incr` operator will increment the variable given as an

argument. By default `incr` will increment by 1, but we can override this behavior by adding a second argument to `incr` specifying the increment to add or subtract. For example, if we want to count down from 10 to 0, we would use the following syntax:

```
for {set COUNT 10} {$COUNT <= 0} {incr COUNT -1} {
```

Notice that the second argument to `incr` is `-1`, telling the `incr` operator to subtract 1 instead of adding 1. We can also count by 2 or 10 or any other integer values.

The output that the `for` loop in Listing 8-21 produced is shown in Listing 8-22.

```
[root@yogi bin]# ./for_test.exp

COUNT is currently at 0

COUNT is currently at 1

COUNT is currently at 2

COUNT is currently at 3

COUNT is currently at 4

COUNT is currently at 5

COUNT is currently at 6

COUNT is currently at 7

COUNT is currently at 8

COUNT is currently at 9

COUNT is currently at 10

[root@yogi bin]#
```

Listing 8-22 for_test.exp Expect script in action

This is the same output that our `while` loop produced. Instead of using the **incr** Expect operator, we can also use a mathematical expression in the `for` loop. Expressions are enclosed in square brackets, [*expression*], to tell Expect to evaluate the expression first. Adding `1` to the `COUNT` variable using an expression is shown here:

```
[ expr $COUNT + 1 ]
```

If we use this expression along with the `set` command, we can increment the `COUNT` variable on each loop iteration, as shown in Listing 8-23.

```
#!/usr/local/bin/expect -f

for {set COUNT 0} {$COUNT <= 10} {set COUNT [expr $COUNT + 1 ]} {

    puts "\nCOUNT is currently at $COUNT"
}
puts ""
```

Listing 8-23 for_test2.exp example for loop using an expression to increment

On each loop iteration we use the `set` command to assign the `COUNT` variable a newly calculated value. The square brackets ensure that the mathematical expression is evaluated before the new value is assigned to the `COUNT` variable.

Expect's Version of a Function

Expect supports functions using the **proc** Expect operator instead of the word **function**. We can define arguments to a `proc` but it is not a requirement, just as in a shell script. Let's modify our counting Expect script to use a function, or `proc`, to increment the `COUNT` variable. The modified version is called `function_test.exp` and is shown in Listing 8-24.

```
#!/usr/local/bin/expect -f
#
# SCRIPT: function_test.exp
#
#######################################
# DEFINE VARIABLES HERE
#######################################

set COUNT 0

#######################################
# DEFINE FUNCTIONS HERE
#######################################

proc increment_by_1 { MY_COUNT } {
     set MY_COUNT [expr $MY_COUNT + 1]
     return "$MY_COUNT"
}

#######################################
# BEGINNING OF MAIN
#######################################
```

Listing 8-24 function_test.exp example using a function in Expect

```
while {$COUNT <= 10} {
    puts "\nCOUNT is currently at $COUNT"
    set COUNT [increment_by_1 $COUNT]
}
puts ""
```

Listing 8-24 (*continued*)

Listing 8-24 starts by initializing the variable `COUNT` to `0`. In the next section we define our function, or `proc`, in pretty much the same way we do in a shell script. Of course, you still need to define the function in the code before the point where it is first used. Our `proc` is named `increment_by_1` and this `proc` is expecting one argument, and we assign the value of the argument to the variable `MY_COUNT`.

In the body of the `proc` we use the `set` command with an `expr` expression to increment `$COUNT` by `1`. To send the value back to the script, we use the `return` command specifying the new `$MY_COUNT` value.

In the main body of the Expect script we use a `while` loop to loop until `$COUNT` is greater than `10`. On each loop iteration we use the `puts` command to display text on the screen, and then use the `set` command to call the `increment_by_1 proc`, giving `$COUNT` as the argument to the `proc`, and the `proc` returns `$COUNT` incremented by `1`.

This is a very simple example of using a `proc` in an Expect script, but it shows the proper syntax and techniques to use functions, or a `proc`, in Expect.

Using Expect Scripts with Sun Blade Chassis and JumpStart

I was playing around with Expect one day while working on some Sun Blade servers. I needed to do a few things with the blades but I had to go through the Blade Chassis to get console access. The first thing I want is to show the Blade Chassis configuration using the `showplatform -v` Blade Chassis command. But to do this I had to first log in to the Sun Blade Chassis. I used `autoexpect` to initially create the `showplatform.exp` Expect script, and then removed the unneeded text. Follow through Listing 8-25 and we will cover the details at the end.

```
#!/usr/local/bin/expect -f
#
# This Expect script was generated by autoexpect on Mon
Apr 2 09:44:34 2007
# Expect and autoexpect were both written by Don Libes, NIST.
#
# Note that autoexpect does not guarantee a working script.  It
# necessarily has to guess about certain things.  Two reasons a script
# might fail are:
```

Listing 8-25 showplatform.exp Expect script

```
#
# 1) timing - A surprising number of programs (rn, ksh, zsh, telnet,
# etc.) and devices discard or ignore keystrokes that arrive "too
# quickly" after prompts.  If you find your new script hanging up at
# one spot, try adding a short sleep just before the previous send.
# Setting "force_conservative" to 1 (see below) makes Expect do this
# automatically - pausing briefly before sending each character.  This
# pacifies every program I know of.  The -c flag makes the script do
# this in the first place.  The -C flag allows you to define a
# character to toggle this mode off and on.

set force_conservative 0  ;# set to 1 to force conservative mode even if
                     ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
            sleep .1
            exp_send -s -- $arg
     }
}

#
# 2) differing output - Some programs produce different output each time
# they run.  The "date" command is an obvious example.  Another is
# ftp, if it produces throughput statistics at the end of a file
# transfer.  If this causes a problem, delete these patterns or replace
# them with wildcards.  An alternative is to use the -p flag (for
# "prompt"), which makes Expect only look for the last line of output
# (i.e., the prompt).  The -P flag allows you to define a character to
# toggle this mode off and on.
#
# Read the man page for more info.
#
# -Don

set chassis [lindex $argv 0]
set timeout -1
spawn $env(SHELL)
send -- "telnet ${chassis}\r"
expect -exact "telnet ${host}\r"
expect  -exact "username: "
send -- "prodmgr\r"
expect -exact "prodmgr\r
password: "
send -- "Abc1234\r"
expect -exact "\r
${host}>"
send -- "showplatform -v\r"
```

Listing 8-25 (*continued*)

```
expect -exact "showplatform -v\r"
send -- "logout\r"
expect -exact "logout\r"
exit
expect eof
```

Listing 8-25 (*continued*)

In the `showplatform.exp` Expect script in Listing 8-25, we first assign the first command-line argument to the variable `chassis`. Next we disable timeouts by setting `timeout` to `-1`. Now we `spawn` a default shell and `telnet` to `$chassis`, which is the hostname of the Blade Chassis.

Next we `expect` the username and password prompts, and `send` the correct response to get logged in to the Chassis. Now we can execute the `showplatform -v` command and log out of the Blade Chassis. A sample output from `showplatform.exp` is shown in Listing 8-26.

```
wilma:> ./showplatform.exp sunchas1
spawn /sbin/sh
wilma:> telnet sunchas1
Trying 192.168.1.142...
Connected to sunchas1.
Escape character is '^]'.

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ALOM-B 1.2

username: prodmgr
password:
sunchas1>showplatform -v
FRU       Status         Type          Part No.  Serial No.
--------  -------------  ------------  --------  ----------
S0        Not Present    ***           ***       ***
S1        Not Present    ***           ***       ***
S2        Faulty         SF B100s      5405078   009897
S3        OK             SF B100s      5405079   013116
S4        Faulty         SF B100s      5405078   009973
S5        Faulty         SF B100s      5405078   010562
S6        Faulty         SF B100s      5405078   010111
S7        Faulty         SF B100s      5405079   010678
S8        Standby        SF B100s      5405079   029965
S9        OK             SF B100s      5405079   029854
S10       OK             SF B100s      5405079   029698
S11       Not Present    ***           ***       ***
S12       Not Present    ***           ***       ***
S13       Not Present    ***           ***       ***
```

Listing 8-26 showplatform.exp Expect script in action

```
S14       Not Present    ***           ***       ***
S15       Not Present    ***           ***       ***
SSC0      OK             SF B1600 SSC  5405185   0004703-0308000162
SSC0/SWT
SSC0/SC
SSC1      OK             SF B1600 SSC  5405185   0004703-0407005951
SSC1/SWT
SSC1/SC
PS0       OK             SF B1600 PSU  3001544   0017527-0324P02770
PS1       OK             SF B1600 PSU  3001544   0017527-0324P02700
CH        OK             SF B1600      5405082   001635

Domain    Status                MAC Address        Hostname
--------  --------------------  -----------------  --------------
S2        OS Running            00:03:bb:84:4c:d0  sunbldt2
S3        OS Running            00:03:bb:8c:ea:bc  sunbldt3
S4        OS Running            00:03:bb:59:fe:e8  sunbldt4
S5        OS Running            00:03:bb:84:33:62  sunbldt1
S6        OS Running            00:03:bb:84:37:c2  sunbldp2
S7        OS Running            00:03:bb:84:2e:80  sunbldp4
S8        Standby               00:03:bb:44:4f:5c  sunbldq1
S9        OS Running            00:03:bb:34:42:1e  sunbldq2
S10       OS Running            00:03:bb:34:40:88  sunbldd1
SSC0/SWT  OS Running            00:03:bb:3b:8b:e3
SSC1/SWT  OS Running            00:03:bb:39:7d:ac
SSC0/SC   OS Running (Active)   00:03:bb:8b:88:fc
SSC1/SC   OS Running            00:03:bb:19:7b:c5
sunchas1>logout
Connection to sunchas1 closed by foreign host.
wilma:>
```

Listing 8-26 (*continued*)

In Listing 8-26 we log in to the remote Sun Blade Chassis `sunchas1` with the username `prodmgr`. After logging in, we execute the `showplatform -v` chassis command and log out of `sunchas1`.

How else can we use this Expect script? Many times we need to know which slot a particular blade server is located in. If we are logged in to the Sun Blade Chassis and we want console access to a specific blade, we use the slot number, not the hostname, to gain console access. Check out the `findslot` Bash script in Listing 8-27 to see how we use the `showplatform.exp` Expect script.

```
#!/usr/bin/Bash
#
# SCRIPT: findslot
# PURPOSE: This script is used to locate a blade server
# within the specified SUN blade chassis.
```

Listing 8-27 findslot Bash Script

```
#

CHAS=$1
HOST=$2

SLOT=`/usr/local/bin/showplatform.exp $CHAS \
      | /usr/bin/grep $HOST | cut -f 1 -d " "`
echo $SLOT
```

Listing 8-27 (*continued*)

The `findslot` Bash script in Listing 8-27 expects two command-line arguments: the chassis hostname, `CHAS`, and the hostname of the blade for which we want the slot number, `HOST`. Using this information we execute the `showplatform.exp` Expect script and `grep` for the blade's hostname, and extract the first field. Then we `echo` the `$SLOT` slot number.

Now that we can easily find the slot a blade is located in, we can write an Expect script that will rebuild a failed blade using JumpStart. It is beyond the scope of this book to cover the details of JumpStart, but at a high level JumpStart is a Sun Microsystems product that enables us to do network OS installations. We are making the assumption that JumpStart is already configured to boot a particular blade and install a new OS image.

The key here is that the blade must be on the blade's console at the `ok` prompt, and then we execute the following command:

```
boot net - install
```

Now we are adding a second layer of logins to this Expect script because we need to be on the blade's console. First we log in to the Blade Chassis, and then, using a known slot number, gain console access to the specific blade server with the chassis command `console S#`, where `S#` is the specific slot where the blade resides — for example `console S1`. At this point we are expecting `ok`, and then we execute `boot net - install` to kick off the JumpStart installation. Take a close look at `boot-net-install.exp` in Listing 8-28.

```
#!/usr/local/bin/expect -f

set force_conservative 0  ;# set to 1 to force conservative mode even if
                          ;# script wasn't run conservatively originally
if {$force_conservative} {
        set send_slow {1 .1}
        proc send {ignore arg} {
                sleep .1
                exp_send -s -- $arg
        }
}
```

Listing 8-28 boot-net-install.exp Expect script

```
set chassis [lindex $argv 0]
set blade [lindex $argv 1]
set timeout -1
spawn -noecho telnet $chassis
log_user 0
match_max 100000
expect "username: "
send -- "prodmgr\r"
expect -exact "prodmgr\r
password: "
send -- "Abc1234\r"
expect ">"
send -- "console -f $blade\r"
send -- "\r"
expect "ok"
send -- "boot net - install\r"
log_user 1
expect ""
send -- "logout\r"
send_user "\r\n"
exit
expect eof
```

Listing 8-28 (*continued*)

In Listing 8-28 we start by assigning the first command-line argument to the variable `chassis`, and the second command-line argument to the variable `blade`, which is a *blade slot*, *not the blade hostname*. Next we disable timeouts by setting `timeout` to `-1`. Then we `spawn` a `telnet` session to the blade chassis, `$chassis`, with the `-noecho` option. This `spawn` switch option suppresses `telnet` output. Then we provide the username and password to log in to the blade chassis. Now that we are on the chassis, we can get `console` access to the specific blade server by knowing the slot it resides in. When we gain console access we are expecting the `ok` prompt. At the `ok` prompt we execute `boot net - install` and the blade starts a network boot for the JumpStart installation.

There is a lot to JumpStart, but I will leave the details up to you to research on your own.

Summary

There is no way I could cover everything about Expect in a single chapter in this book. I included this chapter as a primer of what Expect can do and how to use variables, perform conditional tests, and how to use functions.

To see a great Expect script, download the `passmass` Expect script from the official Expect web site at `http://expect.nist.gov/`. The `passmass` Expect script is used to change passwords on a large number of UNIX servers of varying UNIX flavors.

If you study this `passmass` Expect script, you will pick up some good techniques for Expect.

I tried to provide as many examples as I could to get you familiar with using Expect and `autoexpect`. `autoexpect` is a nice tool to help you build the quick and dirty Expect script, then you can go back and remove the extra text in the replies.

In the next chapter we are going to study some techniques to find large files, and files of a specific type and size. When filesystems fill up, it is sometimes difficult to find the source of the problem. The next chapter will help to resolve the issue.

Lab Assignments

1. Write an Expect script that changes your password on the local UNIX machine. Remember: the new password must be entered twice.
2. Write an Expect script that changes your password on a remote UNIX machine.
3. Write a Bash script that utilizes the Expect script you created in Lab Assignment 2 to change your password on a list of remote UNIX machines. The list of remote machines should reside in a flat text file in the current directory where the script executes.

CHAPTER 9

Finding Large Files and Files of a Specific Type

Filesystem alert! We all hate to get full-filesystem alerts, especially at quitting time on Friday when the developers are trying to meet a deadline. The usual culprit is one or more *large* files that were just created, compiled, or loaded. Determining the definition of a large file varies by system environment, but a ''large'' file can fill up a filesystem quickly, especially in a large database or development environment. To find the files that quickly fill up a filesystem and/or other large files, we need a flexible tool that will search for files larger than a user-defined value. The **find** command is your friend when a filesystem search is needed.

The `find` command is one of the most flexible and powerful commands on the system. Before we get started, I want you to have a copy of the `find` command manual page. You have two options to save a copy of the man page for the `find` command. The first option uses paper (you know, in a printer), and the second option saves a bunch of trees. To send the manual page for the `find` command to a specific print queue (in other words, burn up some trees), enter the following command:

```
man find | lp -d print_queue_name
```

If you are interested in saving the planet, you can archive the `find` command manual page by executing the following command:

```
man find | col -b >> find.txt
```

The previous command will print the manual page output to the printer defined by `print_queue_name`, or save the manual page for future viewing in a file named `find.txt`. If you take the time to study the `find` command manual page in detail, you can see that the `find` command is the most flexible command on the system. You can find files by modification/creation time, last access time, exact size, greater-than

size, owner, group, permission, and a boatload of other options. You can also execute a command to act on the file(s) using the `-exec` command switch. For this chapter we are going to concentrate on two topics. The first is finding files larger than an integer value specified on the command line. The second is finding files recently created and/or modified. I will also give some examples of techniques to quickly narrow down the search to find the offending file. As with all of our shell scripts, we first need to get the correct command syntax for our task.

Syntax

We are going to use the `-size` option for the `find` command to search the system for ''large'' files. There are two things to consider when using the `-size` command switch to search the system. We must supply an argument for this switch, and the argument must be an integer. But the integer number alone as an argument to the `-size` switch specifies an *exact* value, and the value is expressed, by default, in 512-byte blocks instead of measuring the file size in bytes, kilobytes, megabytes, or gigabytes. For a more familiar measurement we would like to specify our search value in megabytes (MB) for this example. To specify the value in bytes instead of 512-byte blocks, we add the character `c` as a suffix to the integer value, and to get to MB we can just add six zeros. We also want to look for file sizes *greater than* the command-line integer value. To specify greater than, we add a + (plus sign) as a prefix to the integer value. With these specifications the command will look like the following:

```
find $SEARCH_PATH -size +integer_valuec  -print
```

To search for files greater than 5 MB we can use the following command:

```
find $SEARCH_PATH -size +5000000c -print
```

The + (plus sign) specifies greater than, and the **c** denotes bytes. Also notice in the previous command that we specified a path to search using the variable `SEARCH_PATH`. The `find` command requires a search path to be defined in the first argument to the command. We also added the `-print` switch at the end of the command line. If you omit the `-print`, you cannot guarantee that any output will be produced if you use the `-exec` option. The command will return the appropriate return code but may not give any output, even if the files were found! I have found this to be a combination of UNIX flavor, release, and executing shell. Just always remember to add the `-print` switch to the `find` command if you need to see what file is being acted upon, and you will not be surprised.

For ease of using this shell script we are going to assume that the search will always begin in the current directory. The **pwd** command, or *print working directory* command, will display the full pathname of the current directory. Using our script this way requires that the shell script is located in a directory that is in the user's `$PATH`, or you must use the full script pathname any time you use the shell script. I typically put all of my scripts in the `/usr/local/bin` directory and add this directory to my `$PATH`

environment. You can add a directory to your path using the following command syntax:

```
PATH=$PATH:/usr/local/bin
export PATH
```

Remember That File and Directory Permissions Thing

If you are not executing the `find` command as `root`, either by logging in as `root`, using `su - root` to gain root access, executing a command as root using `su - root "-c some_command"`, or using `sudo command` to execute a single command as root, file permission errors may scroll across your screen. If the filesystem that filled up is an application or development filesystem, you may have permissions if you have the ability to log in as the *application owner*, or an account used by the application or development, database, and other teams.

Don't Be Shocked by the Size of the Files

If you do a search on a system that has a database, be aware that database files are *huge*! When I first wrote this book in 2000–2001, a *large* disk drive was 32 GB. Now 1TB disk drives are available! Multi-terabyte transactional databases are the norm. Then there are the processing times of 12–24+ hours to massage the data into a usable format to make money.

Just remember to limit your search. Starting a search from the root directory, `/`, implies a full system search. That means all filesystems are searched, and that can take quite a while, depending on the attached storage.

Creating the Script

We have the basic idea of the `find` command syntax, so let's write a script. The only argument that we want from the user is a positive integer representing the number of megabytes (MB) to trigger the search on. We will add the extra six zeros inside the shell script. As always, we need to confirm that the data supplied on the command line is valid and usable. For our search script we are expecting exactly one argument; therefore, the shell variable `$#` must equal one. We are also expecting the argument to be an integer, so the regular expression `+([0-9])` should be true.

NOTE **Bash shell does not support the regular expression `+([0-9])`.**

We will use this regular expression in a `case` statement to confirm that we have an integer. The integer specified must also be a positive value, so the value given must be

greater than zero. If all three tests are true, we have a valid value to trigger our search. All these requirements are not difficult, so please hang with me.

I can envision this script producing a daily report at some shops. To facilitate the reporting we need some information from the system. I would like to know the hostname of the machine that the report represents. The **hostname** command will provide this information. A date and timestamp would be nice to have also. The **date** command has plenty of options for the timestamp, and because this is going to be a report, we should store the data in a file for printing and future review. We can just define a file, pointed to by `$OUTPUT`, to store our report on disk.

Everyone needs to understand that this script always starts the search from the *current working directory*, defined by the system environment variable `$PWD` and by executing the `pwd` command. We are going to use the `pwd` command and assign the output to the `SEARCH_PATH` script variable. The only other thing we want to do before starting the search is to create a report header for the `$OUTFILE` file. For the header information we can append all of the pertinent system data we have already gathered from the system to the `$OUTFILE`.

We are now ready to perform the search starting from the current directory. Starting a search from the current directory implies, again, that this script's filename must be in the `$PATH` for the user who is executing the script, or the full pathname to the script must be used instead.

Study the `findlarge.ksh` shell script in Listing 9-1, and pay attention to the bold type.

```
#!/usr/bin/ksh
#
# SCRIPT:findlarge.ksh
#
# AUTHOR: Randy Michael
#
# DATE: 11/30/2007
#
# REV: 1.0.A
#
# PURPOSE: This script is used to search for files which
# are larger than $1 Meg. Bytes.  The search starts at
# the current directory that the user is in, 'pwd', and
# includes files in and below the user's current directory.
# The output is both displayed to the user and stored
# in a file for later review.
#
# REVISION LIST:
#
#
#
# set -x   # Uncomment to debug this script
```

Listing 9-1 findlarge.ksh shell script

```
###########################################

function usage
{
echo "\n*************************************"
echo "\n\nUSAGE:    findlarge.ksh  [Number_Of_Meg_Bytes]"
echo "\nEXAMPLE:  filelarge.ksh  5"
echo "\n\nWill Find Files Larger Than 5 Mb in, and Below, the \
   Current Directory..."
echo "\n\nEXITING...\n"
echo "\n*************************************"
exit
}

###########################################

function cleanup
{
echo "\n*****************************************************"
echo "\n\nEXITING ON A TRAPPED SIGNAL..."
echo "\n\n*******************************************************\n"
exit
}

###########################################

# Set a trap to exit.  REMEMBER - CANNOT TRAP ON kill -9 !!!!

trap 'cleanup' 1 2 3 15

###########################################

# Check for the correct number of arguments and a number
# Greater than zero

if [ $# -ne 1 ]
then
        usage
fi

if [ $1 -lt 1 ]
then
        usage
fi

###########################################

# Define and initialize files and variables here...
```

Listing 9-1 (*continued*)

```
THISHOST=`hostname`  # Hostname of this machine

DATESTAMP=`date +"%h%d:%Y:%T"`

SEARCH_PATH=`pwd`   # Top level directory to search

MEG_BYTES=$1        # Number of Mb for file size trigger

DATAFILE="/tmp/filesize_datafile.out" # Data storage file
>$DATAFILE          # Initialize to a null file

OUTFILE="/tmp/largefiles.out" # Output user file
>$OUTFILE           # Initialize to a null file

HOLDFILE="/tmp/temp_hold_file.out" # Temporary storage file
>$HOLDFILE          # Initialize to a null file

##########################################

# Prepare the output user file

echo "\n\nSearching for Files Larger Than ${MEG_BYTES}Mb starting in:"
echo "\n==> $SEARCH_PATH"
echo "\n\nPlease Standby for the Search Results..."
echo "\n\nLarge Files Search Results:" >> $OUTFILE
echo "\nHostname of Machine: $THISHOST" >> $OUTFILE
echo "\nTop Level Directory of Search:" >> $OUTFILE
echo "\n==> $SEARCH_PATH" >> $OUTFILE
echo "\nDate/Time of Search: 'date'" >> $OUTFILE
echo "\n\nSearch Results Sorted by Time:" >> $OUTFILE

##########################################

# Search for files > $MEG_BYTES starting at the $SEARCH_PATH

find $SEARCH_PATH -type f -size +${MEG_BYTES}000000c \
      -print > $HOLDFILE

# How many files were found?

if [ -s $HOLDFILE ]
then
    NUMBER_OF_FILES=`cat $HOLDFILE | wc -l`

    echo "\n\nNumber of Files Found: ==> \
   $NUMBER_OF_FILES\n\n" >> $OUTFILE

    # Append to the end of the Output File...
```

Listing 9-1 (*continued*)

```
    ls -lt `cat $HOLDFILE` >> $OUTFILE

    # Display the Time Sorted Output File...

    more $OUTFILE

    echo "\n\nThese Search Results are Stored in ==> $OUTFILE"
    echo "\n\nSearch Complete...EXITING...\n\n\n"
else
    cat $OUTFILE
    echo "\n\nNo Files were Found in the Search Path that"
    echo "are Larger than ${MEG_BYTES}Mb\n\n"
    echo "\nEXITING...\n\n"
fi
```

Listing 9-1 (*continued*)

Let's review the `findlarge.ksh` shell script in Listing 9-1 in a little more detail. We added two functions to our script. We always need a `usage` function, and in case Ctrl+C is pressed, we added a `trap_exit` function. The `trap_exit` function is executed by the `trap` for exit signals `1`, `2`, `3`, and `15` and will display `EXITING ON A TRAPPED SIGNAL` before exiting with a return code of `2`. The `usage` function is executed if any of our three previously discussed data tests fail and the script exits with a return code of 1, one, indicating a script usage error.

In the next block of code we query the system for the hostname, date/timestamp, and the search path (the current directory!) for the `find` command. All of this system data is used in the file header for the `$OUTFILE`. For the search path we could have just used a dot to specify the current directory, but this short notation would result in a *relative pathname* in our report. The *full pathname*, which begins with a forward slash (`/`), provides much clearer information and results in an easier-to-read file report. To get the full pathnames for our report, we use the `pwd` command output assigned to the `SEARCH_PATH` variable.

We define two files for processing the data. The `$HOLDFILE` holds the search results of the `find` command's output. The `$OUTFILE` contains the header data, and the search results of the `find` command are appended to the end of the `$OUTFILE` file. If the `$HOLDFILE` is zero-sized, then the `find` command did not find any files larger than `$MEG_BYTES`, which is the value specified by the `$1` shell positional parameter on the command line. If the `$HOLDFILE` is not empty, we count the lines in the file with the command statement `NUMBER_OF_LINES=`wc –l $HOLDFILE``. Notice that we used back tics for command substitution, `` `command` ``. This file count is displayed along with the report header information in our output file. The search data from the `find` command, stored in `$HOLDFILE`, consists of full pathnames of each file that has exceeded our limit. In the process of appending the `$HOLDFILE` data to our `$OUTFILE`, we do a long listing sorted by the modification time of each file. This long listing is produced using the `ls -lt $HOLDFILE` command. A long listing is needed in the report so that we can see not only the modification date/time, but also the file owner and group as well as the size of each file.

All the data in the `$OUTFILE` is displayed by using the **more** command so that we display the data one page at a time. The `findlarge.ksh` shell script is in action in Listing 9-2.

```
Searching for Files Larger Than 1Mb starting in:

==> /scripts

Please Standby for the Search Results...

Large Files Search Results:

Hostname of Machine: yogi

Top Level Directory of Search:

==> /scripts

Date/Time of Search: Thu Nov  8 10:46:21 EST 2001

Search Results Sorted by File Modification Time:

Number of Files Found: ==>     4

-rwxrwxrwx   1 root  sys    3490332 Oct 25 10:03 /scripts/
   sling_shot621.tar
-rwxrwxrwx   1 root  sys    1280000 Aug 27 15:33 /scripts/
   sudo/sudo-1.6.tar
-rw-r--r--   1 root  sys    46745600 Jul 27 09:48 /scripts/scripts.tar
-rw-r--r--   1 root  system 10065920 Apr 20 2001 /scripts/
   exe/exe_files.tar


These Search Results are Stored in ==> /tmp/largefiles.out


Search Complete...EXITING...
```

Listing 9-2 findlarge.ksh shell script in action

The output in Listing 9-2 is a listing of the entire screen output, which is also the contents of the `$OUTFILE`. The user is informed of the trigger threshold for the search, the top-level directory for the search, the hostname of the machine, the date and time of the search, and the number of files found to exceed the threshold. The long listing of each file is displayed; the long listing has the file owner and group, the size of the file in bytes, the modification time, and the full path to the file. The long listing is very helpful in large shops with thousands of users!

Narrowing Down the Search

If we just got a filesystem alert, that tells us that at least one file in that particular filesystem was recently created and/or modified. So, a good starting point is to look for newly modified/created files. You can add the following command as a cross-reference to find the true cause of the filesystem filling up. This command will search the `$SEARCH_PATH` for all files modified, or created, less than 10 minutes ago:

```
find $SEARCH_PATH -mmin 10 -type f
```

This command will find all files that have been modified or created in the last 10 minutes. You can redirect this output to a file and do a cross-reference to discover the files and users that actually caused the filesystem to fill up.

We can also look at the files most recently accessed by using the `-amin` switch to the `find` command. This search will be more extensive.

```
find $SEARCH_PATH -amin 10 --type f
```

There are many more options to the `find` command for you to try out. Some other `find` command switches are shown in Table 9-1.

This is only a very small sample of `find` command options.

Table 9-1 More `find` Command Search Options

SWITCH	FIND OPTION
`-xdev`	Do not descend directories on other filesystems
`-amin n`	List files accessed within n minutes
`-mmin n`	List files modified or created with n minutes
`-atime n`	List files accesses within n 24 hour periods
`-mtime n`	List files modified or created within n 24 hour periods

Other Options to Consider

The `findlarge.ksh` shell script is simple and does all of the basics for the system reporting, but it can be improved and customized for your particular needs. I think you will be interested in the following ideas and tasks:

1. When we specify our search value we are just adding six zeros to the user-supplied integer value. But we are back to a basic question: Is 1MB equal to 1,000,000 or 1,024,000? Because a Systems Administrator may not be the one reading the report, (maybe a manager will be), I used the mathematical 1,000,000 and not the system-reported power-of-2 value. This is really a toss-up, so you

make the decision on the value you want to use. The value is easy to change by doing a little math to multiply the user-supplied value by 1,024,000.

2. The Lab Assignments tackle some other options to consider.

Summary

In this chapter we have shown how to search the system for large files and create a machine-specific report. There are many ways to do the same task, and as always we have other options to consider. This chapter, along with Chapter 17, ''Filesystem Monitoring,'' can help keep filesystem surprises to a minimum.

In the next chapter we are going to study techniques to monitor processes and applications as well as to write scripts to allow pre-, startup, and post-processing.

I hope you gained some knowledge in this chapter, and I will see you in the next chapter!

Lab Assignments

1. Modify the `findlarge.ksh` shell script in Listing 9-1 to add a second command-line argument so that you can specify a search path other than the current directory. You should add this user-supplied search path as an option, and if a search path is omitted, you use the current directory to start the search. This adds a little more flexibility to the original shell script.
2. When searching large filesystems, the search may take a very long time to complete. To give the user feedback that the search process is continuing, add one of the progress indicators studied in Chapter 4, ''Progress Indicators Using a Series of Dots, a Rotating Line, or Elapsed Time.'' Each of the three progress indicators would be appropriate; refer to Chapter 4 for details. Name the modified file so that the method selected is intuitively obvious.
3. Each time we run the `findlarge.ksh` shell script, we overwrite the `$OUTFILE`. Modify the script to keep a month's worth of reports on the system. An easy way to keep one month of reports is to use the `date` command and extract the day of the month, and then add this value as a suffix to the `$OUTFILE` filename definition. Over time our script will result in filenames `largefile.out.01` through `largefiles.out.31`, depending on the month. Simulate the date to test your script to ensure it will produce files `.01` through `.31`.
4. Modify your last script from Lab Assignment 3 to execute in Bash shell. Hint: it is all about the `echo` command, and testing for an integer.

CHAPTER 10

Process Monitoring and Enabling Pre-Processing, Startup, and Post-Processing Events

All too often a program or script will die, hang, or error out during execution or fail to even start up. This type of problem can be hard to nail down due to the unpredictable behavior and the timing required to catch the event as it happens. We also sometimes want to execute some commands before a process starts, as the process starts (or as the monitoring starts), or as a post event when the process dies. Timing is everything! Instead of reentering the same command over and over to monitor a process, we can write scripts to wait for a process to start or end and record the timestamps, or we can perform some other function as a pre-startup or post-event. To monitor the process we are going to use **grep** to grab one or more matched patterns from the process list output. Because we are going to use `grep`, there is a need for the process to be unique in some way — for example, by process name, user name, process ID (PID), parent process ID (PPID), or even a date/time.

In this chapter we cover four scripts that do the following:

- Monitor for a process (one or more) to start execution.
- Monitor for a process (one or more) to stop execution.
- Monitor as the process(es) stops and starts, and log the events as they happen with a timestamp.
- Monitor as the process(es) starts and stops while keeping track of the current number of active processes, giving user notification with a timestamp, and listing of all the active PIDs. We also add pre-startup or post-event capabilities. Two examples of using one of these functions are waiting for a backup to finish before rebooting the system and sending an email as a process starts up.

Syntax

As with all our scripts, we start out by getting the correct command syntax. To look at the system processes, we want to look at *all* the processes, not a limited view for a particular user. To list all the processes, we use the **ps** command with the BSD `aux` switch (notice there is no hyphen prefix). Using `grep` with the `ps aux` command requires us to filter the output. I use `ps aux` particularly because OpenBSD does not support `ps -ef`. The `grep` command will produce two additional lines of output. One line will result from the `grep` command, and the other will result from the script name, which is doing the grepping. To remove both of these we can use either `grep -v` or `egrep -v` to exclude this output. From this specification, and using variables, we came up with the following command syntax:

```
ps aux | grep $PROCESS | grep -v "grep $PROCESS" | grep -v $SCRIPT_NAME
```

The preceding command will give a full process listing while excluding the shell script's name and the grepping for the target process. This will leave only the actual processes that we are interested in monitoring. The return code for this command is `0`, if at least one process is running, and it will return a nonzero value if no process, specified by the `$PROCESS` variable, is currently executing. To monitor a process to start or stop we need to remain in a tight loop until there is a transition from running to end of execution, and vice versa.

Monitoring for a Process to Start

Now that we have the command syntax we can write the script to wait for a process to start. This shell script is pretty simple because all it does is run in a loop until the process starts. The first step is to check for the correct number of arguments: one — the process to monitor. If the process is currently running, we will just notify the user and exit. Otherwise, we will loop until the target process starts and then display the process name that started, and exit. The loop is listed in Listing 10-1.

```
RC=1

until (( RC == 0 )) # Loop until the return code is zero
do
        # Check for the $PROCESS on each loop iteration

        ps aux | grep $PROCESS | egrep -v "grep $PROCESS" \
               | grep -v $SCRIPT_NAME >/dev/null 2>&1

        # Check the Return Code!!!
        if (( $? == 0 )) # Has it Started????
        then
```

Listing 10-1 Process startup loop

```
                echo "$PROCESS has Started Execution...'date'\n\n"

                # Show the user what started!!

                ps aux | grep $PROCESS | egrep -v "grep $PROCESS" \
                       | grep -v $SCRIPT_NAME
'
                echo "\n\n" # A Couple of Blank Lines Before Exit

                RC=1

                exit 0 # Exit time...
        fi
        sleep $SLEEP_TIME # Needed to reduce CPU load!! 1 Second or more
done
```

Listing 10-1 (*continued*)

There are a few things to point out in Listing 10-1. First, notice that we are using the numeric tests, which are specified by the double parentheses: `(( numeric_expression ))`. The numeric tests can be seen in the `if` and `until` control structures. When using the double-parentheses numeric testing method, we do *not* need to reference any user-defined numeric variables with a dollar sign — that is, `$RC`. The double-parentheses mathematical test knows that anything that is not a number is a variable. Just leave out the `$`. We still must use the `$` reference for system and shell variables — for example, `$?` and `$#`. Also notice that we use double equal signs when making an equality test — for example, `until (( RC == 0 ))`. If you use only one equal sign it is assumed to be an assignment, not an equality test! Failure to use double equal signs is one of the most common mistakes, and it is very hard to find during troubleshooting. Also notice in Listing 10-1 that we `sleep` on each loop iteration. If we do not have a sleep interval, the load on the CPU can be tremendous. Try programming a loop with and without the sleep interval and monitor the CPU load with either the **uptime** or **vmstat** commands. You can definitely see a big difference in the load on the system. What does this mean for our monitoring? The process must remain running for at least the length of time that the `sleep` is executing on each loop iteration. If you need an interval of less than 1 second, you can try setting the sleep interval to `0`, zero, but watch out for the heavy CPU load. Even with a 1-second interval the load can get to around 25 percent. An interval of about 3 to 10 seconds is not bad, if you can stand the wait.

Now let's study the loop. We initialize the return code variable, `RC`, to `1`, one. Then we start an `until` loop that tests for the target process on each loop iteration. If the process is not running, the `sleep` is executed and then the loop is executed again. If the target process is found to be running, we give the user notification that the process has started, with the timestamp, and display to the user the process that actually started. We need to give the user this process information just in case the `grep` command got a pattern match on an unintended pattern. The entire script is on the book's web site (`www.wiley.com/go/michael2e`) with the name `proc_wait.ksh`. This is crude, but it works well. (See Listing 10-2.)

```
[root:yogi]@/scripts/WILEY/PROC_MON# ./proc_wait.ksh xcalc


WAITING for xcalc to start...Thu Sep 27 21:11:47 EDT 2007

xcalc has Started Execution...Thu Sep 27 21:11:55 EDT 2007


    root 26772 17866  13 21:11:54  pts/6  0:00 xcalc
```

Listing 10-2 proc_wait.ksh script in action

Monitoring for a Process to End

Monitoring for a process to end is also a simple procedure because it is really the opposite of the previous shell script. In this new shell script we want to add some extra options. First, we set a `trap` and inform the user if an interrupt occurred — for example, Ctrl+C is pressed. It would be nice to give the user the option of *verbose* mode. The verbose mode enables the listing of the active process(es). We can use a `-v` switch as a command-line argument to the shell script to turn on the verbose mode. To parse through the command-line arguments, we could use the **getopts** command; but for only one or two arguments, we can easily use a nested `case` statement. We will show how to use `getopts` later in the chapter. Again, we will use the double parentheses for numeric tests wherever possible. For the `proc_mon.ksh` script we are going to list out the entire script and review the process at the end. (See Listing 10-3.)

```
#!/usr/bin/ksh
#
# SCRIPT: proc_mon.ksh
# AUTHOR: Randy Michael
# DATE: 02/14/2007
# REV: 1.1.P
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to monitor a process to end
#    specified by ARG1 if a single command-line argument is
#    used. There is also a "verbose" mode where the monitored
#    process is displayed and ARG2 is monitored.
#
# USAGE: proc_mon.ksh [-v] process-to-monitor
#
# EXIT STATUS:
#    0 ==> Monitored process has terminated
#    1 ==> Script usage error
```

Listing 10-3 proc_mon.ksh shell script

```
#    2 ==> Target process to monitor is not active
#    3 ==> This script exits on a trapped signal
#
# REV. LIST:
#
#    02/22/2007 - Added code for a "verbose" mode to output the
#                 results of the 'ps aux' command.  The verbose
#                 mode is set using a "-v" switch.
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution

SCRIPT_NAME='basename $0'

#########################################################
############ DEFINE FUNCTIONS HERE ######################
#########################################################

function usage
{
     echo "\n\n"
     echo "USAGE: $SCRIPT_NAME [-v] {Process_to_monitor}"
     echo "\nEXAMPLE: $SCRIPT_NAME  my_backup\n"
     echo "OR"
     echo "\nEXAMPLE: $SCRIPT_NAME -v  my_backup\n"
     echo "Try again...EXITING...\n"
}

#########################################################

function exit_trap
{
     echo "\n...EXITING on trapped signal...\n"
}

#########################################################
################ START OF MAIN############################
#########################################################

#################
# Set a trap...#
#################

trap 'exit_trap; exit 3' 1 2 3 15

# First Check for the Correct Number of Arguments
# One or Two is acceptable
```

Listing 10-3 (*continued*)

```
if (( $# != 1 && $# != 2 ))
then
     usage
     exit 1
fi

# Parse through the command-line arguments and see if verbose
# mode has been specified. NOTICE that we assign the target
# process to the PROCESS variable!!!
# Embedded case statement...

case $# in
      1)     case $1 in
              '-v') usage
                    exit 1
                    ;;
                 *) PROCESS=$1
        esac
        ;;

      2) case $1 in
                '-v') continue
                      ;;
           esac

           case $2 in
                '-v') usage
                      exit 1
                      ;;

                   *) PROCESS=$2
                      ;;
           esac
           ;;

      *) usage
         exit 1
         ;;
esac

# Check if the process is running or exit!

ps aux | grep "$PROCESS" | grep -v "grep $PROCESS" \
       | grep -v $SCRIPT_NAME >/dev/null

if (( $? != 0 ))
then
     echo "\n\n$PROCESS is NOT an active process...EXITING...\n"
```

Listing 10-3 (*continued*)

```
     exit 2
fi

# Show verbose mode if specified...

if (( $# == 2 )) && [[ $1 = "-v" ]]
then
     # Verbose mode has been specified!
     echo "\n"

     # Extract the columns heading from the ps aux output
     ps aux | head -n 1

     ps aux | grep "$PROCESS" | grep -v "grep $PROCESS" \
               | grep -v $SCRIPT_NAME
fi

##### O.K. The process is running, start monitoring...

SLEEP_TIME="1"   # Seconds between monitoring
RC="0"               # RC is the Return Code
echo "\n\n"   # Give a couple of blank lines

echo "$PROCESS is currently RUNNING...`date`\n"

####################################
# Loop UNTIL the $PROCESS stops...

while (( RC == 0 )) # Loop until the return code is not zero
do
     ps aux | grep $PROCESS | grep -v "grep $PROCESS" \
            | grep -v $SCRIPT_NAME >/dev/null 2>&1

     if (( $? != 0 )) # Check the Return Code!!!!!
     then
          echo "\n...$PROCESS has COMPLETED...`date`\n"
          exit 0
     fi
     sleep $SLEEP_TIME # Needed to reduce CPU Load!!!
done

# End of Script
```

Listing 10-3 (*continued*)

Did you catch all the extra hoops we had to jump through? Adding command switches can be problematic. We will see a much easier way to do this later using the `getopts` shell command.

In Listing 10-3 we first defined two functions, which are both used for abnormal operation. We always need a `usage` function, and in this shell script we added a

`trap_exit` function that is to be executed only when a trapped signal is captured. The `trap` definition specifies `exit` signals `1`, `2`, `3`, and `15`. Of course, you cannot trap `exit` signal `9`. This `trap_exit` function will display `...EXITING on a trapped signal...`. Then the `trap` will execute the second command, `exit 3`. In the next step we check for the correct number of command-line arguments, one or two, and use an embedded `case` statement to assign the target process to a variable, `PROCESS`. If `-v` is specified in the *first* argument, `$1`, of two command-line arguments, then verbose mode is used. Verbose mode will display the `ps aux` output that the `grep` command did the pattern match on. Otherwise, this information is not displayed. This is the first time that we look to see if the target process is active. If the target process is not executing, we just notify the user and `exit` with a return code of `2`. Next comes the use of verbose mode if the `-v` switch is specified on the command line. Notice how we pull out the `ps` command's output columns heading information before we display the process using `ps aux | head -n 1`. This helps the user confirm that this is the correct match with the column header. Now we know the process is currently running so we start a loop. This loop will continue until either the process ends or the program is interrupted — for example, Ctrl+C is pressed.

The `proc_mon.ksh` script did the job, but we have no logging and the monitoring stops when the process stops. It would be really nice to track the process as it starts and stops. If we can monitor the transition, we can keep a log file to review and see if we can find a trend. The `proc_mon.ksh` shell script is shown in action in Listing 10-4.

```
[root:yogi]@/scripts/WILEY/PROC_MON# ./proc_mon.ksh xcalc


xcalc is NOT an active process...EXITING...

[root:yogi]@/scripts/WILEY/PROC_MON# ./proc_mon.ksh xcalc


xcalc is currently RUNNING...Thu Sep 27 21:14:08 EDT 2007


...xcalc has COMPLETED...Thu Sep 27 21:14:26 EDT 2007
```

Listing 10-4 proc_mon.ksh shell script in action

Monitor and Log as a Process Starts and Stops

Catching process activity as it cycles on and off can be a useful tool in problem determination. In this section, we are going to expand on both of our previous scripts and monitor for both startup and end time for a target process. We are also going to log everything and timestamp each start and stop event. Because we are logging everything, we also want to see the same data as it happens on the screen. The log file

can be reviewed at any time; we want to see it in ''real time'' (at least close to real time). We are going to make the startup and end time monitoring into functions this time, and as a result we are going to need to capture the current `tty` device, which may be a pseudo-terminal (`pty`), to use within these functions. The **tty** command will show the current terminal, and we can save this in a variable. For concurrent display and logging within the script, we pipe our output to `tee -a $LOGFILE`. This **tee** command sends the output to both standard output and to the file that `$LOGFILE` points to. But inside the functions we will use the specific `tty` device to send our output to, which we assign to a variable called `TTY`. Enough with the fluff; here is the script (in Listing 10-5), followed by a short explanation.

```
#!/bin/ksh
#
# SCRIPT: proc_watch.ksh
# AUTHOR: Randy Michael
# DATE: 09-12-2007
# REV: 1.0.P
# PLATFORM: Not Platform Dependent
#
# PURPOSE" This script is used to monitor and log
#          the status of a process as it starts and stops.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without ANY execution
#
#####################################################
########## DEFINE FILES AND VARIABLES HERE #########
#####################################################

LOGFILE="/tmp/proc_status.log"
[[ ! -s $LOGFILE ]] && touch $LOGFILE

PROCESS="$1"  # Process to Monitor
SCRIPT_NAME=$(basename $0) # Script Name w/o the PATH
TTY=$(tty)    # Current tty or pty

#####################################################
############# DEFINE FUNCTIONS HERE #################
#####################################################

usage ()
{
     echo "\nUSAGE:  $SCRIPT_NAME  process_to_monitor\n"
}
```

Listing 10-5 proc_watch.ksh shell script

```
#####################################################

trap_exit ()
{
    # Log an ending time for process monitoring
    TIMESTAMP=$(date +%D@%T) # Get a new timestamp...
    echo "MON_STOP: Monitoring for $PROCESS ended ==> $TIMESTAMP" \
         | tee -a $LOGFILE

    # Kill all functions
    kill -9 $(jobs -p) 2>/dev/null
}

#####################################################

mon_proc_end ()
{
     END_RC="0"
     until (( END_RC != 0 ))
     do
          ps aux | grep -v "grep $PROCESS" | grep -v $SCRIPT_NAME \
                 | grep $PROCESS >/dev/null 2>&1

          END_RC=$? # Check the Return Code!!
          sleep 1   # Needed to reduce CPU load!
     done

     echo 'N' # Turn the RUN flag off

     # Grab a Timestamp
     TIMESTAMP=$(date +%D@%T)

     echo "END PROCESS: $PROCESS ended ==> $TIMESTAMP" >> $LOGFILE &
     echo "END PROCESS: $PROCESS ended ==> $TIMESTAMP" > $TTY
}

#####################################################

mon_proc_start ()
{
     START_RC="-1"  # Initialize to -1
     until (( START_RC == 0 ))
     do
          ps aux | grep -v "grep $PROCESS" | grep -v $SCRIPT_NAME \
                 | grep $PROCESS >/dev/null 2>&1

          START_RC=$? # Check the Return Code!!!
          sleep 1     # Needed to reduce CPU load!
```

Listing 10-5 (*continued*)

```
      done

      echo 'Y' # Turn the RUN flag on

      # Grab the timestamp
      TIMESTAMP=$(date +%D@%T)

      echo "START PROCESS: $PROCESS began ==> $TIMESTAMP" >> $LOGFILE &
      echo "START PROCESS: $PROCESS began ==> $TIMESTAMP" > $TTY
}

#####################################################
############### START OF MAIN #######################
#####################################################

### SET A TRAP ####

trap 'trap_exit; exit 0' 1 2 3 15

# Check for the Correct Command Line Argument - Only 1

if (( $# != 1 ))
then
      usage
      exit 1
fi

# Get an Initial Process State and Set the RUN Flag

ps aux | grep -v "grep $PROCESS" | grep -v $SCRIPT_NAME \
       | grep $PROCESS >/dev/null

PROC_RC=$?  # Check the Return Code!!

# Give some initial feedback before starting the loop

if (( PROC_RC == 0 ))
then
      echo "The $PROCESS process is currently running...Monitoring..."
      RUN="Y"       # Set the RUN Flag to YES
else
     echo "The $PROCESS process is not currently running...Monitoring..."
      RUN="N"       # Set the RUN Flag to NO
fi

TIMESTAMP=$(date +%D@%T) # Grab a timestamp for the log

# Use a "tee -a $#LOGFILE" to send output to both standard output
```

Listing 10-5 (*continued*)

```
# and to the file referenced by $LOGFILE

echo "MON_START: Monitoring for $PROCESS began ==> $TIMESTAMP" \
      | tee -a $LOGFILE

# Loop Forever!!

while :
do
     case $RUN in
     'Y') # Loop Until the Process Ends
          RUN=$(mon_proc_end)
          ;;
     'N') # Loop Until the Process Starts
          RUN=$(mon_proc_start)
          ;;
     esac
done

# End of Script
```

Listing 10-5 (*continued*)

The shell script in Listing 10-5 is a nice, modular shell script. The actual monitoring loop is the final `while` loop. The loop is short and tight, with all the work being done within the two functions, `proc_mon_start` and `proc_mon_end`. Notice that in both functions we remain in the loop until there is a transition from run to stop, or from not running to process startup. On each transition we return updated run status information back to the calling shell script with an **echo** command, as opposed to a return code. For the concurrent display to the screen and logging to the file, we use `tee -a $LOGFILE` within the shell script body, and in the functions we redirect output to the `tty` device that we assigned to the `$TTY` variable. We use the `tty` device to ensure that the screen output will go to the terminal, or pseudo-terminal, that we are currently looking at. We again did all numeric tests with the double-parentheses method. Notice that we do *not* use a `$` with a user-defined variable! For the `while` loop we are looping forever. The no-op character (`while :`) allows this to work (`true` would also work). The `proc_watch.ksh` shell script will continue to run until it is interrupted — for example, until Ctrl+C is pressed.

We have improved our script, but it does not let us know how many processes are active. There is no timing mechanism for the shell script; it just runs until interrupted. We are next going to expand on our script to do a few things differently. First, we want to be able to time the monitoring to execute for a specific period of time. We also want to let the user know how many processes are currently active and the PID of each process. In addition, we want to timestamp *each* process's startup and end time. To timestamp each process we can count the number of processes that are running during each loop iteration, and if the count changes we will grab a new timestamp and update the PID list for the currently running processes. We also will give the option to run some pre-startup, and/or post-event before the process starts, as the process

starts, or after the process has ended. We can see the `proc_watch.ksh` shell script in action in Listing 10-6.

```
[root:yogi]@/scripts/WILEY/PROC_MON# ./proc_watch.ksh xcalc

The xcalc process is currently running...Monitoring...
MON_START: Monitoring for xcalc began ==> 09/27/07@21:09:41
END PROCESS: xcalc ended ==> 09/27/07@21:09:56
START PROCESS: xcalc began ==> 09/27/07@21:10:06
END PROCESS: xcalc ended ==> 09/27/07@21:10:25
^C
MON_STOP: Monitoring for xcalc ended ==> 09/27/07@21:10:31
```

Listing 10-6 proc_watch.ksh shell script in action

Timed Execution for Process Monitoring, Showing Each PID, and Timestamp with Event and Timing Capability

Sound like a lot? After we get through this section, each step will be intuitively obvious. In the previous three scripts, we had no ability to monitor *each* process that matched the grepped pattern or to execute the monitoring for a specific amount of time. Because we are using the `grep` command, we might get multiple matches to a pattern. In case of multiple matches, we need to know (1) how many matches we have and (2) *each* process that was matched. This information can be very beneficial if we are monitoring a specific user's activities or anything where we are interested in the exact process IDs that are running.

We also want a good timing mechanism that will allow for easy, flexible timing of the duration of the monitoring activity. Because we have no way of knowing what user requirements may be, we want to allow for as much flexibility as possible. Let's go to the far side and allow timing from seconds to days, and anything in between. The easiest way to handle timing, but not the most accurate, is to add up all the seconds and count down from the total seconds to zero while sleeping for one second between counts. We could continuously check the date/time using the **date** command for a very accurate time, or — even better — we can kick off an `at` job to kill the script at some specific time in the future. The shell variable `SECONDS` is also useful. For this script we are going to use `getopts` to parse the command line for seconds, minutes, hours, days, and the process to monitor. Then we add up the seconds and count down to zero and quit. Alternatively, if the total seconds and a process are the only arguments, the user will be able to enter these directly — for only a process and total seconds `getopts` will not be used. The `usage` function will list two ways to use our new script.

Another nice option is the capability to run pre-startup, and/or post-events. By pre-startup, and post-events we are talking about running some command, script, or function before the process starts, as the process starts, after the process stops, or in

any combination. As an example, we may want to reboot the machine after a backup program ends, or we may want to set up environment variables before some process starts up. For the event options we also need to be as flexible as possible. For flexibility we will just add a function for each event that contains only the no-op character, `:` (colon), as a placeholder. A colon does not execute anything; it does nothing and always has a return code of `0`, zero. Anything that a user may want to run before startup, at startup, or after the process has ended can be added into the appropriate function. We will use flags, or variables, to enable and disable the pre-startup, and post-events individually.

In this section we are going to do two things that may be new, using `getopts` to process the command-line arguments and executing a function in the background as a *co-process*. The `getopts` functionality is an easy and efficient way to parse through mixed command-line arguments, and the command switches can be with or without switch arguments. A co-process is an easy way to set up a communication link with a *background* script or function and the foreground.

Let's first look at how to use `getopts` to parse the command line. The `getopts` command is built into the shell. We use `getopts` to parse the command line for valid options specified by a single character, following a `-` (minus sign) or a `+` (plus sign). To specify that a command switch requires an argument, the switch character definition must be followed by a `:` (colon). If the switch does not require any argument, the `:` should be omitted. All the switch options put together are called the `OptionString`, and this is followed by some variable name that we define. The argument for each switch is stored in a variable called `OPTARG` as the arguments are parsed in a loop one at a time. If the *entire* `OptionString` is *preceded* by a `:` (colon), then any unmatched switch option causes a `?` (question mark) to be loaded into the variable that we defined in the `getopts` command string. The form of the command follows:

```
getopts OptionString Name [ Argument ... ]
```

The easiest way to explain the `getopts` command is with an example. For our script we need seconds, minutes, hours, days, and a process to monitor. For each one we want to supply an argument — for example, `-s 5 -m10 -p my_backup`. In this example we are specifying 5 seconds, 10 minutes, and the process is `my_backup`. Notice that there does not have to be a space between the switch and the argument, and the arguments can be in any order on the command line. This is what makes `getopts` so great! The code to set up our example looks like Listing 10-7.

```
SECS=0          # Initialize all to zero
MINUTES=0
HOURS=0
DAYS=0
PROCESS=        # Initialize to null

while getopts ":s:m:h:d:p:" TIMED 2>/dev/null
do
```

Listing 10-7 Example getopts command usage

```
    case $TIMED in
       s) SECS=$OPTARG
          ;;
       m) (( MINUTES = $OPTARG * 60 ))
          ;;
       h) (( HOURS = $OPTARG * 3600 ))
          ;;
       d) (( DAYS = $OPTARG * 86400 ))
          ;;
       p) PROCESS=$OPTARG
          ;;
       \?) usage
           exit 1
           ;;
    esac
done

(( TOTAL_SECONDS = SECS + MINUTES + HOURS + DAYS ))
```

Listing 10-7 (*continued*)

There are a few things to note in Listing 10-7. The `getopts` command needs to be part of a `while` loop with a `case` statement within the loop. On each option we specified, `-s`, `-m`, `-h`, `-d`, and `-p`, we added a `:` (colon) after each switch character. This tells `getopts` that an argument is required for that particular switch character. The `:` (colon) *before* the `OptionString` list tells `getopts` that if an unspecified option is given on the command line, then `getopts` should set the `TIMED` variable to the `?` character. The `?` allows us to call the `usage` function and `exit` with a return code of `1` for an incorrect command-line option. The only thing to be careful of is that `getopts` does not care what arguments it receives, so it is *our* responsibility to check each argument to ensure that it meets our expectations; then we have to take action if we want to exit. The last thing to note in Listing 10-7 is that the first line of the `while` loop has redirection of the standard error (file descriptor `2`) to the bit bucket. Anytime an unexpected argument is encountered, `getopts` sends a message to standard error, but it is not considered an error, just informational. Because we expect that incorrect command-line arguments may be entered, we can just ignore the messages and discard them with redirection to `/dev/null`, a.k.a. the bit bucket.

We also need to cover setting up a co-process. A *co-process* is a communications link between a foreground and a background process. The most common question is, ''*Why* is this needed?'' In our next script we are going to call a function that will handle all the monitoring for us while we do the timing control in the main script. The problem arises because *we need to run this function in the background*. Within the background process-monitoring function there are two loops, of which one loop is always executing. Without the ability to tell the loop to break out of the internal loop, it will continue to execute on its own after the main script and function have exited due to an interrupt. We know what this causes — *one or more defunct processes!* From the main script we need a way to communicate with the loop in the background function

to tell it to break out of the loop or exit the function cleanly when the countdown is complete and if the script is interrupted — for example, with Ctrl+C. To solve this little problem we kick off our background `proc_watch` function as a co-process. ''How do we do this?'' you ask. ''*Pipe it to the background*'' is the simplest way to put it, and that is also what it looks like. Look at the example in Listing 10-8.

```
function proc_watch
{
# This function is started as a co-process!!!

    while :      # Loop forever
    do
          Some Code Here

          read BREAK_OUT  # Do NOT need a "-p" to read!
          if [[ $BREAK_OUT = 'Y' ]]
          then
               return 0
          fi
    done
}
############################
##### Start of Main ########
############################

### Set a Trap ###

trap 'BREAK='Y'; print -p $BREAK; exit 2' 1 2 3 15

TOTAL_SECONDS=300
BREAK_OUT='N'

proc_watch |&       # Start proc_watch as a co-process!!!!

until (( TOTAL_SECONDS == 0 ))
do
     (( TOTAL_SECONDs = TOTAL_SECONDS - 1 ))
     sleep 1
done

BREAK_OUT='Y'

# Use "print -p" to communicate with the co-process variable

print -p $BREAK_OUT

exit 0
```

Listing 10-8 Example of using a co-process

In the code block in Listing 10-8 we defined the `proc_watch` function, which is the function that we want to start as a *background* process. As you can see, the `proc_watch` function has an infinite loop. If the main script is interrupted, then without a means to exit the loop within the `proc_watch` background function, the loop alone will continue to execute! To solve this we start the `proc_watch` as a co-process by ''piping it to the background'' using *pipe ampersand*, `|&`, as a suffix. Now when we want to communicate with the function from the main script, we use `print -p $BREAK_OUT`. Inside the function, we just use the standard `read` command, `read BREAK_OUT`. The co-process is the mechanism that we are going to use to break out of the loop if the main script is interrupted on a trapped signal, and for normal countdown termination at the end of the script. Of course, we can never catch `kill -9` with a `trap`.

Try setting up the scenario just described, without a co-process, with a background function that has an infinite loop. Then press the Ctrl+C key sequence to kill the main script and do a `ps aux | more`. You will see that the background *loop* is still executing! Get the PID, and do a `kill -9` to kill it. Of course, if the loop's exit criteria are ever met, the loop will exit on its own.

Now take a look at the entire script, and see how we handled all these extra requirements. Pay close attention to the highlighted code in Listing 10-9.

```
#!/bin/ksh
#
# SCRIPT: proc_watch_timed.ksh
# AUTHOR: Randy Michael
# DATE: 09-14-2007
# REV: 1.0.P
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to monitor and log
#          the status of a process as it starts and stops.
#          Command line options are used to identify the target
#          process to monitor and the length of time to monitor.
#          Each event is logged to the file defined by the
#          $LOGFILE variable. This script also has the ability
#          to execute pre, startup, and post events. These are
#          controlled by the $RUN_PRE_EVENT, $RUN_STARTUP_EVENT,
#          and $RUN_POST_EVENT variables. These variables control
#          execution individually. Whatever is to be executed is to
#          be placed in either the "pre_event_script",
#          startup_event_script, or the
#          "post_event_script" functions, or in any combination.
#          Timing is controlled on the command line.
#
#          USAGE:  $SCRIPT_NAME  total_seconds  target_process
#
#          Will monitor the specified process for the
#          specified number of seconds.
```

Listing 10-9 proc_watch_timed.ksh shell script

```
#
#          USAGE:  $SCRIPT_NAME  [-s|-S seconds] [-m|-M minutes]
#                                [-h|-H hours] [-d|-D days]
#                                [-p|-P process]
#
#          Will monitor the specified process for number of
#          seconds specified within -s seconds, -m minutes,
#          -h hours, and -d days.  Any combination of command
#          switches can be used.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without ANY execution
#
#####################################################
########## DEFINE FILES AND VARIABLES HERE #########
#####################################################

typeset -u RUN_PRE_EVENT  # Force to UPPERCASE
typeset -u RUN_STARTUP_EVENT  # Force to UPPERCASE
typeset -u RUN_POST_EVENT # force to UPPERCASE

RUN_PRE_EVENT='N'  # A 'Y' will execute, anything else will not
RUN_STARTUP_EVENT='Y' # A 'Y' will execute, anything else will not
RUN_POST_EVENT='Y' # A 'Y' will execute, anything else will not

LOGFILE="/tmp/proc_status.log"
[[ ! -s $LOGFILE ]] && touch $LOGFILE

SCRIPT_NAME=$(basename $0)
TTY=$(tty)
INTERVAL="1" # Seconds between sampling
JOBS=

#####################################################
############# DEFINE FUNCTIONS HERE #################
#####################################################
usage ()
{
echo "\n\n\t*****USAGE ERROR*****"
echo "\n\nUSAGE:  $SCRIPT_NAME  seconds  process"
echo "\nWill monitor the specified process for the"
echo "specified number of seconds."
echo "\nUSAGE:  $SCRIPT_NAME  [-s|-S seconds] [-m|-M minutes]"
echo "        [-h|-H hours] [-d|-D days] [-p|-P process]\n"
echo "\nWill monitor the specified process for number of"
echo "seconds specified within -s seconds, -m minutes,"
```

Listing 10-9 (*continued*)

```
echo "-h hours and -d days.  Any combination of command"
echo "switches can be used.\n"
echo "\nEXAMPLE: $SCRIPT_NAME  300  dtcalc"
echo "\n\nEXAMPLE: $SCRIPT_NAME  -m 5 -p dtcalc"
echo "\nBoth examples will monitor the dtcalc process"
echo "for 5 minutes.  Can specify days, hours, minutes"
echo "and seconds, using -d, -h, -m and -s\n\n"
}
#####################################################
trap_exit ()
{
# set -x # Uncommant to debug this function
# Log an ending time for process monitoring
echo "INTERRUPT: Program Received an Interrupt...EXITING..." > $TTY
echo "INTERRUPT: Program Received an Interrupt...EXITING..." >> $LOGFILE
TIMESTAMP=$(date +%D@%T) # Get a new timestamp...
echo "MON_STOPPED: Monitoring for $PROCESS ended ==> $TIMESTAMP\n" \
      >> $TTY
echo "MON_STOPPED: Monitoring for $PROCESS ended ==> $TIMESTAMP\n" \
      >> $LOGFILE
echo "LOGFILE: All Events are Logged ==> $LOGFILE \n" > $TTY

# Kill all functions
JOBS=$(jobs -p)
if [[ ! -z $JOBS && $JOBS != '' && $JOBS != '0' ]]
then
      kill $(jobs -p) 2>/dev/null 1>&2
fi
return 2
}
#####################################################
pre_event_script ()
{
# Put anything that you want to execute BEFORE the
# monitored process STARTS in this function
: # No-OP - Needed as a placeholder for an empty function
# Comment Out the Above colon, ':'

PRE_RC=$?
return $PRE_RC
}
#####################################################
startup_event_script ()
{
# Put anything that you want to execute WHEN, or AS, the
# monitored process STARTS in this function

: # No-OP - Needed as a placeholder for an empty function
```

Listing 10-9 (*continued*)

```
# Comment Out the Above colon, ':'

STARTUP_RC=$?
return $STARTUP_RC
}
#####################################################
post_event_script ()
{
# Put anything that you want to execute AFTER the
# monitored process ENDS in this function

: # No-OP - Need as a placeholder for an empty function
# Comment Out the Above colon, ':'

POST_RC=$?
return $POST_RC
}
#####################################################
# This function is used to test character strings

test_string ()
{
if (( $# != 1 ))
then
    echo 'ERROR'
    return
fi

C_STRING=$1
# Test the character string for its composition

case $C_STRING in

     +([0-9])) echo  'POS_INT' # Integer >= 0
               ;;
     +([-0-9])) echo 'NEG_INT' # Integer < 0
               ;;
     +([a-z])) echo  'LOW_CASE'   # lower case text
               ;;
     +([A-Z])) echo  'UP_CASE'    # UPPER case text
               ;;
     +([a-z]|[A-Z])) echo 'MIX_CASE' # MIxed CAse text
               ;;
               *) echo 'UNKNOWN'  # Anything else
esac
}
#####################################################
proc_watch ()
```

Listing 10-9 (*continued*)

```
{
# set -x # Uncomment to debug this function
# This function does all of the process monitoring!

while :     # Loop Forever!!
do
    case $RUN in
    'Y')
          # This will run the startup_event_script, which is a function

          if [[ $RUN_STARTUP_EVENT = 'Y' ]]
          then
             echo "STARTUP EVENT: Executing Startup Event Script..."\
                  > $TTY
             echo "STARTUP EVENT: Executing Startup Event Script..."\
                  >> $LOGFILE

             startup_event_script # USER DEFINED FUNCTION!!!
             RC=$?  # Check the Return Code!!
             if (( "RC" == 0 ))
             then
                 echo "SUCCESS: Startup Event Script Completed RC -\
 ${RC}" > $TTY
                 echo "SUCCESS: Startup Event Script Completed RC -\
 ${RC}" >> $LOGFILE

             else
                 echo "FAILURE: Startup Event Script FAILED RC -\
 ${RC}" > $TTY
                 echo "FAILURE: Startup Event Script FAILED RC -\
 ${RC}" >> $LOGFILE
             fi
          fi
          integer PROC_COUNT='-1' # Reset the Counters
          integer LAST_COUNT='-1'
          # Loop until the process(es) end(s)

          until (( "PROC_COUNT" == 0 ))
          do
               # This function is a Co-Process. $BREAK checks to see if
               # "Program Interrupt" has taken place. If so BREAK will
               # be 'Y' and we exit both the loop and function.

               read BREAK
               if [[ $BREAK = 'Y' ]]
               then
                     return 3
               fi
```

Listing 10-9 (*continued*)

```
                PROC_COUNT=$(ps aux | grep -v "grep $PROCESS" \
                            | grep -v $SCRIPT_NAME \
                            | grep $PROCESS | wc -l) >/dev/null 2>&1

                if (( "LAST_COUNT" > 0 && "LAST_COUNT" != "PROC_COUNT" ))
                then
                     # The Process Count has Changed...
                     TIMESTAMP=$(date +%D@%T)
                     # Get a list of the PID of all of the processes
                     PID_LIST=$(ps aux | grep -v "grep $PROCESS" \
                            | grep -v $SCRIPT_NAME \
                            | grep $PROCESS | awk '{print $2}')

                     echo "PROCESS COUNT: $PROC_COUNT $PROCESS\
Processes Running ==> $TIMESTAMP" >> $LOGFILE &
                     echo "PROCESS COUNT: $PROC_COUNT $PROCESS\
Processes Running ==> $TIMESTAMP" > $TTY

                     echo ACTIVE PIDS: $PID_LIST >> $LOGFILE &
                     echo ACTIVE PIDS: $PID_LIST > $TTY
                fi
                LAST_COUNT=$PROC_COUNT
                sleep $INTERVAL # Needed to reduce CPU load!
          done

          RUN='N' # Turn the RUN Flag Off

          TIMESTAMP=$(date +%D@%T)
          echo "ENDING PROCESS: $PROCESS END time  ==>\
$TIMESTAMP" >> $LOGFILE &
          echo "ENDING PROCESS: $PROCESS END time  ==>\
$TIMESTAMP" > $TTY

          # This will run the post_event_script, which is a function

          if [[ $RUN_POST_EVENT = 'Y' ]]
          then
              echo "POST EVENT: Executing Post Event Script..."\
                    > $TTY
              echo "POST EVENT: Executing Post Event Script..."\
                    >> $LOGFILE &

              post_event_script # USER DEFINED FUNCTION!!!
              integer RC=$?
              if (( "RC" == 0 ))
              then
                  echo "SUCCESS: Post Event Script Completed RC -\
${RC}" > $TTY
```

Listing 10-9 (*continued*)

```
                echo "SUCCESS: Post Event Script Completed RC -\
${RC}" >> $LOGFILE
            else
                echo "FAILURE: Post Event Script FAILED RC - ${RC}"\
                      > $TTY
                echo "FAILURE: Post Event Script FAILED RC - ${RC}"\
                      >> $LOGFILE
            fi
        fi
    ;;

    'N')
        # This will run the pre_event_script, which is a function

        if [[ $RUN_PRE_EVENT = 'Y' ]]
        then
           echo "PRE EVENT: Executing Pre Event Script..." > $TTY
           echo "PRE EVENT: Executing Pre Event Script..." >> $LOGFILE

           pre_event_script # USER DEFINED FUNCTION!!!
           RC=$?   # Check the Return Code!!!
           if (( "RC" == 0 ))
           then
                echo "SUCCESS: Pre Event Script Completed RC - ${RC}"\
                      > $TTY
                echo "SUCCESS: Pre Event Script Completed RC - ${RC}"\
                      >> $LOGFILE
           else
                echo "FAILURE: Pre Event Script FAILED RC - ${RC}"\
                      > $TTY
                echo "FAILURE: Pre Event Script FAILED RC - ${RC}"\
                      >> $LOGFILE
           fi
        fi

        echo "WAITING: Waiting for $PROCESS to
startup...Monitoring..."

        integer PROC_COUNT='-1' # Initialize to a fake value

        # Loop until at least one process starts

        until (( "PROC_COUNT" > 0 ))
        do
             # This is a Co-Process. This checks to see if a "Program
             # Interrupt" has taken place. If so BREAK will be 'Y' and
             # we exit both the loop and function
             read BREAK
```

Listing 10-9 (*continued*)

```
                if [[ $BREAK = 'Y' ]]
                then
                      return 3
                fi

                PROC_COUNT=$(ps aux | grep -v "grep $PROCESS" \
                      | grep -v $SCRIPT_NAME | grep $PROCESS | wc -l) \
                        >/dev/null 2>&1

                sleep $INTERVAL # Needed to reduce CPU load!
          done

          RUN='Y' # Turn the RUN Flag On

          TIMESTAMP=$(date +%D@%T)

          PID_LIST=$(ps aux | grep -v "grep $PROCESS" \
                      | grep -v $SCRIPT_NAME \
                      | grep $PROCESS | awk '{print $2}')

          if (( "PROC_COUNT" == 1 ))
          then
                echo "START PROCESS: $PROCESS START time ==>\
 $TIMESTAMP" >> $LOGFILE &
                echo ACTIVE PIDS: $PID_LIST >> $LOGFILE &
                echo "START PROCESS: $PROCESS START time ==>\
 $TIMESTAMP" > $TTY
                echo ACTIVE PIDS: $PID_LIST > $TTY
          elif (( "PROC_COUNT" > 1 ))
          then
                echo "START PROCESS: $PROC_COUNT $PROCESS\
 Processes Started: START time ==> $TIMESTAMP" >> $LOGFILE &
                echo ACTIVE PIDS: $PID_LIST >> $LOGFILE &
                echo "START PROCESS: $PROC_COUNT $PROCESS\
 Processes Started: START time ==> $TIMESTAMP" > $TTY
                echo ACTIVE PIDS: $PID_LIST > $TTY
          fi
     ;;
   esac
done
}

#####################################################
############## START OF MAIN ########################
#####################################################

### SET A TRAP ####
trap 'BREAK='Y';print -p $BREAK 2>/dev/null;trap_exit\
```

Listing 10-9 (*continued*)

```
 2>/dev/null;exit 0' 1 2 3 15

BREAK='N'  # The BREAK variable is used in the co-process proc_watch
PROCESS=   # Initialize to null
integer TOTAL_SECONDS=0

# Check commnand line arguments

if (( $# > 10 || $# < 2 ))
then
     usage
     exit 1
fi

# Check to see if only the seconds and a process are
# the only arguments

if [[ ($# -eq 2) && ($1 != -*) && ($2 != -*) ]]
then
     NUM_TEST=$(test_string $1)  # Is this an Integer?
     if [[ "$NUM_TEST" = 'POS_INT' ]]
     then
          TOTAL_SECONDS=$1  # Yep - It's an Integer
          PROCESS=$2        # Can be anything
     else
          usage
          exit 1
     fi
else
     # Since getopts does not care what arguments it gets, let's
     # do a quick sanity check to make sure that we only have
     # between 2 and 10 arguments and the first one must start
     # with a -* (hyphen and anything), else usage error

     case "$#" in
     [2-10]) if [[ $1 != -* ]]; then
                 usage; exit 1
             fi
          ;;
     esac

     HOURS=0   # Initialize all to zero
     MINUTES=0
     SECS=0
     DAYS=0

     # Use getopts to parse the command line arguments
```

Listing 10-9 (*continued*)

```
      # For each $OPTARG for DAYS, HOURS, MINUTES and DAYS check to see
      # that each one is an integer by using the check_string function

      while getopts ":h:H:m:M:s:S:d:D:P:p:" OPT_LIST 2>/dev/null
      do
        case $OPT_LIST in
        h|H) [[ $(test_string $OPTARG) != 'POS_INT' ]] && usage && exit 1
             (( HOURS = $OPTARG * 3600 )) # 3600 seconds per hour
             ;;
        m|H) [[ $(test_string $OPTARG) != 'POS_INT' ]] && usage && exit 1
             (( MINUTES = $OPTARG * 60 )) # 60 seconds per minute
             ;;
        s|S) [[ $(test_string $OPTARG) != 'POS_INT' ]] && usage && exit 1
             SECS="$OPTARG"             # seconds are seconds
             ;;
        d|D) [[ $(test_string $OPTARG) != 'POS_INT' ]] && usage && exit 1
             (( DAYS = $OPTARG * 86400 )) # 86400 seconds per day
             ;;
        p|P) PROCESS=$OPTARG              # process can be anything
             ;;
         \?) usage                        # USAGE ERROR
             exit 1
             ;;
          :) usage
             exit 1
             ;;
          *) usage
             exit 1
             ;;
        esac
      done
fi

# We need to make sure that we have a process that
# is NOT null or empty! - sanity check - The double quotes are required!

if [[ -z "$PROCESS" || "$PROCESS" = '' ]]
then
      usage
      exit 1
fi

# Check to see that TOTAL_SECONDS was not previously set

if (( TOTAL_SECONDS == 0 ))
then
      # Add everything together if anything is > 0
```

Listing 10-9 (*continued*)

```
     if [[ $SECS -gt 0 || $MINUTES -gt 0 || $HOURS -gt 0 \
          || $DAYS -gt 0 ]]
     then
          (( TOTAL_SECONDS = SECS + MINUTES + HOURS + DAYS ))
     fi
fi

# Last Sanity Check!

if (( TOTAL_SECONDS <= 0 )) || [ -z $PROCESS ]
then
     # Either There are No Seconds to Count or the
     # $PROCESS Variable is Null...USAGE ERROR...

     usage
     exit 1
fi

############ START MONITORING HERE!############

echo "\nCurrently running $PROCESS processes:\n" > $TTY
ps aux | grep -v "grep $PROCESS" | grep -v $SCRIPT_NAME \
       | grep $PROCESS > $TTY

PROC_RC=$? # Get the initial state of the monitored function

echo >$TTY # Send a blank line to the screen

(( PROC_RC != 0 )) && echo "\nThere are no $PROCESS processes running\n"

if (( PROC_RC == 0 )) # The Target Process(es) is/are running...
then
     RUN='Y' # Set the RUN flag to true, or yes.

     integer PROC_COUNT # Strips out the "padding" for display

     PROC_COUNT=$(ps aux | grep -v "grep $PROCESS" | grep -v \
                  $SCRIPT_NAME | grep $PROCESS | wc -l) >/dev/null 2>&1
     if (( PROC_COUNT == 1 ))
     then
          echo "The $PROCESS process is currently\
 running...Monitoring...\n"
     elif (( PROC_COUNT > 1 ))
     then
          print "There are $PROC_COUNT $PROCESS processes currently\
 running...Monitoring...\n"
     fi
else
```

Listing 10-9 (*continued*)

```
    echo "The $PROCESS process is not currently running...monitoring..."
     RUN='N' # Set the RUN flag to false, or no.
fi

TIMESTAMP=$(date +%D@%T) # Time that this script started monitoring

# Get a list of the currently active process IDs

PID_LIST=$(ps aux | grep -v "grep $PROCESS" \
                  | grep -v $SCRIPT_NAME  \
                  | grep $PROCESS | awk '{print $2}')

echo "MON_STARTED: Monitoring for $PROCESS began ==> $TIMESTAMP" \
      | tee -a $LOGFILE
echo ACTIVE PIDS: $PID_LIST | tee -a $LOGFILE


##### NOTICE ####
# We kick off the "proc_watch" function below as a "Co-Process"
# This sets up a two way communications link between the
# "proc_watch" background function and this "MAIN BODY" of
# the script.  This is needed because the function has two
# "infinite loops", with one always executing at any given time.
# Therefore we need a way to break out of the loop in case of
# an interrupt, i.e. CTRL+C, and when the countdown is complete.
# The "pipe appersand", |&, creates the background Co-Process
# and we use "print -p $VARIABLE" to transfer the variable's
# value back to the background co-process.
###################################

proc_watch |&  # Create a Background Co-Process!!
WATCH_PID=$!   # Get the process ID of the last background job!

# Start the Count Down!

integer SECONDS_LEFT=$TOTAL_SECONDS

while (( SECONDS_LEFT > 0 ))
do
     # Next send the current value of $BREAK to the Co-Process
     # proc_watch, which was piped to the background...

     print -p $BREAK 2>/dev/null

     (( SECONDS_LEFT = SECONDS_LEFT - 1 ))
     sleep 1 #  1 Second Between Counts
done
```

Listing 10-9 (*continued*)

```
# Finished - Normal Timeout Exit...
TIMESTAMP=$(date +%D@%T) # Get a new timestamp...
echo "MON_STOPPED: Monitoring for $PROCESS ended ==> $TIMESTAMP\n" \
      | tee -a $LOGFILE

echo "LOGFILE: All Events are Logged ==> $LOGFILE \n"

# Tell the proc_watch function to break out of the loop and die

BREAK='Y'
print -p $BREAK 2>/dev/null

kill $WATCH_PID 2>/dev/null

exit 0

# End of Script
```

Listing 10-9 (*continued*)

The most important things to note in Listing 10-9 are the communication links used between the foreground main script and the background co-process function, `proc_watch`, and the use of `getopts` to parse the command-line arguments. Some other things to look at are the integer tests using the `string_test` function and the way that the user is notified of a new process either starting or stopping by timestamp. The updated process count, and the listing of all of the PIDs, and how text is sent to the previously captured `tty` display within the function. As usual, we use the double-parentheses numerical test method in the control structures. (Notice again that the `$` is not used to reference the user-defined variables!) This shell script is also full of good practices for using different control structures and the use of the logical AND and logical OR (`&&` and `||`), which reduces the need for `if...then...else...` and `case` structures. One *very important* test needs to be pointed out — the ''null/empty'' test for the `PROCESS` variable just after `getopts` parses the command line. This test is so important because the `getopts` command does not care what arguments it is parsing; nothing will ''error out.'' For this reason, *we need to verify* all the variables ourselves. The only thing `getopts` is doing is matching the command switches to the appropriate arguments, *not* the validity of the command-line argument! If this test is left out and invalid command-line arguments are present, `grep` command errors will cover the screen during the script's execution — bad; very bad!

A good review of Listing 10-9 is needed to point out some other interesting aspects. Let's start at the top.

In the definitions of the files and variables there are three variables that control the execution of the pre-startup, and post-events. The variables are `RUN_PRE_EVENT`, `RUN_STARTUP_EVENT`, and `RUN_POST_EVENT`, and for ease of testing, the variables are `typeset` to UPPERCASE. A ''Y'' will enable the execution of the function, in which a user can put anything that he or she wants to run. The *functions* are called `pre_event_script`, `startup_event_script`, and `post_event_script`, but don't

let the names fool you. We also identify the `LOGFILE` variable and test to see if a log file exists. If the file does not exist, we `touch` the `$LOGFILE` variable, which creates an empty file with the filename that the `$LOGFILE` variable points to. This script section also grabs the `SCRIPT_NAME` using the `basename $0` command, and we define the current `tty` device for display purposes. An important variable is `INTERVAL`. This variable defines the number of seconds between sampling the process list. It is *very* important that this value is greater than `0`, zero! If the `INTERVAL` value is set to `0`, zero, the CPU load will be extreme and will produce a noticeable load, to say the least.

The next section in Listing 10-9 defines all the functions used in this script. We have a `usage` function that is displayed for usage errors. Then there is the `trap_exit` function. The `trap_exit` function will execute on exit codes `1`, `2`, `3`, and `15`, which we will see in the `trap` statement later at `START OF MAIN` in the script. Next are the `pre_event_script`, `startup_event_script`, and `post_event_script` functions. You may ask why a function would have a name indicating it is a script. It is done this way to encourage the use of an external script, or program, for any pre-startup, or post-event activity, rather than editing this script and debugging an internal function. The next function is used to test character strings, thus the name `test_string`. If you have ever wondered how to test a string (the entire string!) for its composition, `test_string` will do the trick. We just use a regular expression test for a range of characters. The preceding + (plus sign) is required in this regular expression to specify that all characters are of the specified type.

NOTE **Bash shell does not support the regular expression notation `+ (reg_expression)` to test strings.**

Then comes the main function in the script that does all the work, `proc_watch`. This function is also the one that is executed as the co-process that we have been talking so much about. The `proc_watch` function is an infinite loop that contains two internal loops, where one internal loop is always executing at any given time. During both of these internal loops we check the variable `BREAK` to see if the value is `'Y'`. The `'Y'` value indicates that the function should `exit` immediately. The `BREAK` variable is updated, or changed, from the main script and is ''transferred'' to this co-process background function using the `print -p $BREAK` command within the main script. This variable is reread in the function, during each loop iteration, using the standard `read BREAK` command. This is what enables the clean exit from the background function's loop. The word *background* is key to understanding the need for the co-process. If the main script is interrupted, the *innermost* loop will continue to execute even after both the function and script end execution. It will exit on its own when the loop's exit parameters are met, but if they are never met we end up with a defunct process. To get around this problem we start the `proc_watch` function as a background co-process using `|&` as a suffix to the function — for example, `proc_watch |&`. An easy way to think of a co-process is as a *pipe to the background*, and through this pipe we have a communications link.

For the main part of the shell script, at the `START OF MAIN`, we first set a `trap`. In the **trap** command, we set the `BREAK` variable to `'Y'` to indicate that the `proc_watch`

co-process should exit, and we make the new BREAK value known to the co-process with the `print -p $BREAK 2 > /dev/null` command. This command sometimes sends error notification to the standard error, file descriptor 2, but we want all error notification suppressed. Otherwise, the error messages would go to the screen during the script's execution, which is highly undesirable.

Next are the standard things of initializing a few variables and checking for the correct number of arguments. There are two ways to run this script: (1) only specifying the total seconds and the process to monitor or (2) using the command-line switches to specify the seconds, minutes, hours, days, and process to monitor. The latter method will use the `getopts` command to parse the arguments, but we do not need `getopts` for the first method. We first check to see if we are given only seconds and a process. We use the `test_string` function to ensure that the `$1` argument is a positive integer. The second argument could be anything except a null string or a string that begins with a - (hyphen). Otherwise, we will use the `getopts` command to parse the command line.

The `getopts` command makes life much easier when we need to process command-line arguments; however, `getopts` does have its limitations. We just need to remember that `getopts` is parsing the command-line arguments, but it really does not care what the arguments are. Therefore, we need to do a sanity check on each and every argument to ensure that it meets the criteria that are expected. If the argument fails, we just run the `usage` function and `exit` with a return code of `1`, one. Two tests are conducted on each argument. We test the `PROCESS` variable to make sure that it is not null, or empty, and we check all the numeric variables used for timing to make sure they are positive integers or `0`, zero. The positive integer test is to ensure that at least one of the numeric variables, `SECS`, `MINUTES`, `HOURS`, and `DAYS`, has an integer value greater than `0`, zero. If we get past this stage we assume we have creditable data to start monitoring.

The monitoring starts by getting an initial state of the process, either currently running or not running. With this information we initialize the `RUN` variable, which is used as a control mechanism for the rest of the script. Once the initialization text is both logged and sent to the screen, the `proc_watch` function is started as a background co-process, again using `proc_watch |&`. The main script just does a countdown to `0`, zero, and exits. To make the `proc_watch` function exit cleanly we assign `'Y'` to the `BREAK` variable and make this new value known to the co-process with the `print -p $BREAK` command. Then we `kill` the background PID that we saved in the `WATCH_PID` variable and then `exit` the script with a return code of `0`, zero. If the script is interrupted, the `trap` will handle stopping the co-process and exiting. See Listing 10-10.

```
[root:yogi]@/scripts/WILEY/PROC_MON# ./proc_watch_timed.ksh -m 5 -pxcalc

Currently running xcalc processes:

There are no xcalc processes running

The xcalc process is not currently running...monitoring...
MON_STARTED: Monitoring for xcalc began ==> 09/27/07@21:15:02
```

Listing 10-10 proc_watch_times.ksh shell script in action

```
ACTIVE PIDS:
START PROCESS: xcalc START time ==> 09/27/07@21:15:19
ACTIVE PIDS: 26190
STARTUP EVENT: Executing Startup Event Script...
SUCCESS: Startup Event Script Completed RC - 0
PROCESS COUNT: 2 xcalc Processes Running ==> 09/27/07@21:15:46
ACTIVE PIDS: 13060 26190
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:16:04
ACTIVE PIDS: 13060 18462 26190
PROCESS COUNT: 4 xcalc Processes Running ==> 09/27/07@21:16:27
ACTIVE PIDS: 13060 18462 22996 26190
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:16:39
ACTIVE PIDS: 18462 22996 26190
PROCESS COUNT: 4 xcalc Processes Running ==> 09/27/07@21:16:56
ACTIVE PIDS: 18462 22996 24134 26190
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:17:31
ACTIVE PIDS: 22996 24134 26190
PROCESS COUNT: 2 xcalc Processes Running ==> 09/27/07@21:17:41
ACTIVE PIDS: 22996 24134
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:18:39
ACTIVE PIDS: 21622 22996 24134
PROCESS COUNT: 2 xcalc Processes Running ==> 09/27/07@21:18:58
ACTIVE PIDS: 21622 22996
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:19:04
ACTIVE PIDS: 18180 21622 22996
PROCESS COUNT: 4 xcalc Processes Running ==> 09/27/07@21:19:10
ACTIVE PIDS: 18180 21622 22758 22996
PROCESS COUNT: 6 xcalc Processes Running ==> 09/27/07@21:19:17
ACTIVE PIDS: 18180 21622 22758 22996 23164 26244
PROCESS COUNT: 5 xcalc Processes Running ==> 09/27/07@21:19:37
ACTIVE PIDS: 18180 22758 22996 23164 26244
PROCESS COUNT: 4 xcalc Processes Running ==> 09/27/07@21:19:47
ACTIVE PIDS: 18180 22996 23164 26244
PROCESS COUNT: 3 xcalc Processes Running ==> 09/27/07@21:19:53
ACTIVE PIDS: 18180 22996 26244
PROCESS COUNT: 2 xcalc Processes Running ==> 09/27/07@21:19:55
ACTIVE PIDS: 18180 26244
PROCESS COUNT: 1 xcalc Processes Running ==> 09/27/07@21:20:05
ACTIVE PIDS: 18180
PROCESS COUNT: 0 xcalc Processes Running ==> 09/27/07@21:20:09
ACTIVE PIDS:
ENDING PROCESS: xcalc END time  ==> 09/27/07@21:20:11
POST EVENT: Executing Post Event Script...
SUCCESS: Post Event Script Completed RC - 0
MON_STOPPED: Monitoring for xcalc ended ==> 09/27/07@21:20:23

LOGFILE: All Events are Logged ==> /tmp/proc_status.log
```

Listing 10-10 (*continued*)

Other Options to Consider

The `proc_watch_timed.ksh` shell script is thorough, but it may need to be tailored to a more specific need. Some additional considerations are listed next.

Common Uses

These scripts are suited for things like monitoring how long a process runs, logging a process as it starts and stops, restarting a process that has terminated prematurely, and monitoring a problem user or contractor. We can also monitor activity on a particular `tty` port and send an email as a process starts execution. Use your imagination.

We can start the monitoring script on the command line, or as a cron or `at` job, and run it during the work day. A cron table entry might look like the following:

```
0 7 * * 1-5 /usr/local/bin/proc_watch_timed.ksh -h9 -p fred >/dev/null
```

This cron table entry would monitor any process in the process table that contained ''fred'' from 7:00 a.m. Monday through Friday for nine hours. Anything in the system's process list can be monitored from seconds to days.

Modifications to Consider

These scripts are generic, and you may want to make modifications. One option to consider is to list the actual lines in the process list instead of only the PID and a process count with a timestamp. For a more accurate timing you may want to check the date/time at longer intervals (as opposed to counting down). Another good idea is to get the timing data and run an `at` command to `kill` the script at the specified time. Also, consider using the shell built-in variable `SECONDS`. First initialize the `SECONDS` variable to `0`, zero, and it will automatically increment each second as long as the parent process is executing. The pre-startup, and post-events are something else to look at, the startup in particular. The `startup_event_script` currently executes only when (1) the monitoring starts and the target process is running and (2) when the very first, if more than one, process starts, not as *each* process starts. You may want to modify this function's execution to run only as each individual process starts, and not to execute when monitoring starts and the target process is already running. Additionally, depending on what is to be executed for any of these events, some `sleep` time might be needed to allow for things to settle down. As we can see, there are many ways to do all this, and everyone has different expectations and requirements. Just remember that we never have a *final script*; we just try to be flexible!

Summary

In this chapter we started with a very basic idea of monitoring for a process to start or stop. We quickly built on user options to monitor the process state for a specified period of time and added timestamps. We also allowed the user to specify pre-startup, and post-events to execute as an option. Never try to do everything at once. Build

a short shell script that does the basic steps of your target goal and expand on the base shell script to build in the nice-to-have things. I use the `proc_mon.ksh` and `proc_wait.ksh` shell scripts almost daily for monitoring system events, and they sure do save a lot of time otherwise spent reentering the same command over and over again.

In the next chapter we are going to play around with random numbers — well, that would actually be pseudo-random numbers, because the computer is going to generate them. Stick around; the next chapter is very interesting.

Lab Assignments

1. Adapt the pre-event, startup, and post-event strategy to a generic shell script. Create a generic shell script that controls a program or application, currently unknown, and has pre-processing, startup, and post-processing capability. Just use a no-op as a placeholder in each function.
2. Modify the `proc_watch_timed.ksh` shell script in Listing 10-9 to show each process as well as the number of currently active processes.
3. Modify the shell script that resulted in Lab Assignment 2 to use the built-in shell variable `SECONDS`. To start timing, initialize the `SECONDS` variable to `0`, zero. As the `SECONDS` variable automatically increments, your script should exit at the correct time.
4. Modify the `proc_watch_timed.ksh` shell script in Listing 10-9 to exit at the specified time, using the `at` command to kill the script.

CHAPTER 11

Pseudo-Random Number and Data Generation

When we enter the realm of randomness, we head straight for the highest level of mathematical complexity and outright conflict between researchers. This conflict revolves around the following question:

Can a computer create a *true* random number?

If you believe some experts, you are living in dreamland if you think a computer can create a true random number. However, we are going to study several ways to produce pseudo-random numbers. Some of these techniques are able to create numbers that are suitable for encryption keys and for cryptographic secure communication links, and some are not.

What Makes a Random Number?

It is very difficult, if not impossible, to create a *true* random number in a computer system. The problem is, at some level, repeatability and predictability of the number. When you start researching random numbers you quickly enter the realm of heavy mathematical theory, and many of the researchers have varying opinions of randomness. I will leave this discussion to university professors and professional statisticians. The only *true* random numbers that I know of, in my limited research, are the frequency variations of radioactive decay events and the frequency variations of white noise. Radioactive decay events would have to be detected in some way, and because we do not want to have any radioactive material hanging around we can use built-in computer programs called pseudo-random number generators, and even query the UNIX kernel's own random number generator by reading the `/dev/random` character special file.

A popular UNIX technique is to use a UNIX character special file called `/dev/random`. If you search the Internet for `/dev/random`, you will find more information

than you could imagine on the topic of randomness. Randomness is a discussion topic with many experts in the field having widely varying viewpoints. I am not an expert on randomness, and an in-depth study of this topic is beyond the scope of this book.

Some of the numbers we will create in this chapter are sufficiently random for one-time encryption keys. Other numbers should not be used because they can be repeatable and cyclical in nature, at some level, but they are suitable to create unique filenames and pseudo-random data for a file.

The Bash, Bourne, and Korn shells provide a shell variable called — you guessed it — `RANDOM`. This pseudo-random number generator uses a *seed* as a starting point to create all future numbers in the sequence. After the initial seed is used to create a pseudo-random number, this resulting number is used to create the next random number, and so on. As you would expect, if you always start generating your numbers with the same seed each time, you will get the exact same number sequence each time. To change the repeatability we need to have a mechanism to vary the initial seed each time we start generating numbers. I like to use two different methods. The first is to use the current process ID (PID) because this number will vary widely and is an easy way to change the seed value each time we start generating numbers. The second method is to read the `/dev/random` character special file to create the initial seed. The `/dev/urandom` character special file is a better option than using the shell's `RANDOM` variable.

The Methods

In this chapter we are going to look at four techniques to generate pseudo-random numbers, and one method of using random data:

- Create numbers between zero and the maximum number allowed by the shell (32,767)
- Create numbers between one and a user-defined maximum
- Create fixed-length numbers between one and a user-defined maximum, with leading zeros added if needed
- Create a large 64-bit random number, and smaller random numbers, by reading the `/dev/random` character special file, in concert with the **dd** and **od** commands
- Create a specific-MB-size file filled with random alphanumeric characters

Each method is valid for a filename extension, but the `/dev/random` special character file will produce the highest level of randomness, followed by the `/dev/urandom` character special file. Of course, you may have other uses that require either a range of numbers or a random number of a fixed length, with leading zeros to fill the extra spaces. For example, you might need to create 64 random numbers. In any case, the basic concept is the same. We are going to look at all these methods throughout this chapter.

Method 1: Creating a Pseudo-Random Number Utilizing the PID and the RANDOM Shell Variable

To begin with the basic command-line syntax, we start out by initializing the RANDOM shell variable to the current PID:

```
RANDOM=$$
```

The double dollar signs ($$) specify the PID of the current system process. The PID will vary, so this is a good way to initialize the RANDOM variable so that we do not always repeat the same number sequence. Once the RANDOM environment variable is initialized we can use RANDOM just like any other variable. Most of the time we will use the echo command to print the next pseudo-random number. An example of using the RANDOM environment variable is shown in Listing 11-1.

```
# RANDOM=$$
# echo $RANDOM
23775
# echo $RANDOM
3431
# echo $RANDOM
12127
# echo $RANDOM $RANDOM
2087 21108
```

Listing 11-1 Using the RANDOM environment variable

By default the RANDOM variable will produce numbers between 0 and 32,767. Notice the last entry in Listing 11-1. We can produce more than one number at a time if we need to by adding more $RANDOM entries to our echo statement. In showing our four methods of creating random numbers in this chapter, we are going to create four functions and then create a shell script that will use one of the four methods, depending on the user-supplied input. The next step is to write a shell script that will create unique filenames using a date/time stamp and a random number, and a file full of random characters.

Method 2: Creating Numbers between 0 and 32,767

Creating pseudo-random numbers using this default method is the simplest way to use the RANDOM environment variable. The only thing that we need to do is to initialize the RANDOM environment variable to an initial seed value and use the echo command to display the new number. The numbers will range from 0 to 32,767, which is the maximum for the RANDOM shell variable. You do not have control over the number of digits, except that the number of digits will not exceed five, and you cannot specify a maximum value for the number in this first method. The function get_random_number is shown in Listing 11-2.

```
function get_random_number
{
# This function gets the next random number from the
# $RANDOM variable. The range is 0 to 32767.

echo "$RANDOM"
}
```

Listing 11-2 get_random_number function

As you can see, the function is just one line, and we are assuming that the `RANDOM` environment variable is initialized in the main body of the calling shell script.

Method 3: Creating Numbers between 1 and a User-Defined Maximum

We often want to limit the range of numbers to not exceed a user-defined maximum. An example is creating lottery numbers between 1 and the maximum number, which might be 36 or 52. We are going to use the modulo arithmetic operator to reduce all numbers to a fixed set of numbers between [0..N-1], which is called *modulo N arithmetic*.

For our number range we need a user-supplied maximum value, which we will assign to a variable called `UPPER_LIMIT`. The modulo operator is the percent sign (%), and we use this operator the same way that we use the forward slash (/) in division. The modulo operation returns the remainder of the division. We still use the `RANDOM` environment variable to get a new pseudo-random number. This time, though, we are going to use the following equation to limit the number to not exceed the user-defined maximum using *modulo N arithmetic*.

```
RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))
```

Notice that we added 1 to the equation.

Using the preceding equation will produce a pseudo-random number between 1 and the user-defined `$UPPER_LIMIT`. The function using this equation is `in_range_random_number` and is shown in Listing 11-3.

```
function in_range_random_number
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

echo "$RANDOM_NUMBER"
}
```

Listing 11-3 in_range_random_number function

The function in Listing 11-3 assumes that the RANDOM variable seed has been initialized in the main body of the calling shell script and that a user-defined UPPER_LIMIT variable has been set. This function will produce numbers between 1 and the user-defined maximum value, but the number of digits will vary as the numbers are produced.

Method 4: Creating Fixed-Length Numbers between 1 and a User-Defined Maximum

In both of the previous two examples we had no way of knowing how many digits the new number would contain. When we are creating unique filenames, it would be nice to have filenames that are consistent in length. We can produce fixed-length numbers by padding the number with leading zeros for each missing digit. As an example we want all of our numbers to have four digits. Now let's assume that the number that is produced is 24. Because we want 24 to have four digits, we need to pad the number with two leading zeros, which will make the number 0024. To pad the number we need to know the length of the character string that makes up the number. The Korn and Bash shells use the hash mark (#) preceding the variable enclosed within curly braces ({}), as shown here:

```
RN_LENGTH=$(echo ${#RANDOM_NUMBER})
```

If the RANDOM_NUMBER variable has the value 24 assigned, the result of the previous command is 2 (this RN_LENGTH variable points to the value 2), indicating a string length of two digits. We will also need the length of the UPPER_LIMIT value, and we will use the difference to know how many zeros to use to pad the pseudo-random number output. Take a close look at the code in Listing 11-4, where you will find the function in_range_fixed_length_random_number.

```
function in_range_fixed_length_random_number
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined.
# This function will also pad the output with leading
# zeros to keep the number of digits consistent.

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

# Find the length of each character string

RN_LENGTH=$(echo ${#RANDOM_NUMBER})
UL_LENGTH=$(echo ${#UPPER_LIMIT})

# Calculate the difference in string length

(( LENGTH_DIFF = UL_LENGTH - RN_LENGTH ))
```

Listing 11-4 in_range_fixed_length_random_number function

```
# Pad the $RANDOM_NUMBER value with leading zeros
# to keep the number of digits consistent.

case $LENGTH_DIFF in
0)  echo "$RANDOM_NUMBER"
    ;;
1)  echo "0$RANDOM_NUMBER"
    ;;
2)  echo "00$RANDOM_NUMBER"
    ;;
3)  echo "000$RANDOM_NUMBER"
    ;;
4)  echo "0000$RANDOM_NUMBER"
    ;;
5)  echo "00000$RANDOM_NUMBER"
    ;;
*)  echo "$RANDOM_NUMBER"
    ;;
esac
}
```

Listing 11-4 (*continued*)

In Listing 11-4 we use the same technique from Listing 11-3 to set an upper limit to create our numbers, but we add in code to find the string length of both the `UPPER_LIMIT` and `RANDOM_NUMBER` values, specified by the `${#UPPER_LIMIT}` and `echo ${#RANDOM_NUMBER}` statements, respectively. The `#`, hash mark, tells the `echo` command to return the length of the string assigned to the variable. By knowing the length of both strings we subtract the random-number length from the upper-limit length and use the difference in a `case` statement to add the correct number of zeros to the output.

Because this is a function, we again need to assume that the `UPPER_LIMIT` is defined and the `RANDOM` environment variable is initialized in the main body of the calling shell script. The resulting output is a fixed-length pseudo-random number padded with leading zeros if the output string length is less than the upper-limit string length. Example output is shown in Listing 11-5 for an `UPPER_LIMIT` value of 9999.

```
0024
3145
9301
0328
0004
4029
2011
0295
0159
4863
```

Listing 11-5 Sample output for fixed-length random numbers

Why Pad the Number with Zeros the Hard Way?

An easier, and much cleaner, way to pad a number with leading zeros is to **`typeset`** the variable to a fixed length. The command in Listing 11-6 works for any length of number.

```
typeset -Z5 FIXED_LENGTH
FIXED_LENGTH=25
echo $FIXED_LENGTH
00025
```

Listing 11-6 Using the typeset command to fix the length of a variable

The example in Listing 11-6 used the `typeset` command to set the length of the `FIXED_LENGTH` variable to five digits. Then we assigned the value 25 to it. When we use the `echo` command to show the value assigned to the variable the result is 00025, which is fixed to five digits. Let's modify the function in Listing 11-4 to use this technique, as shown in Listing 11-7.

```
function in_range_fixed_length_random_number_typeset
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined.
# This function will also pad the output with leading
# zeros to keep the number of digits consistent using
# the typeset command.

# Find the length of each character string

UL_LENGTH=$(echo ${#UPPER_LIMIT})

# Fix the length of the RANDOM_NUMBER variable to
# the length of the UPPER_LIMIT variable, specified
# by the $UL_LENGTH variable.

typeset -Z$UL_LENGTH  RANDOM_NUMBER

# Create a fixed length pseudo-random number

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

# Return the value of the fixed length $RANDOM_NUMBER

echo $RANDOM_NUMBER
}
```

Listing 11-7 Using the typeset command in a random-number function

As you can see in Listing 11-7, we took all the complexity out of fixing the length of a number. The only value we need to know is the length of the `UPPER_LIMIT` variable

assignment. For example, if the upper limit is 9999, the length is 4. We use 4 to `typeset` the `RANDOM_NUMBER` variable to four digits.

Now that we have four functions that will create pseudo-random numbers, but before we proceed with a shell script that will use these functions, let's study the `/dev/random` and `/dev/urandom` character special files to produce random numbers.

Method 5: Using the /dev/random and /dev/urandom Character Special Files

Other methods to create pseudo-random numbers include using the character special files `/dev/random` and `/dev/urandom`. These character special files are an interface to the kernel's random number generator. The kernel random number generator uses *system noise* from device drivers, and other environmental noise a computer generates to create an *entropy pool* of random noise data. The kernel's random number generator keeps track of the number of bits of noise remaining in the entropy pool. When we read the `/dev/random` character special file, using the `dd` command, random bytes of noise are returned within the range of available noise in the entropy pool. When the entropy pool is empty, `/dev/random` will *block* while the kernel gathers more environmental system noise. During this blocking period, `/dev/random` will not return data and we can see a pause in execution of our shell scripts.

The `/dev/urandom` character special file does not block when the entropy pool is empty; therefore, the randomness is to a lesser degree. Using `/dev/urandom` in a shell script will not show the possible delays in execution as `/dev/random` will, so `/dev/urandom` is often the preferred method.

All of the techniques studied in this chapter using the `/dev/random` will produce numbers with the highest degree of randomness.

To *read* the `/dev/random` character special file, we will use the `dd` command. The `dd` command is used to convert and copy files. If you are not familiar with using the `dd` command, study the `dd` manual page, **man dd**.

Trying to read the `/dev/random` and `/dev/urandom` character special files directly with `dd` returns non-printable binary data. To get some usable random numbers, we need to pipe the `dd` command output to the **od**, octal dump, command. Specifically, we use `od` to dump the data to an unsigned integer. The code shown in Listing 11-8 assigns an unsigned random integer to the `RN` variable.

```
RN=$(dd if=/dev/random count=1 2>/dev/null \
    | od -t u4 | awk '{print $2}'| head -n 1)
```

Listing 11-8 Using /dev/random to return a random number

Notice in Listing 11-8 that the `dd` command uses `/dev/random` as the input file. We set the `count` equal to `1` to return one byte of data. Then, and this is important, we send all the standard error output, specified by file descriptor 2, to the bit bucket. If we omit the `2>/dev/null` redirection, we get unwanted data. The remaining standard output is piped to the `od` command to convert the binary data to an unsigned integer, specified by the `-t u4` command switch. By changing the value assigned to `u`, we

change the length of the random number returned. To create a 64-bit, not 64-character, random number, we just change the `-t u4` to `-t u8`. An example of using different `u` values is shown in Listing 11-9.

```
[root@booboo ~]#  dd if=/dev/urandom count=1 2>/dev/null |
od -t u1 | awk '{print $2}'| head -n 1

121
[root@booboo ~]#  dd if=/dev/urandom count=1 2>/dev/null |
 od -t u2 | awk '{print $2}'| head -n1

10694

[root@booboo ~]#  dd if=/dev/urandom count=1 2>/dev/null |
 od -t u4 | awk '{print $2}'| head -n 1

1891340326

[root@booboo ~]#  dd if=/dev/urandom count=1 2>/dev/null |
 od -t u8 | awk '{print $2}'| head -n 1

2438974545704940532

[root@booboo ~]#
```

Listing 11-9 Creating different-size random numbers utilizing od

Notice in Listing 11-9 that as we increment the value assigned to the `-t u#`, our random number increases in length. A `u` value of `1` produces an 8-bit number, in this case `121`. Increasing the `u` value to `2` produces a 16-bit random number, `10694`. Going to a `u` value of `4` produces the 32-bit number `1891340326`. The longest number using this method is the 64-bit number `2438974545704940532` we produced with a `u` value of `8`. These are the only valid `u` values for unsigned integers.

Also notice in Listing 11-9 that we used `/dev/urandom` in place of `/dev/random`. By using `/dev/urandom`, we avoid blocking if the entropy pool becomes empty. No big deal here, but `/dev/random` produces a higher level of randomness.

There are many other things we can do when creating random numbers in this manner. In Listing 11-10 we use the `/dev/urandom` character special file to create an output with a specific number of random numbers, with one number on each line. Pay special attention to the last `dd` command.

```
#!/bin/Bash
#
# SCRIPT: random_number_testing.Bash
# AUTHOR: Randy Michael
# DATE: 8/8/2007
```

Listing 11-10 random_number_testing.Bash shell script

```
# For each 1K count we get 64 lines of random numbers

dd if=/dev/urandom count=1k bs=1 2>/dev/null | od -t u2 \
   | awk '{print $2}' | sed /^$/d > 64random_numbers.txt

# For each 1M count we get 65536 lines of random numbers

dd if=/dev/urandom count=1M bs=1 2>/dev/null | od -t u2 \
   | awk '{print $2}' | sed /^$/d > 65536random_numbers.txt

# The opposite is /dev/zero which will create a null
# file of a specific size

dd if=/dev/zero of=1MBemptyfile count=1M bs=1  2>/dev/null
```

Listing 11-10 (*continued*)

The results of executing the `random_number_testing.Bash` shell script in Listing 11-10 are shown in Listing 11-11.

```
[root@booboo scripts]# ls -ltr
-rwxr-xr--  1 root  root  582 07:17 random_number_testing.Bash
-rw-r--r--  1 root  root  370 07:30 64random_numbers.txt
-rw-r--r--  1 root  root  382031 07:30 65536random_numbers.txt
-rw-r--r--  1 root  root  1048576 07:30 1MBemptyfile
[root@booboo scripts]# wc -l 64random_numbers.txt
64 64random_numbers.txt
[root@booboo scripts]# wc -l 65536random_numbers.txt
65536 65536random_numbers.txt
[root@booboo scripts]# head 64random_numbers.txt
51890
17416
58012
4220
48095
18080
6847
4963
39421
44931
[root@booboo scripts]#
```

Listing 11-11 random_number_testing.Bash script in action

Notice the three files created in Listing 11-11. The first file, `64random_numbers.txt`, contains 64 random numbers, one per line. The second file, `65536random_numbers.txt`, contains 65,536 random numbers, one per line.

The third file is named `1Mbemptyfile`. Notice in Listing 11-10 that the third `dd` command uses the `/dev/zero` character special file. This file produces NULL data. So, by replacing the `/dev/random` with `/dev/zero`, we create a specific size file of NULL data. This is kind of like a sparse file.

NOTE **Be very careful using this method so that you do not wipe out a critical system file. I'm not really sure of an application where you would need a 1 MB file filled with NULL data, but if you need one, here you go!**

Shell Script to Create Pseudo-Random Numbers

Using the three functions from Listings 11-2, 11-3, and 11-7, we are going to create a shell script that, depending on the command-line arguments, will use one of these three functions. We first need to define how we are going to use each function.

With the usage definitions from Table 11-1 let's create a shell script. We already have the functions to create the numbers, so we will start with `BEGINNING OF MAIN` in the shell script.

For the `usage` function we will need the name of the shell script. We never want to hard-code the name of a shell script because someone may rename the shell script for one reason or another. To query the system for the actual name of the shell script we use the `basename $0` command. This command will return the name of the shell script, specified by the `$0` argument, with the directory path stripped out. I like to use either of the following command-substitution methods to create a `SCRIPT_NAME` variable:

```
SCRIPT_NAME=`basename $0`
```

or

```
SCRIPT_NAME=$(basename $0)
```

The result of both command-substitution commands is the same. Next we need to initialize the `RANDOM` environment variable. As previously described, we are going to use the current process ID as the initial seed for the `RANDOM` variable:

```
RANDOM=$$
```

Table 11-1 random_number.ksh Shell Script Usage

SHELL SCRIPT USAGE	FUNCTION USED TO CREATE THE NUMBER
`random_number.ksh`	Without argument will use `get_random_number`
`random_number.ksh 9999`	With one numeric argument will use `in_range_random_number`
`random_number.ksh -f 9999`	With `-f` as the first argument followed by a numeric argument will use `in_range_fixed_length_random_number_typeset`

The SCRIPT_NAME and the RANDOM variables are the only initialization needed for this shell script. The rest of the script is a case statement that uses the number of command-line arguments ($#) as a value to decide which random number function we will use. We also do some numeric tests to ensure that ''numbers'' are actually numeric values. For the numeric tests we use the regular expression +([0-9]) in a case statement. If the value is a number, then we do nothing, which is specified by the no-op character, colon (:).

NOTE The Bash shell does not support the regular expression notation +([0-9]) to test strings.

The entire shell script is shown in Listing 11-12.

```
#!/usr/bin/ksh
#
# AUTHOR: Randy Michael
# SCRIPT: random_number.ksh
# DATE: 11/12/2007
# REV: 1.2.P
#
# PLATFORM: Not Platform Dependent
#
# EXIT CODES:
#          0 - Normal script execution
#          1 - Usage error
#
# REV LIST:
#
#
# set -x # Uncomment to debug
# set -n # Uncomment to check syntax without any command execution
#
#####################################################
########## DEFINE FUNCTIONS HERE ###################
#####################################################

function usage
{
echo "\nUSAGE: $SCRIPT_NAME [-f] [upper_number_range]"
echo "\nEXAMPLE: $SCRIPT_NAME"
echo "Will return a random number between 0 and 32767"
echo "\nEXAMPLE: $SCRIPT_NAME 1000"
echo "Will return a random number between 1 and 1000"
echo "\nEXAMPLE: $SCRIPT_NAME -f 1000"
echo "Will add leading zeros to a random number from"
echo "1 to 1000, which keeps the number of digits consistent\n"
}
```

Listing 11-12 random_number.ksh shell script

```
####################################################

function get_random_number
{
# This function gets the next random number from the
# $RANDOM variable. The range is 0 to 32767.

echo "$RANDOM"
}

####################################################

function in_range_random_number
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

echo "$RANDOM_NUMBER"
}

####################################################


function in_range_fixed_length_random_number_typeset
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined.
# This function will also pad the output with leading
# zeros to keep the number of digits consistent using
# the typeset command.

# Find the length of each character string

UL_LENGTH=$(echo ${#UPPER_LIMIT})

# Fix the length of the RANDOM_NUMBER variable to
# the length of the UPPER_LIMIT variable, specified
# by the $UL_LENGTH variable.

typeset -Z$UL_LENGTH  RANDOM_NUMBER

# Create a fixed length pseudo-random number

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

# Return the value of the fixed length $RANDOM_NUMBER
```

Listing 11-12 (*continued*)

```
echo $RANDOM_NUMBER
}

#####################################################
############## BEGINNING OF MAIN ###################
#####################################################

SCRIPT_NAME=`basename $0`

RANDOM=$$  # Initialize the RANDOM environment variable
           # using the PID as the initial seed

case $# in
0)   get_random_number
;;

1)  UPPER_LIMIT="$1"

    # Test to see if $UPPER_LIMIT is a number

    case $UPPER_LIMIT in
    +([0-9])) :    # Do Nothing...It's a number
                   # NOTE: A colon (:) is a no-op in Korn shell
           ;;
    *)       echo "\nERROR: $UPPER_LIMIT is not a number..."
             usage
             exit 1
           ;;
    esac

    # We have a valid UPPER_LIMIT. Get the number.

    in_range_random_number
;;

2)  # Check for the -f switch to fix the length.

    if [[ $1 = '-f' ]] || [[ $1 = '-F' ]]
    then

         UPPER_LIMIT="$2"

         # Test to see if $UPPER_LIMIT is a number

         case $UPPER_LIMIT in
         +([0-9])) :    # Do nothing...It's a number
                        # NOTE: A colon (:) is a no-op in Korn shell
```

Listing 11-12 (*continued*)

```
                ;;
          *)        echo "\nERROR: $UPPER_LIMIT is not a number..."
                    usage
                    exit 1
                ;;
          esac

          in_range_fixed_length_random_number_typeset

     else
          echo "\nInvalid argument $1, see usage below..."
          usage
          exit 1
     fi
;;

*)  usage
     exit 1
;;
esac

# End of random_number.ksh shell script
```

Listing 11-12 (*continued*)

Notice in Listing 11-12 that we will allow only zero, one, or two command-line arguments. More than three arguments produces an error, and nonnumeric values, other than `-f` or `-F` in argument one, will produce a `usage` error. Output using the `random_number.ksh` shell script is shown in Listing 11-13.

```
yogi@/scripts# random_number.ksh 32000
10859
yogi@/scripts# random_number.ksh -f 32000
14493
yogi@/scripts# ./random_number.ksh -f 32000
05402
yogi@/scripts# ./random_number.ksh -f

ERROR: -f is not a number...

USAGE: random_number.ksh [-f] [upper_number_range]

EXAMPLE: random_number.ksh
Will return a random number between 0 and 32767

EXAMPLE: random_number.ksh 1000
```

Listing 11-13 random_number.ksh shell script in action

```
Will return a random number between 1 and 1000

EXAMPLE: random_number.ksh -f 1000
Will add leading zeros to a random number from
1 to 1000, which keeps the number of digits consistent
```

Listing 11-13 (*continued*)

The last part of Listing 11-13 is a usage error. Notice that we give an example of each of the three uses for the `random_number.ksh` shell script as well as state why the usage error occurred.

Now that we have the shell script to produce pseudo-random numbers, we need to move on to creating unique filenames.

Creating Unique Filenames

In writing shell scripts we sometimes run into a situation where we are creating files faster than we can make the filenames unique. Most of the time a date/time stamp can be added as a suffix to the filename to make the filename unique, but if we are creating more than one file per second, we end up overwriting the same file during a single second. To get around this problem, we can create pseudo-random numbers to append to the filename after the date/time stamp. In the next section and in Chapter 12, ''Creating Pseudo-Random Passwords,'' we will study creating *pseudo-random characters* by using the computer-generated numbers as pointers to array elements that contain keyboard characters. We will use a similar method to create a *random file*.

The goal of this section is to write a shell script that will produce unique filenames using a date/time stamp with a pseudo-random number as an extended suffix. When I create these unique filenames I like to keep the length of the filenames consistent, so we are going to use only one of the random number functions, `in_range_fixed_length_random_number_typeset`.

We have a few new pieces to put into this new shell script. First we have to assume that there is some program or shell script that will be putting data into each of the unique files. To take care of executing the program or shell script we can add a function that will call the external program, and we will redirect our output to the new unique filename on each loop iteration. The second piece is that we need to ensure that we never use the same number during the same second. Otherwise, the filename is not unique and the data will be overwritten. We need to keep a list of each number that we use during each second and reset the `USED_NUMBERS` list to null on each new second. In addition we need to `grep` the list each time we create a new number to see if it has already been used. If the number has been used we just create a new number and check for previous usage again.

The procedure to step through our new requirements is not difficult to understand once you look at the code. The full shell script is shown in Listing 11-14, and an example of using the shell script is shown in Listing 11-15. Please study the script carefully, and we will go through the details at the end.

```
#!/usr/bin/ksh
#
# AUTHOR: Randy Michael
# SCRIPT: mk_unique_filename.ksh
# DATE: 11/12/2007
# REV: 1.2.P
#
# PLATFORM: Not Platform Dependent
#
# EXIT CODES:
#               0 - Normal script execution
#               1 - Usage error
#
# REV LIST:
#
#
# set -x # Uncomment to debug
# set -n # Uncomment to debug without any execution
#
#######################################################
########## DEFINE FUNCTIONS HERE ###################
#######################################################

function usage
{
echo "\nUSAGE: $SCRIPT_NAME base_file_name\n"
exit 1
}

#######################################################

function get_date_time_stamp
{
DATE_STAMP=$(date +'%m%d%y.%H%M%S')
echo $DATE_STAMP
}

#######################################################

function get_second
{
THIS_SECOND=$(date +%S)
echo $THIS_SECOND
}

#######################################################

function in_range_fixed_length_random_number_typeset
```

Listing 11-14 mk_unique_filename.ksh shell script

```
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is user defined.
# This function will also pad the output with leading
# zeros to keep the number of digits consistent using
# the typeset command.

# Find the length of each character string

UL_LENGTH=$(echo ${#UPPER_LIMIT})

# Fix the length of the RANDOM_NUMBER variable to
# the length of the UPPER_LIMIT variable, specified
# by the $UL_LENGTH variable.

typeset -Z$UL_LENGTH  RANDOM_NUMBER

# Create a fixed length pseudo-random number

RANDOM_NUMBER=$(($RANDOM % $UPPER_LIMIT + 1))

# Return the value of the fixed length $RANDOM_NUMBER

echo $RANDOM_NUMBER
}


######################################################

function my_program
{
# Put anything you want to process in this function. I
# recommend that you specify an external program of shell
# script to execute.

echo "HELLO WORLD - $DATE_ST" > $UNIQUE_FN &

#    :  # No-Op - Does nothing but has a return code of zero
}

######################################################
################ BEGINNING OF MAIN ##################
######################################################

SCRIPT_NAME=$(basename $0) # Query the system for this script name

# Check for the correct number of arguments - exactly 1
```

Listing 11-14 (*continued*)

```
if (( $# != 1 ))
then
      echo "\nERROR: Usage error...EXITING..."
      usage
fi

# What filename do we need to make unique?

BASE_FN=$1     # Get the BASE filename to make unique

RANDOM=$$      # Initialize the RANDOM environment variable
               # with the current process ID (PID)

UPPER_LIMIT=32767 # Set the UPPER_LIMIT

CURRENT_SECOND=99 # Initialize to a nonsecond
LAST_SECOND=98    # Initialize to a nonsecond

USED_NUMBERS=     # Initialize to null

PROCESSING="TRUE" # Initialize to run mode

while [[ $PROCESSING = "TRUE" ]]
do
    DATE_ST=$(get_date_time_stamp) # Get the current date/time
    CURRENT_SECOND=$(get_second)   # Get the current second

    RN=$(in_range_fixed_length_random_number_typeset) #
Get a new number

    # Check to see if we have already used this number this second

    if (( CURRENT_SECOND == LAST_SECOND ))
    then
         UNIQUE=FALSE # Initialize to FALSE
         while [[ "$UNIQUE" != "TRUE" ]] && [[ ! -z "$UNIQUE" ]]
         do
            # Has this number already been used this second?
            echo $USED_NUMBERS | grep $RN >/dev/null 2>&1
            if (( $? == 0 ))
            then
                # Has been used...Get another number
                RN=$(in_range_fixed_length_random_number)
            else
                # Number is unique this second...
                UNIQUE=TRUE
                # Add this number to the used number list
                USED_NUMBERS="$USED_NUMBERS $RN"
```

Listing 11-14 (*continued*)

```
            fi
        done
    else
        USED_NUMBERS=   # New second...Reinitialize to null
    fi
    # Assign the unique filename to the UNIQUE_FN variable

    UNIQUE_FN=${BASE_FN}.${DATE_ST}.$RN

    # echo $UNIQUE_FN # Comment out this line!!

    LAST_SECOND=$CURRENT_SECOND # Save the last second value

    # We have a unique filename...
    #

    # Process something here and redirect output to $UNIQUE FN
    #
    my_program
    #

    # If processing is finished assign "FALSE" to the
    # PROCESSING VARIABLE
    #
    # if [[ $MY_PROCESS = "done" ]]
    # then
    #       PROCESSING="FALSE"
    # fi
done
```

Listing 11-14 (*continued*)

We use five functions in the shell script in Listing 11-14. As usual, we need a function for correct `usage`. We are expecting exactly one argument to this shell script, the *base filename* to make into a unique filename. The second function is used to get a date/time stamp. The **date** command has a lot of command switches that allow for flexible date/time stamps. We are using two digits for month, day, year, hour, minute, and second, with a period (.) between the date and time portions of the output. This structure is the first part that is appended to the base filename. The `date` command has the following syntax: `date+'%m%d%y.%H%M%S'`.

We also need the current second of the current minute. The current second is used to ensure that the pseudo-random number that is created is unique to each second, thus a unique filename. The `date` command is used again using the following syntax: `date+%S`.

The `in_range_fixed_length_random_number_typeset` function is used to create our pseudo-random numbers in this shell script. This function keeps the number of digits consistent for each number that is created. With the base filename, date/time stamp, and the unique number put together, we are assured that every filename has the same number of characters.

One more function is added to this shell script. The `my_program` function is used to point to the program or shell script that needs all of these unique filenames. It is better to point to an external program or shell script than to try to put everything in the internal `my_program` function and debug the internal function on an already working shell script. Of course, I am making an assumption that you will execute the external program once during each loop iteration, which may not be the case. At any rate, this script will show the concept of creating unique filenames while remaining in a tight loop. Or just write the functions into your application.

At the `BEGINNING OF MAIN` in the main body of the shell script we first query the system for the name of the shell script. The script name is needed for the `usage` function. Next we check for exactly one command-line argument. This single command-line argument is the base filename that we use to create further unique filenames. The next step is to assign our base filename to the variable `BASE_FN` for later use.

The `RANDOM` shell variable is initialized with an initial seed, which we decided to be the current process ID (PID), specified by the `$$` shell variable. This technique helps to ensure that the initial seed changes each time the shell script is executed. For this shell script we want to use the maximum value as the `UPPER_LIMIT`, which is 32,767. If you need a longer or shorter pseudo-random number, you can change this value to anything you want. If you make this number longer than five digits the extra preceding digits will be zeros. There are four more variables that need to be initialized. We initialize both `CURRENT_SECOND` and `LAST_SECOND` to non-second values `99` and `98`, respectively. The `USED_NUMBERS` list is initialized to NULL, and the `PROCESSING` variable is initialized to `TRUE`. The `PROCESSING` variable allows the loop to continue creating unique filenames and to keep calling the `my_process` function. Any non-`TRUE` value stops the loop and thus ends execution of the shell script.

A `while` loop is next in our shell script, and this loop is where all of the work is done. We start out by getting a new date/time stamp and the current second on each loop iteration. Next a new pseudo-random number is created and is assigned to the `RN` variable. If the current second is the same as the last second, then we start another loop to ensure that the number that we created has not been previously used during the current second. It is highly unlikely that a duplicate number would be produced in such a short amount of time, but to be safe we need to do a sanity check for any duplicate numbers.

When we get a unique number we are ready to put the new filename together. We have three variables that together make up the filename: `$BASE_FN`, `$DATE_ST`, and `$RN`. The next command puts the pieces together and assigns the newly constructed filename to the variable to the `UNIQUE_FN` variable:

```
UNIQUE_FN=${BASE_FN}.${DATE_ST}.$RN
```

Notice the use of the curly braces (`{}`) around the first two variables, `BASE_FN` and `DATE_ST`. The curly braces are needed because there is a character that is not part of the variable name without a space. The curly braces separate the variable from the character to ensure that we do not get unpredictable output. Because the last variable, `$RN`, does not have any character next to its name, the curly braces are not needed, but it is *not* a mistake to add them.

The only thing left is to assign the `$CURRENT_SECOND` value to the `LAST_SECOND` variable and to execute the `my_program` function, which actually uses the newly created filename. I have commented out the code that would stop the script's execution. You will need to edit this script and make it suitable for your particular purpose. The `mk_unique_filename.ksh` shell script is shown in action in Listing 11-15.

```
yogi@/scripts# ./mk_unique_filename.ksh /tmp/myfilename
/tmp/myfilename.120607.131507.03038
/tmp/myfilename.120607.131507.15593
/tmp/myfilename.120607.131507.11760
/tmp/myfilename.120607.131508.08374
/tmp/myfilename.120607.131508.01926
/tmp/myfilename.120607.131508.07238
/tmp/myfilename.120607.131509.07554
/tmp/myfilename.120607.131509.12343
/tmp/myfilename.120607.131510.08496
/tmp/myfilename.120607.131510.18285
/tmp/myfilename.120607.131510.18895
/tmp/myfilename.120607.131511.16618
/tmp/myfilename.120607.131511.30612
/tmp/myfilename.120607.131511.16865
/tmp/myfilename.120607.131512.01134
/tmp/myfilename.120607.131512.19362
/tmp/myfilename.120607.131512.04287
/tmp/myfilename.120607.131513.10616
/tmp/myfilename.120607.131513.08707
/tmp/myfilename.120607.131513.27006
/tmp/myfilename.120607.131514.15899
/tmp/myfilename.120607.131514.18913
/tmp/myfilename.120607.131515.27120
/tmp/myfilename.120607.131515.23639
/tmp/myfilename.120607.131515.13096
/tmp/myfilename.120607.131516.19111
/tmp/myfilename.120607.131516.05964
/tmp/myfilename.120607.131516.07809
/tmp/myfilename.120607.131524.03831
/tmp/myfilename.120607.131524.21628
/tmp/myfilename.120607.131524.19801
/tmp/myfilename.120607.131518.13556
/tmp/myfilename.120607.131518.24618
/tmp/myfilename.120607.131518.12763

# Listing of newly created files

yogi@/tmp# ls -ltr /tmp/myfilename.*
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131507.15593
```

Listing 11-15 mk_unique_filename.ksh shell script in action

```
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131507.03038
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131508.08374
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131508.01926
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131507.11760
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131509.12343
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131509.07554
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131508.07238
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131510.18285
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131510.08496
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131511.30612
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131511.16618
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131510.18895
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131512.19362
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131512.01134
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131511.16865
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131513.10616
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131513.08707
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131512.04287
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131514.18913
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131514.15899
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131513.27006
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131515.27120
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131515.23639
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131515.13096
```

Listing 11-15 (*continued*)

```
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131516.19111
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131516.05964
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131524.21628
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131524.03831
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131516.07809
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131518.24618
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131518.13556
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131524.19801
-rw-r--r-- root  system  Dec 06 13:15
/tmp/myfilename.120607.131518.12763
```

Listing 11-15 (*continued*)

Creating a File Filled with Random Characters

Ever need a file filled with random character data? Well, here's your miracle! The shell script in Listing 11-16 will create a user-defined-MB-size file that contains random alphanumeric characters.

For this one, study the `random_file.Bash` shell script in Listing 11-16 first. At the end we will cover this script in detail.

```
#!/bin/Bash
#
# SCRIPT: random_file.Bash
# AUTHOR: Randy Michael
# DATE: 8/3/2007
# REV: 1.0
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to create a
#      specific size file of random characters.
#      The methods used in this script include
#      loading an array with alphanumeric
#      characters, then using the /dev/random
#      character special file to seed the RANDOM
#      shell variable, which in turn is used to
```

Listing 11-16 random_file.Bash shell script

```
#      extract a random set of characters from the
#      KEYS array to build the OUTFILE of a
#      specified MB size.
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check script syntax
#        # without any execution. Do not forget
#        # to put the comment back in or the
#        # script will never execute.
#
##########################################
# DEFINE FILES AND VARIABLES HERE
##########################################

typeset -i MB_SIZE=$1
typeset -i RN
typeset -i i=1
typeset -i X=0
WORKDIR=/scripts
OUTFILE=${WORKDIR}/largefile.random.txt
>$OUTFILE
THIS_SCRIPT=$(basename $0)
CHAR_FILE=${WORKDIR}/char_file.txt

##########################################
# DEFINE FUNCTIONS HERE
##########################################

build_random_line ()
{
# This function extracts random characters
# from the KEYS array by using the RANDOM
# shell variable

C=1
LINE=
until (( C > 79 ))
do
   LINE="${LINE}${KEYS[$(($RANDOM % X + 1))]}"
   (( C = C + 1 ))
done

# Return the line of random characters

echo "$LINE"
}
```

Listing 11-16 (*continued*)

```
##########################################

elapsed_time ()
{
SEC=$1

(( SEC < 60 )) && echo -e "[Elapsed time: \
$SEC seconds]\c"

(( SEC >= 60  &&  SEC < 3600 )) && echo -e \
"[Elapsed time: $(( SEC / 60 )) min $(( SEC % 60 )) sec]\c"

(( SEC > 3600 )) && echo -e "[Elapsed time: \
$(( SEC / 3600 )) hr $(( (SEC % 3600) / 60 )) min \
$(( (SEC % 3600) % 60 )) sec]\c"
}

##########################################

load_default_keyboard ()
{
# Loop through each character in the following list and
# append each character to the $CHAR_FILE file. This
# produces a file with one character on each line.

for CHAR in 1 2 3 4 5 6 7 8 9 0 q w e r t y u i o \
            p a s d f g h j k l  z x c v b n m \
            Q W E R T Y U I O P A S D F G H J K L \
            Z X C V B N M 0 1 2 3 4 5 6 7 8 9
do
     echo "$CHAR" >> $CHAR_FILE
done
}
##########################################

usage ()
{
echo -e "\nUSAGE: $THIS_SCRIPT Mb_size"
echo -e "Where Mb_size is the size of the file to build\n"
}

##########################################
# BEGINNING OF MAIN
##########################################

if (( $# != 1 ))
then
     usage
```

Listing 11-16 (*continued*)

```
     exit 1
fi

# Test for an integer value

case $MB_SIZE in
[0-9]) : # Do nothing
          ;;
       *) usage
          ;;
esac

# Test for the $CHAR_FILE

if [ ! -s "$CHAR_FILE" ]
then
     echo -e "\nNOTE: $CHAR_FILE does not esist"
     echo "Loading default keyboard data."
     echo -e "Creating $CHAR_FILE...\c"
     load_default_keyboard
     echo "Done"
fi

# Load Character Array

echo -e "\nLoading array with alphanumeric character elements"

while read ARRAY_ELEMENT
do
    (( X = X + 1 ))
    KEYS[$X]=$ARRAY_ELEMENT

done < $CHAR_FILE

echo "Total Array Character Elements: $X"

# Use /dev/random to seed the shell variable RANDOM

echo "Querying the kernel random number generator for a random seed"

RN=$(dd if=/dev/random count=1 2>/dev/null \
    | od -t u4 | awk '{print $2}'| head -n 1)

# The shell variable RANDOM is limited to 32767

echo "Reducing the random seed value to between 1 and 32767"

RN=$(( RN % 32767 + 1 ))
```

Listing 11-16 (*continued*)

```
# Initialize RANDOM with a new seed

echo "Assigning a new seed to the RANDOM shell variable"

RANDOM=$RN

echo "Building a $MB_SIZE MB random character file ==> $OUTFILE"
echo "Please be patient, this may take some time to complete..."
echo -e "Executing: .\c"

# Reset the shell SECONDS variable to zero seconds.
SECONDS=0

TOT_LINES=$(( MB_SIZE * 12800 ))

until (( i > TOT_LINES ))
do
     build_random_line >> $OUTFILE
     (( $(( i % 100 )) == 0 )) && echo -e ".\c"
     (( i = i + 1 ))
done

# Capture the total seconds

TOT_SEC=$SECONDS

echo -e "\n\nSUCCESS: $OUTFILE created at $MB_SIZE MB\n"

elapsed_time $TOT_SEC

# Calculate the bytes/second file creation rate

(( MB_SEC = ( MB_SIZE * 1024000 ) / TOT_SEC ))

echo -e "\n\nFile Creation Rate: $MB_SEC bytes/second\n"

echo -e "File size:\n"
ls -l $OUTFILE
echo

########################################
# END OF random_file.Bash SCRIPT
########################################
```

Listing 11-16 (*continued*)

For this script to work as written, you will need to create a `/scripts` directory. Before we go through the code in the `random_file.Bash` script in Listing 11-16, let's look at the resulting output in Listing 11-17.

```
[root@booboo scripts]# ./random_ le.Bash 5

Loading array with alphanumeric character elements
Total Array Character Elements: 72
Querying the kernel random number generator for a random seed
Reducing the random seed value to between 1 and 32767
Assigning a new seed to the RANDOM shell variable
Building a 5 MB random character  le ==> /scripts/large le.random.txt
Please be patient, this may take some time to complete...
Executing:
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................................
..................................

SUCCESS: /scripts/large le.random.txt created at 5 MB

[Elapsed time: 5 min 42 sec]

File Creation Rate: 14970 bytes/second

File size:

-rwxr-xr-x 1 root root 5120000 2007-08-07 09:04
/scripts/large le.random.txt

[root@booboo scripts]# head /scripts/large le.random.txt
zo0ZT4y0K4OAacvW7l2S0Xi18262xQV6b4Zt67lFzzfDL9j487F62OYHC1nN830PDCj4aR0R8y8Mn26
AYWUDcHP74ElNWtBQBomvA0KpXAE4Q7k5oFCLaQ23HJ9eWb0UMimE6Rx50LkpIEFlHwRbGaInVIFz4y
vW98z9cJhkJ0B66kdGT67fI4t1BQF7G1c1Lgd0q3Fde49oh1W3pUZ3v4Sutu176SYs8qdMRI9SPM0g9
CjaWtjnTD0lRp6Go8qgtbiQjgwN8eieGT8D8YGzQMjl9AnHPbZmVkJ3ngYu574t1tNI0GwvAtx6ZQDr
5RK66tJzIwl68Q2wHQHTn5oRZA22Ab3v3GHLB0a16KU7dhco2X968MQNKIuzMP3pnE3vlptj1RrF1MC
6b8bqw3kc4UB3dqKs2hKAjVJkvk9VNPhzPaA0j2U4Q2hzZOrUdRem2Q5ypqa6H0I8m8NZr7vwMSB39C
yyIJZdbb65HECXD13JXZys8sGeJ88T17fZmCvhbO6Q5G4Wx5Sr4Vc2Y2Ft5y3kfTzaK0ifHN9kBW1sX
K9tgpgpWvLld7A0h53S6uvneBrT21crJXMD8NDEJ9CGS9yleMPmLfuH7prMME0Bn45ladD36MJRR1E6
BcaBGO87NZslC38X7aaj44NW3fn8yz7sWD4TwBtUpJvm6w1x32P9tcviM1Q6YyWm3DXrP31hNTvcZfX
KqtILEaLBjv21NJU8bpk9f3zwAy92h8XE1I5wxpKw3Qqvbmc8V0OiTdU8zqHj9P8h965lQaqh9qrtr9
[root@booboo scripts]#
```

Listing 11-17 random_file.Bash shell script in action

Now let's go through the `random_file.Bash` shell script in Listing 11-16 from the top.

We first define some files and variables. The `MB_SIZE` variable is a user-defined command-line argument, `$1`. We `typeset` the `MB_SIZE` variable to an integer value, and assign `$1` to this variable all in one statement. We also define our `$OUTFILE` and `$CHAR_FILE` files. The `$OUTFILE` is the random file we create and the `$CHAR_FILE` is the character file we use to load alphanumeric characters into the `KEYS` array.

Next we define some functions. The `build_random_line` utilizes the following `while` loop to create one line of random alphanumeric characters:

```
until (( C > 79 ))
do
   LINE="${LINE}${KEYS[$(($RANDOM % X + 1))]}"
   (( C = C + 1 ))
done
```

You may wonder why we produce 79 and not 80 characters per line. The new-line character takes up the last character in the line.

The next function is `elapsed_time`. This function evaluates the seconds, passed as `ARG1` to the function, and outputs the hours, minutes, and seconds.

We added the `load_default_keyboard` function to build a `$CHAR_FILE` if the user has not created a custom file.

The `BEGINNING OF MAIN` is intuitively obvious when you look closely at the code. We first check for a single command-line argument. Next we test the value to ensure `$MB_SIZE` is an integer. Then we test to ensure the `$CHAR_FILE` exists and its size is greater than zero bytes. If this test fails, we execute the `build_default_keyboard` function to build our required `$CHAR_FILE`. The next loop loads the array `KEYS` with all the characters in the `$CHAR_FILE`. By creating random numbers between 1 and the total number of array elements, we can point to random characters stored in the array.

The next step is to use the `/dev/random` character special file to create a seed for the shell variable `RANDOM`. The trick for this is to use modulo N arithmetic to reduce the number to less than 32,767, and assign this value to the `RANDOM` variable.

Now, just before we start producing random characters, we reset the shell `SECONDS` variable to `0`, zero. The shell `SECONDS` variable continuously counts seconds. It starts counting seconds as soon as the shell is started. If you type `echo $SECONDS` on the command line, you will see the seconds that elapsed since you logged in, or at least since you started this particular shell. We can set the `SECONDS` shell variable to any integer values we want, and it will continue counting from that point as the seconds tick by. We need the second of execution for the `elapsed_time` function.

For each 1 MB in desired file size, we need to create 12,700 lines of random characters. So, we just multiply `$MB_SIZE` by 12,700 and that is how many times we loop to create the random file.

Once this loop completes, we save the `SECONDS` by assigning this value to the `TOT_SEC` variable. We execute the `elapsed_time` function and give the user feedback of the execution time, then we calculate the bytes per second, and finally do a long listing of the `$OUTFILE` using `ls -l $OUTFILE`.

Other Things to Consider

As with any chapter, we can add to the shell scripts. To find the fastest method, we sometimes need to use the shell's built-in **time** command. To time the execution of a script, just precede the program or shell script to execute with time:

```
time my_shell_script
```

The shell's `time` command is different from the UNIX `/usr/bin/time` command. The shell's `time` command produces a more granular result, as shown here:

Command:

```
/usr/bin/time ls -l /usr
```

Timing result:

```
Real   0.32
User   0.07
System 0.08
```

Command:

```
time ls -l /usr
```

Timing result:

```
real    0m0.15s
user    0m0.08s
sys     0m0.07s
```

Summary

In this chapter we stepped through some different techniques of creating pseudo-random numbers. We then used this knowledge to create unique filenames, and then created a file, of a specified MB size, filled with random character data.

Using the `/dev/random` character special file produces numbers suitable for some security-related projects; however, the `RANDOM` shell variable will produce predictable and cyclical numbers. Play around with these shell scripts and functions and modify them for your needs. In Chapter 12 we will use pseudo-random numbers to create pseudo-random passwords. Just remember, you can make mathematics as difficult as you wish. I hope you gained a lot of knowledge in this chapter and that you stick around for the next chapter!

Lab Assignments

1. Write a shell script that contains three functions. Function 1 will create 1,000 random numbers using the `RANDOM` shell variable. Function 2 will create 1,000 random numbers using the `/dev/urandom` character special file. Function 3 will create 1,000 random numbers using the `/dev/random` character special file. In the shell script, use the shell `time` utility to record the execution times of each method. Explain any differences you observe.
2. Write a shell script to create a 128-character encryption key. Use the highest level of randomness for this script.
3. Rewrite the `random_file.Bash` shell script in Listing 11-16 but this time use the `/dev/urandom` character special file to create all the random numbers. Is there a difference in execution time? Explain any differences observed.

CHAPTER 12

Creating Pseudo-Random Passwords

Got security? Most of the user community does not know how to create secure passwords that are not easy to guess. Users tend to have several passwords that they rotate. The problem with these ''rotating'' passwords is that they are usually easy to guess. For example, users find that birth dates, children's names, Social Security numbers, addresses, department names/numbers, and so on make good passwords that are easy to remember. Sometimes they even use words found in any dictionary, which is a starting point for any cracker. In this chapter we are going to create a shell script that creates *pseudo-random passwords*.

Randomness

If you look back at Chapter 11, ''Pseudo-Random Number and Data Generation,'' you can see the exercise that we used to create pseudo-random numbers. If you have not studied Chapter 11, it would help a lot if you did.

The numbers we created in Chapter 11 are not true random numbers, but some are secure enough for encryption applications and software keys. Others, however, are not as secure because of the cyclical nature of how ''random numbers'' are created if the same seed is used as a starting point. For example, if you are using the `RANDOM` shell variable, and you always start a random number sequence with the same *seed*, or first number, you will always have the same sequence of numbers. In Chapter 11, one method used is to use the process ID (PID) of the current process, which is the executing shell script, as the seed for creating pseudo-random numbers. This use of the PID is one good choice because PIDs are created by the system in a somewhat random nature.

The other methods we studied include using the character special files `/dev/random` and `/dev/urandom`. These character special files are an interface to the kernel's random number generator. The kernel's random number generator uses *system noise* from device

drivers, and other environmental noise a computer generates, to create an *entropy pool*. The kernel's random number generator keeps track of the number of bits of noise remaining in the entropy pool. When we read the `/dev/random` character special file, using the **dd** command, random bytes of noise are returned within the range of available noise in the entropy pool. When the entropy pool is empty, `/dev/random` will *block* while the kernel gathers more environmental system noise. During this blocking period, `/dev/random` will not return data and we can see a pause in execution of our shell scripts.

The `/dev/urandom` character special file does not block when the entropy pool is empty; therefore, the randomness is to a lesser degree. Using `/dev/urandom` in a shell script will not show the possible delays in execution as `/dev/random` and therefore is the preferred method for many shell scripts.

Now that I have lost you in random numbers, you are probably asking, ''What does a random number have to do with a password?'' As we proceed, the answer will be intuitively obvious.

Creating Pseudo-Random Passwords

We started this chapter with a discussion on randomness because we are going to use computer-generated pseudo-random numbers, and then use these generated numbers as pointers to specific array elements of keyboard characters, which are stored in the array `KEYS`. In this chapter you get a practical use for generating random numbers. And you thought Chapter 11 was a waste of time.

The script idea goes like this: We use an external file that contains keyboard characters, one character per line. You can put any keyboard characters that you want in this file. I just went down the rows on the keyboard from left to right, starting on the top row of keys with numbers. As I went through all the keyboard keys, I then added a second set of numbers from the number keypad, as well as all the uppercase and lowercase characters. The nice thing about this strategy is that you have the ability to specify the exact group of characters that make a valid password in your shop. Country-specific keyboards, which use characters other than those of the U.S. keyboards, also benefit from this strategy. Beware that characters with a special meaning should be delimited with a backslash (\) — for example, `\!`.

Once we have the keyboard file created, we load the keyboard data into an *array*. Don't panic! Bash, Bourne, and Korn shell arrays are easy to work with, as you will see in the scripting section as well as in the array introduction section. When we have all array elements loaded, we know how many total elements we have to work with. Using techniques described in Chapter 11, we create pseudo-random numbers between one and the total number of array elements, *n*. With an array *pointer*, which is nothing more than our pseudo-random number, pointing to an individual array element, which is the next random character, we add this character as we build a text string. The default length of this character string, which is the password we are creating, is eight characters; however, this can be changed on the command line to make the password longer or shorter by adding an integer value specifying the new password length.

The final step is to print the password to the screen. We also add two command-line switch options, `-n` and `-m`. The `-n` switch specifies that the user wants to create a

new default keyboard data file. The `-m` switch specifies that the user wants to print a *password page*. In our shop we are required to put some passwords, such as root, in multiple security envelopes to be locked in a safe, just in case. To remove the risk of typos, I print the password page, which has three copies of the password data on the same page, and then I cut the sheet into three pieces. After folding each of the three slips of paper and sealing each one in a security envelope, I give them to my Admin Manager.

As you can see, creating passwords is not something that I take lightly! Weak passwords make for a real security risk, and any user, especially a Systems Administrator, needs to take a proactive approach to create secure passwords that are as random as you can make them. This chapter is a valuable asset to any security team as well as for the common user.

Syntax

As with any of our scripting sessions we first need the correct syntax for the primary commands that we are going to use in the shell script. In this case we need to introduce arrays and the commands that are used to work with the array and the array elements. There is a lot more than loading an array to creating this shell script. We will get to the random numbers later. When we get to the scripting section, you will see the other tasks that I have in mind, and you can pick up a pointer or two from the chapter.

Arrays

In Bash, Bourne, and Korn shells, we can create one-dimensional *arrays*. A one-dimensional array contains a sequence of *array elements*, which are like the boxcars connected together on a train track. An array element can be just about anything, except for another array. I know you're thinking that you can use an array to access an array to create two- and three-dimensional arrays. This sounds like a great Lab Assignment, but otherwise, it is beyond the scope of this book, so we will stick to one-dimensional arrays.

For our task, we are going to load our array with single-character array elements that are loaded into the array from an external file. However, an array element can be a text string, number, line of text, print queue name, web address, or just about anything you can list. For this application of an array we only need a single character.

Loading an Array

An array can be loaded in two ways. You can define and load the array in one step with the `set -A` command, or you can load the array one element at a time. Both techniques are shown here.

Defining and Loading the KEYS Array in One Step

We can load the `KEYS` array in one step using the `set` command with the `-A` (defining an array) switch option, as shown here.

```
set -A KEYS q w e r t y u i o p \[ \] a s d f g h j k l \$
```

Notice in this list that the characters `[`, `]`, and `$` have been *escaped* to remove their special function by adding a *backslash* character. If we do not escape these characters, errors and strange behavior may occur as you tried to load or display the array elements. You will see this on a larger scale in the shell script. Also remember that if you enclose a list in double quotes or single tic marks, it is treated as a single array element for the assignment, not as individual array elements.

Loading the KEYS Array One Array Element at a Time

The second option for loading the array `KEYS` is to use a `while read` loop and use a file as input to the `while` loop. In this example we load the array elements one at a time using a counter to index the `KEYS` array:

```
X=0
while read ARRAY_ELEMENT
do
      (( X = X + 1 ))

      KEYS[$X]="$ARRAY_ELEMENT"

done < $ARRAY_ELEMENT_FILE
```

The first loading option, which uses the `set -A` command, requires that you hard-code the keyboard layout into the shell script, which removes much of the flexibility that you want when restricting or expanding password content. Using the `while` loop method we can use an external file and load this file with any characters that we want, and we can have as many or as few characters defined for passwords as we like. We can also duplicate characters and change the order of the characters any way we wish.

As the counter is incremented on each `while` loop iteration, we load the array elements in sequential order from the top of the file, and starting with array element 1, `KEYS[1]`. When we get to the end of the file, we know how many elements we have loaded in the array by the value of the array counter, `$X`. To see the specific value of array element `22`, you can use the following syntax:

```
# echo ${KEYS[22]}
;
```

As you can see from the response, the 22nd array element that was loaded is a semicolon character (`;`). We can also display the number of array elements using either of the following two options:

```
# echo ${#KEYS[*]}
# echo ${#KEYS[@]}
```

Notice we started with array element 1, one. The UNIX shells also support array element 0, zero, but the pseudo-random numbers we create start at array element one, not zero. We will look at arrays more closely as we write our shell script.

Building the Password-Creation Script

I want to explain this shell script one step at a time, and we have a lot to cover, so let's get started. First, you need to understand the order of execution and each task that is involved in this script.

Order of Appearance

We need to start out by defining the files and variables that are required for the script. The following section shows the variables that are defined for this shell script.

```
# Default password length.
LENGTH=8
# Persons to notify if the password is revealed or the ''glass has been broken.''
NOTIFICATION_LIST=<Manager notification list>
# Default printer to print the password report.
DEFAULT_PRINTER=<printer or queue name>
# The name of this shell script with the directory path removed.
SCRIPT=$ (basename $0)
# Temporary hold file for the printer report.
OUTFILE=/tmp/tmppwd.out
# File containing keyboard characters.
KEYBOARD_FILE=/scripts/keyboard.keys
# Print report flag.
PRINT_PASSWORD_MANAGER_REPORT=<TRUE or Anything else>


# This next test ensures we use the correct
# echo command based on the executing shell

ECHO="echo -e"
[[ $(basename $SHELL) == ksh ]] && ECHO=echo #  Ensure we
    use the correct echo command syntax for each executing shell.
```

The purpose of each variable is shown after the pound sign (#) on each line. Notice in particular the last entry where we test for the shell we are executing in. Because we use the `echo` command, and we sometimes use the *backslash operators*, (for example, `\n`), the executing shell is important. If the `$SHELL` variable is `sh` or `Bash`, we need to add the `-e` switch to the `echo` command. If we are executing in `ksh`, the `-e` is not required to recognize these special operators. For the purpose of reviewing the following functions, only a single `echo` will be used. The actual `mk_passwd.Bash` shell script does test and use this shell test method, and thus `$ECHO` executes the proper `echo` command.

Define Functions

We have six functions to go through in this section. The functions described here are listed in their order of appearance in the shell script, `mk_passwd.Bash`. In each of the function descriptions there is a function listing for you to follow through. The shell declaration on the first line of the script can be Bourne, Bash, or Korn; we are working shell-neutral.

in_range_random_number Function Description

As we studied in Chapter 11, the `/dev/random` and `/dev/urandom` character special files use system noise to create random numbers. Both methods offer an easy way to change the seed value each time we start generating numbers. However, the `/dev/urandom` will not block should the entropy pool become empty. So, we will use this option for our random numbers.

We often want to limit the range of numbers not to exceed a user-defined maximum. An example is creating lottery numbers between 1 and the maximum number, which might be 36. We are going to use the modulo arithmetic operator (%) to reduce all numbers to a fixed set of numbers between [0..N-1], which is called *modulo N arithmetic*. We are going to use this pseudo-random number to index array elements in the `KEYS` array.

For our number range we need a script-defined maximum value, which we will assign to a variable called `UPPER_LIMIT`. This `UPPER_LIMIT` variable is defined when the `KEYS` array has been loaded because it represents the total number of elements that are contained in the `KEYS` array. The modulo operator is the percent sign (%), and we use this operator the same way that we use the forward slash (/) in division. However, the result is the *remainder* of the division, where the / returns the integer part of the division result. On each loop iteration we assign our new pseudo-random number to the `RN` variable. This time, though, we are going to use the following equation to limit the number to not exceed the script-defined maximum:

```
RANDOM_NUMBER=$(( RN % UPPER_LIMIT + 1))
```

Notice that we added one to the result. Using the preceding equation will produce a pseudo-random number between `1` and the script-defined `$UPPER_LIMIT`, which is the total number of elements in the `KEYS` array. We use this function to point to a random array element to produce a password character. The function using this equation is `in_range_random_number` and is shown in Listing 12-1.

```
function in_range_random_number
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is defined in the
# main body of the shell script.

RN=$(dd if=/dev/random count=1 2>/dev/null \
```

Listing 12-1 in_range_random_number function

```
     | od -t u2 | awk '{print $2}'| head -n 1)

RANDOM_NUMBER=$(( RN % UPPER_LIMIT + 1))

echo "$RANDOM_NUMBER"
}
```

Listing 12-1 (*continued*)

Notice in the function in Listing 12-1 that we use the `/dev/urandom` character special file in concert with `dd` and `od`. We assume here that there is a script-defined `UPPER_LIMIT` variable set. This function will produce numbers between 1 and the script-defined maximum value.

load_default_keyboard Function Description

As it turns out, the `$KEYBOARD_FILE` can have as many or as few characters as you wish to add. However, many users want a quick startup and an easy way to create this required file? This is the reason why I added this function to the `mk_passwd.ksh` shell script.

There are two mechanisms for loading a *default* keyboard layout. The first way is when the shell script is unable to locate the `$KEYBOARD_FILE` on the system. In this case, the user is prompted to load the default keyboard layout. The second option is to add `-n` as a command-line switch. We will get to parsing command-line switches later in this chapter. In either of the two situations the user is still prompted before the `$KEYBOARD_FILE` is loaded with default keyboard layout.

Other than prompting the user to load the default keyboard layout, we need to supply a list of keyboard characters to load into the file. At this point let's look at the function code in Listing 12-2 and cover the details at the end.

```
function load_default_keyboard
{
# If a keyboard data file does not exist then the user
# is prompted to load the standard keyboard data into the
# $KEYBOARD_FILE, which is defined in the main body of
# the shell script.

clear  # Clear the screen

echo "\nLoad the default keyboard data file? (Y/N): \c"
read REPLY

case $REPLY in
y|Y) :
     ;;
  *) echo "\nSkipping the load of the default keyboard file...\n"
```

Listing 12-2 load_default_keyboard function

```
     return
     ;;
esac

cat /dev/null > $KEYBOARD_FILE

echo "\nLoading the Standard U.S. QWERTY Keyboard File...\c"

# Loop through each character in the following list and
# append each character to the $KEYBOARD_FILE file. This
# produces a file with one character on each line.

for CHAR in \' 1 2 3 4 5 6 7 8 9 0 \- \= \\ q w e r t y u i o \
            p \[ \] a s d f g h j k l \; \' z x c v b n m \, \
            \. \/ \\ \~ \! \@ \# \$ \% \^ \& \* \( \) _ \+ \| \
            Q W E R T Y U I O P \{ \} A S D F G H J K L \: \" \
            Z X C V B N M \< \> \? \| \. 0 1 2 3 4 5 6 7 8 9 \/ \
            \* \- \+
do
     echo "$CHAR" >> $KEYBOARD_FILE
done
echo "\n\n\t...Done...\n"

sleep 1
```

Listing 12-2 (*continued*)

Now I want to direct your attention to the `for` loop in Listing 12-2, which is in boldface text. The idea is to loop through each character one at a time and append the character to the `$KEYBOARD_FILE`. The result is a file that contains the keyboard layout, listed one character per line. The file shows one character per line to make it easier to load the file and the `KEYS` array.

In the list of characters please notice that most of the non-alphanumeric characters are preceded by a backslash (\), not just the shell special characters. As we discussed previously, this backslash is used to *escape* the special meaning of these characters. When you precede a special character with the backslash, you are able to use the character as a literal character, just like the alphanumeric characters, and if a backslash precedes the other non-alphanumeric characters, it is ignored. The list of characters that are escaped is shown here:

```
' ! @ # $ % ^ & * ( ) _ - = + [ ] { }
```

On each loop iteration one character is appended to the `$KEYBOARD_FILE` using the following command:

```
echo "$CHAR" >> $KEYBOARD_FILE
```

When the file is loaded, which happens extremely fast, we notify the user that the load is complete and then `sleep` for one second. I added this `sleep 1` at the end of

this function because the load happened so fast that the user needed a second to see the message.

check_for_and_create_keyboard_file Function Description

Is this function name descriptive enough? I like to know exactly what a function is used for by the name of the function.

The purpose of this function is to check for the existence of the `$KEYBOARD_FILE` and to prompt the user to load the default keyboard layout into the `$KEYBOARD_FILE`. The user has the option to load the default data or not to load it. If the user declines to load the keyboard data file, this script will not work. To get around this little problem, we just notify the user of this error and exit the shell script.

When the user gets the error message, he or she is also informed of the name of the missing file and a description of what the script expects in the file — specifically, one keyboard character per line. The full function is shown in Listing 12-3.

```
function check_for_and_create_keyboard_file
{
# If the $KEYBOARD_FILE does not exist then
# ask the user to load the "standard" keyboard
# layout, which is done with the load_default_keyboard
# function.

if [ ! -s $KEYBOARD_FILE ]
then
     echo "\n\nERROR: Missing Keyboard File"
     echo "\n\nWould You Like to Load the"
     echo "Default Keyboard Layout?"
     echo "\n\t(Y/N): \c"
     typeset -u REPLY=FALSE
     read REPLY
     if [[ $REPLY != Y ]]
     then
          echo "\n\nERROR: This shell script cannot operate"
          echo "without a keyboard data file located in"
          echo "\n==>  $KEYBOARD_FILE\n"
          echo "\nThis file expects one character per line."
          echo "\n\t...EXITING...\n"
          exit 3
else
          load_default_keyboard
          echo "\nPress ENTER when you are you ready to continue: \c"
          read REPLY
          clear
     fi
fi
}
```

Listing 12-3 check_for_and_create_keyboard_file function

To check for the existence of the $KEYBOARD_FILE, we use the -s test in an if statement, as shown here:

```
if [ ! -s $KEYBOARD_FILE ]
then
     ...
fi
```

Notice that we negated the test by adding an exclamation point (! -s). This is actually a test to see if the file is *not* greater than zero bytes in size *or* that the $KEYBOARD_FILE does not exist. If either of these conditions is met, we display some messages to the user and ask the user if the default keyboard layout should be loaded.

If the user acknowledges the question with a ''Y'' or a ''y,'' we execute the load_default_keyboard function, which we studied in the previous section, ''load_default_keyboard Function Description.'' After the keyboard data is loaded into the $KEYBOARD_FILE, we stop and ask the user to press ENTER to continue. Once the user presses ENTER, the script creates a pseudo-random password, which we will cover in a later section.

build_manager_password_report Function Description

You may be asking, ''Why do you want to *print* a password?'' There are a lot of reasons to print a password, but only *one* of the answers is valid! *For security reasons*. Now I really lost you! How can a printed password be good for security? It's simple: The root password needs to be protected at all costs. Our machines do not have direct login access to root, but we use an auditing script that captures every keystroke of the root user. If a machine has failed and you need to log on to the system on the console, you are definitely going to need access to the root password. For this reason we keep three copies of the root password in secure envelopes, and they get locked up for safekeeping.

The build_manager_password_report function creates a file, pointed to by the $OUTFILE variable, that has three copies of the same information on a single page. Look at the function shown in Listing 12-4 to see the message.

```
function build_manager_password_report
{
# Build a file to print for the secure envelope
(
echo "\n                RESTRICTED USE!!!"
echo "\n\n\tImmediately send an e-mail to:\n"

echo "    $NOTIFICATION_LIST"

echo "\n\tif this password is revealed!"
echo "\n\tAIX root password:  $PW\n"

echo "\n\n"
```

Listing 12-4 build_manager_password_report function

```
echo "\n                RESTRICTED USE!!!"
echo "\n\n\tImmediately send an e-mail to:\n"

echo "    $NOTIFICATION_LIST"

echo "\n\tif this password is revealed!"
echo "\n\tAIX root password:  $PW\n"

echo "\n\n"

echo "\n                RESTRICTED USE!!!"
echo "\n\n\tImmediately send an e-mail to:\n"

echo "    $NOTIFICATION_LIST"

echo "\n\tif this password is revealed!"
echo "\n\tAIX root password:  $PW\n"

    ) > $OUTFILE

}
```

Listing 12-4 (*continued*)

Notice that the entire message is enclosed in parentheses, with the final output redirected to the `$OUTFILE` file using a single output redirection statement at the end of the function, as shown in the following syntax:

```
( echo statements.... ) > $OUTFILE
```

This method runs all the `echo` commands as a separate shell and sends the resulting output to the `$OUTFILE` using output redirection.

Also notice the `$NOTIFICATION_LIST` variable. This variable is set in the main body of the script. This variable contains the list of people who must be notified if the password is ever released, as stated in the message in the function. This list can also be accomplished by using a sendmail alias. To create a sendmail alias, edit the `aliases` file, which is usually located in the `/etc/mail` or `/etc/sendmail` directory. Edit the `aliases` file in that directory and include the following syntax to create a new alias:

```
pwd_alert:  eddie@mycomp.com, susan@mycorp.com, admin_support
```

Adding this line to the `aliases` file creates a new mail alias named `pwd_alert`. Sending mail to this alias will send email to everyone listed after the colon: Eddie, Susan, and everyone listed in the `admin_support` mail alias.

To make the new alias work, though, do not forget to run the **newaliases** command. The `newaliases` command rereads the `aliases` file to pick up the changes. For more details, see the `sendmail` man page, **man sendmail**.

When I want to send one of these printouts to the printer, I always run to get it as soon as the page comes out of the printer. This is an extremely important piece of

paper! I take it to my desk and cut the page into three pieces and seal each one in a secure envelope and have it locked up for safekeeping.

A sample manager's password report is shown in Listing 12-5.

```
               RESTRICTED USE!!!


        Immediately send an e-mail to:

    Donald Duck, Yogi Bear, and Mr. Ranger

        if this password is revealed!

        UNIX root password:  E-,6Kc11




               RESTRICTED USE!!!


        Immediately send an e-mail to:

    Donald Duck, Yogi Bear, and Mr. Ranger

        if this root password is revealed!

        UNIX root password:  E-,6Kc11




               RESTRICTED USE!!!


        Immediately send an e-mail to:

    Donald Duck, Yogi Bear, and Mr. Ranger

        if this root password is revealed!

        UNIX root password:  E-,6Kc11
```

Listing 12-5 Password report printout

You need to edit this function and change the message to suit your environment. If you do not need this functionality, then never use the `-m` switch, or reply ''No'' when

asked to confirm the printing. This sounds like a good Lab Assignment. Edit the script and remove the functionality completely.

usage Function Description

It is always a good idea to show the user a `USAGE:` statement when incorrect or insufficient input is detected. (We will get to detecting input errors later in this chapter.) For our `mk_passwd.ksh` shell script we have four options and several combinations.

We can execute the `mk_passwd.ksh` script with no arguments, and we can execute the `mk_passwd.ksh` shell script with the `-n` and `-m` command-line switches. The `-n` switch automatically loads the default keyboard layout into the `$KEYBOARD_FILE` file. We can also change the length of the password, which is defined as eight characters by default. Any combination of these command options can be executed. Please look closely at the Backus-Naur form (BNF) of the `USAGE:` statement shown in Listing 12-6.

```
function usage
{
echo "\nUSAGE: $SCRIPT [-m] [-n]  [password_length]\n"
echo "   Where:

     -m  Creates a password printout for Security

     -n  Loads the default keyboard data keys file

     password_length   Integer value that overrides
                       the default 8 character
                       password length.\n"
}
```

Listing 12-6 usage function

The Backus-Naur form is a standard for expressing the proper order and usage of a statement. First introduced by John Backus in 1959, it was later simplified by Peter Naur, thus its current name. John Backus died in 2007. Study the next usage statement for John, please.

When a usage error is detected, the script executes the `usage` function that displays the following message:

```
USAGE: mk_passwd.ksh [-m] [-n]  [password_length]
 Where:

     -m  Creates a password printout for Security

     -n  Loads the default keyboard data keys file

     password_length   Integer value that overrides
                       the default 8 character
                       password length.\n"
```

trap˙exit Function Description

This function, `trap_exit`, is executed only when an exit signal is *trapped*. You will see how to set a trap a little later. The purpose of this function is to execute any commands that are listed in the function. In our case, we want to remove the `$OUTFILE` before exiting the shell script. Additionally, we do not want to see any messages sent to `stderr` if the file does not exist. The statement is shown in the following code:

```
function trap_exit
{
rm -f $OUTFILE >/dev/null 2>&1
}
```

Notice that we redirect the `stderr` output to `stdout`, which is specified by the file descriptor notation `2>&1`, but not before we send everything to the bit bucket, specified by `>/dev/null`.

That is it for the functions. The next section covers the testing and parsing required for the command arguments.

Testing and Parsing Command-Line Arguments

Because this shell script has command-line options to control execution, we need to test the validity of each command-line argument and then parse through each one to set up how the script is to be executed. We have four tests that need to be performed to validate each argument.

Validating the Number of Command-Line Arguments

The first step is to ensure that the number of command-line arguments is within the limit of arguments we are expecting. For this script we are expecting no more than three arguments. To test the number of arguments, we use the `$#` shell variable to test if the number of arguments is greater than 3. This test code is shown here:

```
# Check command line arguments - $# > 3

if (( $# > 3 ))
then
     usage
     exit 1
fi
```

Notice that we used the mathematical test, denoted by the double parentheses expression `(( expression ))`. One thing to note about the syntax of this test is that for user- or script-defined variables it is not required to use the dollar sign (`$`) in front of the variable name. For shell variables you must use the shell notation here, too. If the number of arguments on the command line exceeds 3, we display the `usage` function and exit the shell script with a return code of 1.

Test for Valid Command-Line Arguments

We really have only three valid command-line arguments. Because `-n` and `-m` are lowercase alphabetic characters, we may as well add their uppercase counterparts for people who love to type uppercase characters. Now we have only five valid command-line arguments:

- Any integer
- `-n` and `-N` to indicate creating a new `$KEYBOARD_FILE`
- `-m` and `-M` to indicate that the manager's password report is to be printed

This seems easy enough to test for using a **case** statement to parse through the command-line arguments using the `$@` values, which is a list of the command-line arguments separated by a single space. Look at the block of code in Listing 12-7 for details.

```
# Test for valid command line arguments -
# Valid arguments are "-n, -N, -m, -M, and any integer

if (( $# != 0 ))
then
   for CMD_ARG in $@
   do
         case $CMD_ARG in
         +([-0-9]))
               # The '+([-0-9]))' test notation is looking for
               # an integer. Any integer is assigned to the
               # length of password variable, LENGTH

               LENGTH=$CMD_ARG
               ;;
       -n|-N)     :  # The colon (:) is a no-op, which does nothing
               ;;
       -m|-M)     :  # The colon (:) is a no-op, which does nothing
               ;;
          *)       # Invalid command-line argument, show usage and exit
               usage
               exit 1
               ;;
         esac
   done
fi
```

Listing 12-7 Code for testing for command-line arguments

Before we test the validity of each argument, we ensure that there is at least one command-line argument to test. If we have some arguments to test, we start a `case`

statement to parse through each argument on the command line. As the arguments are parsed, the value is assigned to the `CMD_ARG` variable.

Notice the very first test, `+([0-9])`. This regular expression is testing for an integer value. When we add this integer test to the `case` statement, we need to add the last close parenthesis, `)`, for the `case` statement. If the test is true, we know that an integer has been supplied that overrides the default eight-character password length, specified by the `LENGTH` variable.

NOTE Bash shell does not support the regular expression `+([0-9])` to test for an integer.

The tests for `-n`, `-N`, `-m`, and `-M` are do-nothings, or no-ops in this case. A no-op is specified by the colon character (`:`). The no-op does not do anything, but it always has a 0, zero, return code. When our valid command options are found, the `case` statement goes to the next argument on the command line.

When an invalid command-line option is detected, the function displays the `usage` message and exits the script with a return code of 1, one, which is defined as a usage error.

Ensuring the $LENGTH Variable Is an Integer

As a final sanity check of the `$LENGTH` variable, I added this extra step to ensure that it is assigned an integer value. This test is similar to the test in the previous section, but it is restricted to testing the `LENGTH` variable assignment. This test code is shown in Listing 12-8.

```
#
# Ensure that the $LENGTH variable is an integer
#
case $LENGTH in
+([0-9])) : # The '+([0-9]))' test notation is looking for
            # an integer. If it is an integer then the
            # no-op, specified by a colon, (Do Nothing)
            # command is executed, otherwise this script
            # exits with a return code of 1, one, after
            # displaying the usage message
          ;;
*) usage
   exit 1
;;
esac
```

Listing 12-8 Testing $LENGTH for an integer value

If the `LENGTH` variable does not have an integer assignment, the `usage` message function is shown and the script exits with a return code of 1, which is defined as a usage error.

Parsing Command-Line Arguments with getopts

The `getopts` shell function is the best tool for parsing through command-line arguments. With the `getopts` function we can take direct action or set variables as a valid command-line arguments are found. We can also find invalid command-line arguments, if they are preceded with a minus sign (-).

The `getopts` function is used with a `while` loop that contains a `case` statement. The basic syntax is shown in Listing 12-9.

```
while getopts ":n N V: m M" ARGUMENT 2>/dev/null 2>&1
do
     case $ARGUMENT in
     n|N) # Do stuff for -n and -N
          ;;
     m|M) # Do stuff for -m and -M
          ;;
       V) # The colon (:) after the V, V:, specifies
          # that -V must have an option attached on the command line.
          ;;
      \?) # The very first colon (:n) specifies that any unknown
          # argument (-A, for example) produces a question mark (?) as
          # output. For these unknown arguments we show the usage
          # message and exit with a return code of 1, one.
          ;;
     esac
done
```

Listing 12-9 Basic syntax for using the shell getopts function

As you can see, using `getopts` to parse command-line arguments is an easy way to catch invalid command-line arguments and also to assign values or tasks to specific arguments. The nice thing about this method is that we do not have to worry about the order of the arguments, or command-line spacing between the command-line argument and the argument to the command-line switch.

Let's look at the code for parsing the command line for this shell script, as shown in Listing 12-10.

```
# Use the getopts function to parse the command-
# line arguments.

while getopts "n N m M" ARGUMENT 2>/dev/null
do
     case $ARGUMENT in
     n|N)
         # Create a new Keyboard Data file
         load_default_keyboard
```

Listing 12-10 getopts command-line parsing

```
            echo "\nPress ENTER when you are you ready to continue: \c"
            read REPLY
            clear
            ;;
        m|M)
            # Print the Manager Password Report
            PRINT_PASSWORD_MANAGER_REPORT=TRUE
            ;;
        \?) # Show the usage message
            usage
            exit 1
        esac
done
```

Listing 12-10 (*continued*)

In our `getopts` statement, located on the line with the `while` loop, we provide for four command-line options. These include `-n` and `-N` options to execute the `load_default_keyboard` function. For the `-m` and `-M` options the printer variable is set to `TRUE`. Any other options result in the script exiting with a return code of `1`. Notice the `\?` in the `case` statement. This specifies that any invalid option is assigned the question mark (`?`), specifying an unknown option. We do not have any colons after any options, so we are not expecting any values to be assigned to any arguments.

Beginning of Main

Now that we have defined all the variables and functions and verified all the command-line arguments, we are ready to start the main part of the `mk_passwd.ksh` shell script.

Setting a Trap

The first thing to do is to set a trap. A trap allows us to take action before the shell script or function exits, if an exit signal is trappable and defined. We can *never* trap a `kill -9 exit`. This `kill` option does not do anything graceful; it just removes the process from the system process table, and it no longer exists. The more common exit signals are 1, 2, 3, and 15. For a complete list of exit signals, see Chapter 1, ''Scripting Quick Start and Review,'' or enter **kill -l** (that's a lowercase *L*) on the command line.

Our `trap` is shown here:

```
trap 'trap_exit; exit 2' 1 2 3 15
```

When a trapped exit signal is detected, in this case signals 1, 2, 3, or 15, the `trap` executes the two commands enclosed within the single tic marks, (`' commands '`). The commands include running the `trap_exit` function that removes the `$OUTFILE` file; then the script exits with a return code of 2, which has been defined as a trap exit for this shell script.

Checking for the Keyboard File

This shell script is useless without a keyboard data file and cannot execute anything. To check for the existence of the `$KEYBOARD_FILE`, we execute the `check_for_and_create_keyboard_file` function. As we saw previously, this function checks to see if a keyboard data file is on the system. If the file is not found, the user is prompted to automatically load the default keyboard layout, which is a standard 109-key QWERTY keyboard. This functionality allows for a quick start for new users and an easy recovery if the file is deleted. When we want to load a custom keyboard layout, all that is needed is to replace the default keyboard file with a new keyboard layout file.

Loading the KEYS Array

Once we have a `$KEYBOARD_FILE` we are ready to load the `KEYS` array with the keyboard characters. This shell script segment loads the `KEYS` array with file data. The easiest way to do this is to use a `while` loop to read each line of the file, which in this case is a single character, while feeding the loop from the bottom, as shown in Listing 12-11.

```
X=0 # Initialize the array counter to zero

# Load the array called "KEYS" with keyboard elements
# located in the $KEYBOARD_FILE.

while read ARRAY_ELEMENT
do
     ((X = X + 1)) # Increment the counter by 1

     # Load an array element in the array

     KEYS[$X]=$ARRAY_ELEMENT

done < $KEYBOARD_FILE


UPPER_LIMIT=$X  # Random Number Upper Limit
```

Listing 12-11 Code to load the KEYS array

In Listing 12-11 we initialize a loop counter, `X`, to zero. This counter is used to index each array element in sequential order. Next we start the `while` loop to read each line of data, a single character, and assign the value to the `ARRAY_ELEMENT` variable on each loop iteration.

Inside of the `while` loop the counter is incremented as the loop progresses, and the `KEYS` array is assigned a new array element on each loop iteration until all the file data is loaded into the `KEYS` array. Notice the command syntax we use to load an array element:

```
KEYS[$X]=$ARRAY_ELEMENT
```

At the bottom of the `while` loop after `done`, notice the *input* redirection into the loop. This is one of the fastest ways to parse a file line-by-line. For more information on this and other file-parsing methods, see Chapter 2, ''24 Ways to Process a File Line-by-Line.'' The last task is to define the `UPPER_LIMIT` variable. This variable is used to create the pseudo-random numbers that are used to point to the `KEYS` array elements when creating a new pseudo-random password.

Building a New Pseudo-Random Password

The code to build a new password is short and relatively easy to understand. The code is shown in Listing 12-12. After the code listing, we will cover the details.

```
# Create the pseudo-random password in this section

clear   # Clear the screen

PW=     # Initialize the password to NULL

# Build the password using random numbers to grab array
# elements from the KEYS array.

X=0
while ((X < LENGTH))
do
    # Increment the password length counter
    (( X = X + 1 ))

    # Build the password one char at a time in this loop
    PW=${PW}${KEYS[$(in_range_random_number $UPPER_LIMIT)]}
done

# Done building the password
```

Listing 12-12 Building a new pseudo-random password code

We first initialize the password variable (`PW`) to a null value, specified by `PW=`. When we make a variable assigned to nothing, the variable is set to NULL. Next we use a `while` loop to count through the password length, and on each loop iteration create a new random alphanumeric character until the password is built.

Inside the `while` loop we use a single command to build the password by adding a new pseudo-random character as we go through each loop iteration. Building the password works like this: We start with a NULL variable, `PW`. Then, on each loop iteration, we assign the `PW` variable the previous `$PW` assignment, which it had from the last loop iteration. Then we add to this current character string a new character, which we generate using the `in_range_random_number` function inside the `KEYS` array element assignment using command substitution. The `in_range_random_number` function expects as input the `$UPPER_LIMIT` value, which is 109 keys for the default keyboard layout in this script. Using this method we use the function directly in the `KEY` array element assignment. This is one method to build a list.

Printing the Manager's Password Report for Safekeeping

This last section of code will create a temporary report file for printing purposes. The only time this section of code is executed is when the `-m` or `-M` command-line argument is present. In the `getopts` command-line parsing section, the `PRINT_PASSWORD_MANAGER_REPORT` variable is assigned the value `TRUE`. Any other value disables the printing option.

This section of code, shown in Listing 12-13, tests the printing variable and if `TRUE`, executes the `build_manager_password_report` function. The user is then prompted to print to the default printer, which is listed in the text. The user has a chance to change the printer/queue at this point or to cancel the printing completely. If the `$OUTFILE` is printed, the `lp` command adds the `-c` switch to make a copy of the file in the spooler. This method allows us to immediately delete the password report file from the system. We just do not want this report file sitting on the system for very long.

```
# Print the Manager's password report, if specified
# on the command with the -m command switch.

if [ $PRINT_PASSWORD_MANAGER_REPORT = TRUE ]
then

  typeset -u REPLY=N

  echo "\nPrint Password Sheet for the Secure Envelope? (Y/N)? \c"
  read REPLY

  if [[ $REPLY = 'Y' ]]
  then
     build_manager_password_report

     REPLY=    # Set REPLY to NULL

     echo "\nPrint to the Default Printer ${DEFAULT_PRINTER} (Y/N)? \c"
     read REPLY
     if [[ $REPLY = 'Y' ]]
     then
          echo "\nPrinting to $DEFAULT_PRINTER\n"
          lp -c -d $DEFAULT_PRINTER $OUTFILE

     else
          echo "\nNEW PRINT QUEUE: \c"
          read DEFAULT_PRINTER
          echo "\nPrinting to $DEFAULT_PRINTER\n"
          lp -c -d $DEFAULT_PRINTER $OUTFILE
     fi
  else
     echo "\n\n\tO.K. - Printing Skipped..."
```

Listing 12-13 Code to create and print the password report

```
  fi
fi

#####################################################
#
# Remove the $OUTFILE, if it exists and has a size
# greater than zero bytes.

[ -s $OUTFILE ] && rm -f $OUTFILE
```

Listing 12-13 (*continued*)

The last two things that are done at the end of this shell script are to remove the `$OUTFILE`, if it exists, and then prompt the user to press `Enter` to clear the screen and exit. We do not want to leave a password on the screen for anyone to read.

That is it for the steps involved to create the `mk_passwd.ksh` shell script. The entire shell script is shown in Listing 12-14. Pay particular attention to the boldface text throughout the `mk_passwd.ksh` shell script.

```
#!/bin/ksh
#
# AUTHOR: Randy Michael
# SCRIPT: mk_passwd.ksh
# DATE: 11/12/2007
# REV: 2.5.P
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to create pseudo-random passwords.
#          An external keyboard data file is utilized, which is
#          defined by the KEYBOARD_FILE variable. This keyboard
#          file is expected to have one character on each line.
#          These characters are loaded into an array, and using
#          pseudo-random numbers generated, the characters are
#          "randomly" put together to form a string of characters.
#          By default, this script produces 8 character passwords,
#          but this length can be changed on the command line by
#          adding an integer value after the script name. There are
#          two command line options, -n, which creates the default
#          KEYBOARD_FILE, and -m, which prints the manager's
#          password report. This password report is intended
#          to be locked in a safe for safe keeping.
#
# EXIT CODES:
#               0 - Normal script execution
#               1 - Usage error
```

Listing 12-14 mk_passwd.ksh shell script

```
#               2 - Trap exit
#               3 - Missing Keyboard data file
#               4 - $DEFAULT_PRINTER is NULL
#
# REV LIST:
#          6/26/2007: Added two command line options, -n, which
#          creates a new $KEYBOARD_FILE, and -m, which prints
#          the manager's password report.
#
#          8/8/2007: Changed the random number method from the
#          shell RANDOM variable to now use the /dev/urandom
#          character special file in concert with dd and od.
#
# set -x # Uncomment to debug
# set -n # Uncomment to check syntax without any command execution
#
#####################################################
########### DEFINE SOME VARIABLES HERE #############
#####################################################

LENGTH=8 # Default Password Length

# Notification List for Printing the Manager's
# Password Report for Locking Away Passwords
# Just in Case You are Unavailable.

NOTIFICATION_LIST="Donald Duck, Yogi Bear, and Mr. Ranger"

# Define the Default Printer for Printing the Manager's
# Password Report. The user has a chance to change this
# printer at execution time.

DEFAULT_PRINTER="hp4@yogi"
SCRIPT=$(basename $0)
OUTFILE="/tmp/tmppdw.file"
KEYBOARD_FILE=/scripts/keyboard.keys
PRINT_PASSWORD_MANAGER_REPORT="TO_BE_SET"

# This next test ensures we use the correct
# echo command based on the executing shell

ECHO="echo -e"
[[ $(basename $SHELL) = ksh ]] && ECHO=echo

#####################################################
########## DEFINE FUNCTIONS HERE ###################
#####################################################
#
```

Listing 12-14 (*continued*)

```
function in_range_random_number
{
# Create a pseudo-random number less than or equal
# to the $UPPER_LIMIT value, which is defined in the
# main body of the shell script.

RN=$(dd if=/dev/urandom count=1 2>/dev/null \
    | od -t u2 | awk '{print $2}'| head -n 1)

RANDOM_NUMBER=$(( RN % UPPER_LIMIT + 1))

echo "$RANDOM_NUMBER"
}
#
#####################################################
#
function load_default_keyboard
{
# If a keyboard data file does not exist then the user is
# prompted to load the standard keyboard data into the
# $KEYBOARD_FILE, which is defined in the main body of
# the shell script.

clear  # Clear the screen

$ECHO "\nLoad the default keyboard data file? (Y/N): \c"
read REPLY

case $REPLY in
y|Y) :
     ;;
  *) $ECHO "\nSkipping the load of the default keyboard file...\n"
     return
     ;;
esac

cat /dev/null > $KEYBOARD_FILE

$ECHO "\nLoading the Standard Keyboard File...\c"

# Loop through each character in the following list and
# append each character to the $KEYBOARD_FILE file. This
# produces a file with one character on each line.

for CHAR in \' 1 2 3 4 5 6 7 8 9 0 - = \\ q w e r t y u i o \
            p \[ \] a s d f g h j k l \; \' z x c v b n m \, \
            \. \/ \\ \~ \! \@ \# \$ \% \^ \& \* \( \) _ \+ \| \
            Q W E R T Y U I O P \{ \} A S D F G H J K L \: \" \
```

Listing 12-14 (*continued*)

```
            Z X C V B N M \< \> \? \| \. 0 1 2 3 4 5 6 7 8 9 \/ \
            \* \- \+
do
     $ECHO "$CHAR" >> $KEYBOARD_FILE
done
$ECHO "\n\n\t...Done...\n"

sleep 1
}
#
#####################################################
#
function check_for_and_create_keyboard_file
{
# If the $KEYBOARD_FILE does not exist then
# ask the user to load the "standard" keyboard
# layout, which is done with the load_default_keyboard
# function.

if [ ! -s $KEYBOARD_FILE ]
then
     $ECHO "\n\nERROR: Missing Keyboard File"
     $ECHO "\n\nWould You Like to Load the"
     $ECHO "Default Keyboard Layout?"
     $ECHO "\n\t(Y/N): \c"
     typeset -u REPLY=FALSE
     read REPLY
     if [ $REPLY != Y ]
     then
          $ECHO "\n\nERROR: This shell script cannot operate"
          $ECHO "without a keyboard data file located in"
          $ECHO "\n==>  $KEYBOARD_FILE\n"
          $ECHO "\nThis file expects one character per line."
          $ECHO "\n\t...EXITING...\n"
          exit 3
     else
          load_default_keyboard
          $ECHO "\nPress ENTER when you are ready to continue: \c"
          read REPLY
          clear
     fi
fi
}
#
#####################################################
#
function build_manager_password_report
{
```

Listing 12-14 (*continued*)

```
# Build a file to print for the secure envelope
(
$ECHO "\n                RESTRICTED USE!!!"
$ECHO "\n\n\tImmediately send an e-mail to:\n"

$ECHO "    $NOTIFICATION_LIST"

$ECHO "\n\tif this password is revealed!"
$ECHO "\n\tAIX root password:  $PW\n"

$ECHO "\n\n"

$ECHO "\n                RESTRICTED USE!!!"
$ECHO "\n\n\tImmediately send an e-mail to:\n"

$ECHO "    $NOTIFICATION_LIST"

$ECHO "\n\tif this password is revealed!"
$ECHO "\n\tAIX root password:  $PW\n"

$ECHO "\n\n"

$ECHO "\n                RESTRICTED USE!!!"
$ECHO "\n\n\tImmediately send an e-mail to:\n"

$ECHO "    $NOTIFICATION_LIST"

$ECHO "\n\tif this password is revealed!"
$ECHO "\n\tAIX root password:  $PW\n"

    ) > $OUTFILE

}
#
######################################################
#
function usage
{
$ECHO "\nUSAGE: $SCRIPT [-m] [-n]  [password_length]\n"
$ECHO "   Where:

     -m  Creates a password printout for Security

     -n  Loads the default keyboard data keys file

     password_length - Integer value that overrides
                       the default 8 character
                       password length.\n"
```

Listing 12-14 (*continued*)

```
}
#
#######################################################
#
function trap_exit
{
rm -f $OUTFILE >/dev/null 2>&1
}

#######################################################
########## END OF FUNCTION DEFINITIONS #############
#######################################################

#######################################################
####### VALIDATE EACH COMMAND LINE ARGUMENT ########
#######################################################

# Check command line arguments - $# < 3

if (($# > 3))
then
     usage
     exit 1
fi

#######################################################
#
# Test for valid command line arguments -
# Valid arguments are "-n, -N, -m, -M, and any integer

if (($# != 0))
then
   for CMD_ARG in $@
   do
         case $CMD_ARG in
         +([-0-9]))
               # The '+([-0-9]))' test notation is looking for
               # an integer. Any integer is assigned to the
               # length of password variable, LENGTH

               LENGTH=$CMD_ARG
               ;;
         -n) :
               ;;
         -N)  :
               ;;
         -m)  :
               ;;
```

Listing 12-14 (*continued*)

```
          -M)   :
                ;;
          *)
                usage
                exit 1
                ;;
          esac
   done
fi

#####################################################
#
# Ensure that the $LENGTH variable is an integer

case $LENGTH in
+([0-9])) : # The '+([-0]))' test notation is looking for
            # an integer. If it is an integer then the
            # No-Op, specified by a colon, (Do Nothing)
            # command is executed, otherwise this script
            # exits with a return code of 1, one.
          ;;
*) usage
   exit 1
   ;;
esac

#####################################################
#
# Use the getopts function to parse the command
# line arguments.

while getopts ":nNmM" ARGUMENT 2>/dev/null
do
     case $ARGUMENT in
     n|N)
        # Create a new Keyboard Data file
        load_default_keyboard
        $ECHO "\nPress ENTER when you are ready to continue: \c"
        read REPLY
        clear
        ;;
     m|M)
        # Print the Manager Password Report
        PRINT_PASSWORD_MANAGER_REPORT=TRUE
        ;;
     \?)
        # Show the usage message
        usage
```

Listing 12-14 (*continued*)

```
        exit 1
     esac
done

#######################################################
################ START OF MAIN ########################
#######################################################

# Set a trap

trap 'trap_exit;exit 2' 1 2 3 15

#######################################################
#
# Check for a keyboard data file

check_for_and_create_keyboard_file

#######################################################
############### LOAD THE ARRAY ########################
#######################################################

X=0 # Initialize the array counter to zero

# Load the array called "KEYS" with keyboard elements
# located in the $KEYBOARD_FILE.

while read ARRAY_ELEMENT
do
     ((X = X + 1)) # Increment the counter by 1

     # Load an array element in the array

     KEYS[$X]=$ARRAY_ELEMENT

done < $KEYBOARD_FILE


UPPER_LIMIT=$X  # Random Number Upper Limit

#######################################################
#
# Create the pseudo-random password in this section



clear   # Clear the screen
```

Listing 12-14 (*continued*)

```
PW=     # Initialize the password to NULL

# Build the password using random numbers to grab array
# elements from the KEYS array.

X=0
while ((X < LENGTH))
do
    # Increment the password length counter
    (( X = X + 1 ))

    # Build the password one char at a time in this loop
    PW=${PW}${KEYS[$(in_range_random_number $UPPER_LIMIT)]}
done

# Done building the password

#####################################################
#
# Display the new pseudo-random password to the screen

$ECHO "\n\n     The new $LENGTH character password is:\n"
$ECHO "\n          ${PW}\n"

#####################################################
#
# Print the Manager's password report, if specified
# on the command with the -m command switch.

if [ $PRINT_PASSWORD_MANAGER_REPORT = TRUE ]
then

  typeset -u REPLY=N

  $ECHO "\nPrint Password Sheet for the Secure Envelope? (Y/N)? \c"
  read REPLY

  if [[ $REPLY = 'Y' ]]
  then
     build_manager_password_report

     REPLY=    # Set REPLY to NULL

     $ECHO "\nSend to Default Printer ${DEFAULT_PRINTER} (Y/N)? \c"
     read REPLY
     if [[ $REPLY = 'Y' ]]
     then
          $ECHO "\nPrinting to $DEFAULT_PRINTER\n"
```

Listing 12-14 (*continued*)

```
            lp -c -d $DEFAULT_PRINTER $OUTFILE

      else
            $ECHO "\nNEW PRINT QUEUE: \c"
            read DEFAULT_PRINTER
            if [ -z "$DEFAULT_PRINTER" ]
            then
                echo "ERROR: Default printer cannot be NULL...Exiting..."
                exit 5
            fi
            $ECHO "\nPrinting to $DEFAULT_PRINTER\n"
            lp -c -d $DEFAULT_PRINTER $OUTFILE
      fi
   else
      $ECHO "\n\n\tO.K. - Printing Skipped..."
   fi
fi

#####################################################
#
# Remove the $OUTFILE, if it exists and has a size
# greater than zero bytes.

[ -s $OUTFILE ] && rm $OUTFILE

#####################################################
#
# Clear the screen and exit

$ECHO "\n\nPress ENTER to Clear the Screen and EXIT: \c"
read X
clear

# End of mk_passwd.ksh shell script
```

Listing 12-14 (*continued*)

This was an interesting shell script to create. I hope you picked up some pointers in this chapter. I tried to add a lot of script options but not make the script too difficult to understand.

Other Options to Consider

As with any script, improvements can be made. Remember the proper usage of the `echo` command. For Bourne and Bash shells, add the `-e` switch when using the backslash operators, `\n`, and so on (for example, `echo -e \nHello World\n"`), but not Korn shell, where the `-e` is not needed to enable these operators.

Password Reports?

Do you need to create password reports for your manager and directors? If not, you should disable the ability to create any file that contains any password and disable printing any passwords. This is easy to disable by commenting out the `getopts` parsing for the `-m` and `-M` command-line options.

Which Password?

You certainly do not have to accept the first password that is produced by this script. It usually takes me 5 to 10 tries to get a password that I may be able to remember. Don't stop at the first one — keep going until you get a password that you like but is not guessable.

Other Uses?

Sure, there are other uses for this shell script. Any time that you need a pseudo-random list of keyboard characters, you can use this shell script to create the list. License and encryption keys come to mind. If you are selling software and you need to create some unguessable keys, run the script and specify the length of the key as an integer value.

Summary

This was an excellent exercise in creating pseudo-random numbers and using a function directly in a command assignment. We used arrays to store our keyboard data so that any element is directly accessible. This chapter goes a long way in making any task intuitively obvious to solve. We love a good challenge.

In the next chapter we are going to look at floating-point math in shell scripts and the `bc` utility. I hope you stick around for some more tips and tricks.

Lab Assignments

1. Time the execution of the following three shell scripts, and explain any difference you observe:
   a. Write a shell script to create a 32-character license key using the `/dev/random` character special file.
   b. Write a shell script to create a 32-character license key using the `/dev/urandom` character special file.
   c. Write a shell script to create a 32-character license key using the `/dev/random` character special file to seed the `RANDOM` shell variable, and then create the encryption key using the `RANDOM` shell variable,
2. Create a 5,000-character password. How long did that task take?

CHAPTER 13

Floating-Point Math and the bc Utility

Have you ever needed to do some floating-point math in a shell script? If the answer is yes, then you're in luck. On UNIX machines there is an interactive program called **bc** that is an interpreter for the arbitrary-precision arithmetic language. You can start an interactive session by typing `bc` on the command line. Once in the session you can enter most complex arithmetic expressions as you would in a calculator. The `bc` utility can handle more than I can cover in this chapter, so we are going to keep the scope limited to simple floating-point math in shell scripts.

In this chapter we are going to create shell scripts that add, subtract, multiply, divide, and average a list of numbers. With each of these shell scripts the user has the option of specifying a *scale*, which is the number of significant digits to the right of the decimal point. If no scale is specified, an integer value is given in the result. Because the `bc` utility is an interactive program, we are going to use a *here document* to supply input to the interactive `bc` program. We cover using a here document in detail throughout this chapter. Of course, we can write an `expect` script to handle the automation. Sounds like a good Lab Assignment.

Syntax

By now you know the routine: We need to know the syntax before we can create a shell script. Depending on what we are doing we need to create a mathematical statement to present to `bc` for a here document to work. A here document works kind of like a *label* in other programming languages. The syntax that we are going to use in this chapter will have the following form:

```
VARIABLE=$(bc <<LABEL
scale=$SCALE
$(MATH_STATEMENT)
LABEL)
```

The way a here document works is some label name, in this case `LABEL`, is added just after the `bc` command. This `LABEL` has double redirection for input into the interactive program, `bc <<LABEL`. From this starting label until the same label is encountered again, everything in between is used as input to the `bc` program. By doing this we are automating an interactive program. We can also do this automation using another technique. We can use `echo`, `print`, and `printf` to print all of the data for the math statement and pipe the output to `bc`. It works like the following commands:

```
VARIABLE=$(print 'scale = 10; 104348/33215' | bc)
```

or

```
VARIABLE=$(print 'scale=$SCALE; ($MATH_STATEMENT)' | bc)
```

In either case we are automating an interactive program. This is the purpose of a here document. It is called a here document because the required input is *here*, as opposed to somewhere else, such as user input from the keyboard. When all of the required input is supplied *here*, it is a here document.

Creating Some Shell Scripts Using bc

We have the basic syntax, so let's start with a simple shell script to add numbers together. The script is expecting a list of numbers as command-line arguments. Additionally, the user may specify a *scale* if the user wants the result calculated as a floating-point number to a set precision. If a floating-point number is *not* specified, the result is presented as an integer value.

Creating the float_add.ksh Shell Script

The first shell script that we are going to create is `float_add.ksh`. The idea of this shell script is to add together a list of numbers that the user provides as command-line arguments. The user also has the option of setting a scale for the precision of floating-point numbers. Let's take a look at the `float_add.ksh` shell script in Listing 13-1, and we will go through the details at the end.

```
#!/usr/bin/ksh
#
# SCRIPT: float_add.ksh
# AUTHOR: Randy Michael
# DATE: 03/01/2007
# REV: 1.1.A
#
# PURPOSE: This shell script is used to add a list of numbers
#          together. The numbers can be either integers or floating-
#          point numbers. For floating-point numbers the user has
```

Listing 13-1 float_add.ksh shell script

```
#          the option of specifying a scale of the number of digits to
#          the right of the decimal point. The scale is set by adding
#          a -s or -S followed by an integer number.
#
# EXIT CODES:
#       0 ==> This script completed without error
#       1 ==> Usage error
#       2 ==> This script exited on a trapped signal
#
# REV. LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution
#
#########################################################
############### DEFINE VARIABLE HERE ####################
#########################################################

SCRIPT_NAME=$(basename $0)  # The name of this shell script
SCALE="0"      # Initialize the scale value to zero
NUM_LIST=      # Initialize the NUM_LIST variable to NULL
COUNT=0        # Initialize the counter to zero
MAX_COUNT=$#   # Set MAX_COUNT to the total number of
               # command-line arguments.

#########################################################
################ FUNCTIONS ##############################
#########################################################

function usage
{
echo "\nPURPOSE: Adds a list of numbers together\n"
echo "USAGE: $SCRIPT_NAME [-s scale_value]  N1 N2...Nn"
echo "\nFor an integer result without any significant decimal places..."
echo "\nEXAMPLE: $SCRIPT_NAME 2048.221 65536 \n"
echo "OR for 4 significant decimal places"
echo "\nEXAMPLE: $SCRIPT_NAME -s 4  8.09838 2048 65536 42.632"
echo "\n\t...EXITING...\n"
}

#########################################################

function exit_trap
{
echo "\n...EXITING on trapped signal...\n"
}
```

Listing 13-1 (*continued*)

```
############################################################
################## START OF MAIN ###########################
############################################################

###### Set a Trap ######

trap 'exit_trap; exit 2' 1 2 3 15

############################################################

# Check for at least two command-line arguments

if [ $# -lt 2 ]
then
     echo "\nERROR: Please provide a list of numbers to add"
     usage
     exit 1
fi

# Parse the command-line arguments to find the scale value, if present.

while getopts ":s:S:" ARGUMENT
do
    case $ARGUMENT in
         s|S) SCALE=$OPTARG
              ;;
          \?) # Because we may have negative numbers we need
              # to test to see if the ARGUMENT that begins with a
              # hyphen (-) is a number, and not an invalid switch!!!

              for TST_ARG in $*
              do
                 if [[ $(echo $TST_ARG | cut -c1) = '-' ]] \
                    && [ $TST_ARG != '-s' -a $TST_ARG != '-S' ]
                 then
                    case $TST_ARG in
                    +([-0-9])) : # No-op, do nothing
                         ;;
                    +([-0-9].[0-9]))
                         : # No-op, do nothing
                         ;;
                    +([-.0-9])) : # No-op, do nothing
                         ;;
                    *) echo "\nERROR: Invalid argument \
on the command line"
                       usage
                       exit 1
                       ;;
```

Listing 13-1 (*continued*)

```
                    esac
                fi
            done
            ;;
    esac
done

#########################################################

# Parse through the command-line arguments and gather a list
# of numbers to add together and test each value.

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1   # Grab a command-line argument on each loop iteration
     case $TOKEN in    # Test each value and look for a scale value.
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
          -S${SCALE}) shift
                      ;;
                   *) # Add the number ($TOKEN) to the list
                      NUM_LIST="${NUM_LIST} $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done

#########################################################

# Ensure that the scale is an integer value

case $SCALE in
                  # Test for an integer
     +([0-9])) :  # No-Op - Do Nothing
               ;;
            *) echo "\nERROR: Invalid scale - $SCALE - \
Must be an integer"
               usage
               exit 1
               ;;
esac

#########################################################
```

Listing 13-1 (*continued*)

```
# Check each number supplied to ensure that the "numbers"
# are either integers or floating-point numbers.
for NUM in $NUM_LIST
do
     case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +([-0-9]) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     +(+[0-9][.][0-9]))
               # Check for a positive floating-point number
               # with a + prefix
               : # No-op, do nothing
               ;;
     +(-[0-9][.][0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +([-.0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +([+.0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     *) echo "\nERROR: $NUM is NOT a valid number"
        usage
        exit 1
        ;;
     esac
done

#########################################################

# Build the list of numbers to add

ADD=    # Initialize the ADD variable to NULL
PLUS=   # Initialize the PLUS variable to NULL

# Loop through each number and build a math statement that
# will add all of the numbers together.
```

Listing 13-1 (*continued*)

```
for X in $NUM_LIST
do
      # If the number has a + prefix, remove it!
      if [[ $(echo $X | cut -c1) = '+' ]]
      then
           X=$(echo $X | cut -c2-)
      fi
      ADD="$ADD $PLUS $X"
      PLUS="+"
done

#########################################################

# Do the math here by using a here document to supply
# input to the bc command. The sum of the numbers is
# assigned to the SUM variable.

SUM=$(bc <<EOF
scale = $SCALE
(${ADD})
EOF)

#########################################################

# Present the result of the addition to the user.

echo "\nThe sum of: $ADD"
echo "\nis: ${SUM}\n"
```

Listing 13-1 (*continued*)

Let's take it from the top. We start the shell script in Listing 13-1 by defining some variables. These five variables, `SCRIPT_NAME`, `SCALE`, `NUM_LIST`, `COUNT`, and `MAX_COUNT`, are predefined for later use. The `SCRIPT_NAME` variable assignment extracts the filename of the script from the system using the `basename $0` command, and `SCALE` is used to define the precision of floating-point numbers that are calculated. The `NUM_LIST` variable is used to hold valid numbers that are to be calculated, where the command switch and the switch-argument are removed from the list. The `COUNT` and `MAX_COUNT` variables are used to scan all the command-line arguments to find the numbers.

In the next section we define the functions. This shell script has two functions, `usage` and `exit_trap`. The `usage` function shows the user how to use the script, and the `exit_trap` function is executed only when a trapped exit signal is captured. Of course, you cannot trap a `kill -9`. At the `START OF MAIN` the first thing that we do is to set a `trap`. A `trap` allows us to take some action when the trapped signal is captured. For example, if the user presses Ctrl+C, we may want to clean up some temporary files before the script exits. A `trap` allows us to do this.

A `trap` has the form of `trap 'command; command; ... ; exit 2' 1 2 3 15`. We first enclose the commands that we want to execute within tic marks (single

quotes) and then give a list of `exit` signals that we want to capture. As I said before, it is not possible to capture a `kill -9` signal because the system really just yanks the process out of the process table and it ceases to exist.

After setting the `trap` we move on to verifying that each of the command-line arguments is valid. To do this verification we do five tests. These five tests consist of checking for at least two command-line arguments, using `getopts` to parse the command-line switches, test for invalid switches, and assign switch-arguments to variables for use in the shell script. The next step is to scan each argument on the command line and extract the numbers that we need to do our calculations. Then the `$SCALE` value is checked to ensure that it points to an integer value, and the final test is to check the ''numbers'' that we gathered from the command-line scan and ensure that each one is either an integer or a floating-point number.

Testing for Integers and Floating-Point Numbers

I want to go over the integer and floating-point test before we move on. At this point in the script we have a list of ''numbers'' — at least they are supposed to be numbers — and this list is assigned to the `NUM_LIST` variable. Our job is to verify that each value in the list is either an integer or a floating-pointing number. Look at the code segment shown in Listing 13-2.

```
# Check each number supplied to ensure that the "numbers"
# are either integers or floating-point numbers.

for NUM in $NUM_LIST
do
     case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +(-[0-9])) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     +(+[0-9]|[.][0-9]))
               # Check for a positive floating-point number
               # with a + prefix
               : # No-op, do nothing
               ;;
     +(-[0-9][.][0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
```

Listing 13-2 Testing for integers and floating-point numbers

```
      +([-.0-9]))
                # Check for a negative floating-point number
                : # No-op, do nothing
                ;;
      +([+.0-9]))
                # Check for a positive floating-point number
                : # No-op, do nothing
                ;;
      *) echo "\nERROR: $NUM is NOT a valid number"
         usage
         exit 1
         ;;
      esac
done
```

Listing 13-2 (*continued*)

We use a `for` loop to test each value in the `NUM_LIST`. On each loop iteration the current value in the `$NUM_LIST` is assigned to the `NUM` variable. Within the `for` loop we have set up a `case` statement. For the tests we use regular expressions to indicate a range, or type of value, that we are expecting. If the value does not meet the criteria that we defined, the `*` is matched and we execute the `usage` function before exiting the shell script.

The Korn shell regular expressions for testing for integers and floating-point numbers include `+([0-9])`, `+(-[0-9])`, `+([0-9]|.[0-9]`, `+(+[0-9].[0-9]`, `+(-[0-9].[0-9]`, `+([-.0-9])`, and `+([+.0-9])`. The first two tests are for integers and negative whole numbers. The last five tests are for positive and negative floating-point numbers. Notice the use of the plus sign (`+`), minus sign (`-`), and the decimal point (`.`). The placement of the plus sign, minus sign, and the decimal point are important when testing the string. Because a floating-point number, both positive and negative, can be represented in many forms, we need to test for all combinations. Floating-point numbers are one of the more difficult tests to make, as you can see by the number of tests that are required.

NOTE The Bash and Bourne shells do not support regular expressions using the `+([0-9])` type notations as shown in the above Korn shell examples.

Building a Math Statement for the bc Command

Once we are sure that all the data is valid, we proceed to building the actual math statement that we are sending to the `bc` utility. To build this statement, we are going to loop through our newly confirmed `$NUM_LIST` of numbers and build a string with a plus sign (`+`) between each of the numbers in the `$NUM_LIST`. This is a neat trick. We first initialize two variables to NULL, as shown here:

```
ADD=
PLUS=
```

As we build the math statement, the ADD variable will hold the entire statement as it is added to. The PLUS variable will be assigned the + character inside the for loop on the first loop iteration. This action prevents the + sign showing up as the first character in the string we are building. Let's look at this code segment here:

```
ADD=    # Initialize the ADD variable to NULL
PLUS=   # Initialize the PLUS variable to NULL

# Loop through each number and build a math statement that
# will add all of the numbers together.

for X in $NUM_LIST
do
      if [[ $(echo $X | cut -c1) = '+' ]]
      then
           X=$(echo $X | cut -c2-)
      fi
      ADD="$ADD $PLUS $X"
      PLUS="+"
done
```

On the first loop iteration only the first number in the $NUM_LIST is assigned to the ADD variable. On each of the following loop iterations a plus sign (+) is added, followed by the next number in the $NUM_LIST, specified by the X variable on each loop iteration, until all of the numbers and plus signs have been assigned to the ADD variable. As an example, we have the following list of numbers:

```
12  453.766  223.6  3.145927  22
```

Also notice that we added a test for the number beginning with a + sign. We need to strip out this character so that we do not have two plus signs together when we present the equation to the bc program, or an error will occur. As we build the math statement the following assignments are made to the ADD variable on each loop iteration:

```
ADD="12"
ADD="12 + 453.766"
ADD="12 + 453.766 + 223.6"
ADD="12 + 453.766 + 223.6 + 3.145927"
ADD="12 + 453.766 + 223.6 + 3.145927 + 22"
```

Using a Here Document

When the looping finishes we have built the entire math statement and have it assigned to the ADD variable. Now we are ready to create the here document to add all of the numbers together with the bc utility. Take a look at the here document shown here:

```
# Do the math here by using a here document to supply
# input to the bc command. The sum of the numbers is
# assigned to the SUM variable.

SUM=$(bc <<EOF
```

```
scale=$SCALE
(${ADD})
EOF)
```

For this here document the label is the `EOF` character string (you will see this used a lot in shell scripts). The `bc` command has its input between the first `EOF` and the ending `EOF`. The first `EOF` label starts the here document, and the second `EOF` label ends the here document. Each line between the two labels is used as input to the `bc` command. There are a couple of requirements for a here document. The first requirement is that the starting label *must* be preceded by double input redirection (`<<EOF`). The second requirement is that there are *never* any blank spaces at the beginning of *any* line in the here document. If even one blank space is placed in column one, strange things may begin to happen. Depending on what you are doing, and the interactive program you are using, the here document may work, but it may not! This is one of the most difficult programming errors to find when you are testing, or using, a shell script with a here document. To be safe, just leave out any beginning spaces.

The final step is to display the result to the user. Listing 13-3 shows the `float_add.ksh` shell script in action.

```
[root:yogi]@/scripts# ./float_add.ksh -s 8 2 223.545 332.009976553

The sum of: 2 + 223.545 + 332.009976553

to a scale of 8 is 557.554976553
```

Listing 13-3 float_add.ksh shell script in action

Notice that the scale is set to 8, but the output has 9 decimal places because we used 9 significant digits to the right of the decimal point with 332.009976553. The 9 decimal places take precedence over the scale value. However, if we had not specified a scale value our answer would be an integer instead of a floating-point number. This is just how the `bc` program works. It is not an error to add in a scale, but the result does not use it in this case. The `man` page for the `bc` program can provide you with more details on this effect. We will see how the scale works in some of the other shell scripts later in this chapter.

That is it for the addition shell script, but we still have four more shell scripts to go in this chapter. Each of the following shell scripts is very similar to the script in Listing 13-1. With this being the case I am going to cover different aspects of each of the following scripts and also show where the differences lie. Please keep reading to catch a few more shell programming tips.

Creating the float_subtract.ksh Shell Script

As the `float_add.ksh` shell script performed addition on a series of numbers, this section studies the technique of subtraction. Because this shell script is very similar to the shell script in Listing 13-1, we are going to show the shell script and study the details at the end. The `float_subtract.ksh` shell script is shown in Listing 13-4.

```
#!/usr/bin/ksh
#
# SCRIPT: float_subtract.ksh
# AUTHOR: Randy Michael
# DATE: 02/23/2007
# REV: 1.1.A
#
# PURPOSE: This shell script is used to subtract a list of numbers.
#          The numbers can be either integers or floating-point
#          numbers. For floating-point numbers the user has the
#          option to specify a scale of the number of digits to
#          the right of the decimal point. The scale is set by
#          adding a -s or -S followed by an integer number.
#
# EXIT STATUS:
#       0 ==> This script completed without error
#       1 ==> Usage error
#       2 ==> This script exited on a trapped signal
#
# REV. LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution
#
############################################################
############## DEFINE VARIABLE HERE ########################
############################################################

SCRIPT_NAME=`basename $0` # The name of this shell script
SCALE="0"      # Initialize the scale value to zero
NUM_LIST=      # Initialize the NUM_LIST to NULL
COUNT=0        # Initialize the counter to zero
MAX_COUNT=$#   # Set MAX_COUNT to the total number of
               # command-line arguments

############################################################
################ FUNCTIONS #################################
############################################################

function usage
{
echo "\nPURPOSE: Subtracts a list of numbers\n"
echo "USAGE: $SCRIPT_NAME [-s scale_value]  N1 N2...Nn"
echo "\nFor an integer result without any significant decimal places..."
echo "\nEXAMPLE: $SCRIPT_NAME 2048.221 65536 \n"
echo "OR for 4 significant decimal places"
echo "\nEXAMPLE: $SCRIPT_NAME -s 4  8.09838 2048 65536 42.632"
```

Listing 13-4 float_subtract.ksh shell script

```
echo "\n\t...EXITING...\n"
}

#########################################################

function exit_trap
{
        echo "\n...EXITING on trapped signal...\n"
}

#########################################################
################ START OF MAIN ##########################
#########################################################

###### Set a Trap ######

trap 'exit_trap; exit 2' 1 2 3 15

########################

# Check for at least two command-line arguments

if (($# < 2))
then
        echo "\nERROR: Please provide a list of numbers to subtract"
        usage
        exit 1
fi
# Parse the command-line arguments to find the scale value, if present.

while getopts ":s:S:" ARGUMENT
do
    case $ARGUMENT in
         s|S) SCALE=$OPTARG
              ;;
          \?) # Because we may have negative numbers we need
              # to test to see if the ARGUMENT that begins with a
              # hyphen (-) is a number, and not an invalid switch!!!

              for TST_ARG in $*
              do
                 if [[ $(echo $TST_ARG | cut -c1) = '-' ]] \
                    && [ $TST_ARG != '-s' -a $TST_ARG != '-S' ]
                 then
                    case $TST_ARG in
                    +([-0-9])) : # No-op, do nothing
                               ;;
                    +([-0-9].[0-9]))
```

Listing 13-4 (*continued*)

```
                                : # No-op, do nothing
                                ;;
                    +([-.0-9])) : # No-op, do nothing
                                ;;
                *) echo "\nERROR: Invalid argument on the command line"
                     usage
                     exit 1
                     ;;
                  esac
                fi
            done
            ;;
    esac
done

#########################################################

# Parse through the command-line arguments and gather a list
# of numbers to subtract.

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1
     case $TOKEN in
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
          -S${SCALE}) shift
                      ;;
                   *) NUM_LIST="${NUM_LIST} $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done

#########################################################

# Ensure that the scale is an integer value

case $SCALE in
     +([0-9])) :  # No-Op - Do Nothing
               ;;
           *) echo "\nERROR: Invalid scale - $SCALE - Must be an integer"
              usage
              exit 1
```

Listing 13-4 (*continued*)

```
                ;;
esac

#########################################################

# Check each number supplied to ensure that the "numbers"
# are either integers or floating-point numbers.


for NUM in $NUM_LIST
do
     case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +([-0-9])) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     +(+[0-9]|[.][0-9]))
               # Check for a positive floating-point number
               # with a + prefix
               : # No-op, do nothing
               ;;
     +([-0-9]|.[0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +(-[.][0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +([+.0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     *) echo "\nERROR: $NUM is NOT a valid number"
        usage
        exit 1
        ;;
     esac
done

#########################################################
```

Listing 13-4 (*continued*)

```
# Build the list of numbers to subtract

SUBTRACT=   # Initialize the SUBTRACT variable to NULL
MINUS=      # Initialize the MINUS variable to NULL

# Loop through each number and build a math statement that
# will subtract the numbers in the list.

for X in $NUM_LIST
do
      # If the number has a + prefix, remove it!
      if [[ $(echo $X | cut -c1) = '+' ]]
      then
           X=$(echo $X | cut -c2-)
      fi
      SUBTRACT="$SUBTRACT $MINUS $X"
      MINUS='-'
done

#########################################################

# Do the math here by using a here document to supply
# input to the bc command. The difference of the numbers is
# assigned to the DIFFERENCE variable.

DIFFERENCE=$(bc <<EOF
scale=$SCALE
(${SUBTRACT})
EOF)

#########################################################

# Present the result of the subtraction to the user.

echo "\nThe difference of: $SUBTRACT"
echo "\nis: ${DIFFERENCE}\n"
```

Listing 13-4 (*continued*)

The parts of the `float_subtract.ksh` shell script, shown in Listing 13-4, that remain unchanged from Listing 13-1 include the following sections: variable definitions and the `usage` function, which is unchanged except that the references to addition are changed to subtraction. Additionally, all the same tests are performed on the user-provided data to ensure the data integrity. When we get to the end of the shell script where the math statement is created and the here document performs the calculation, we get into some changes.

Using getopts to Parse the Command Line

Let's first cover parsing the command line for the `-s` and `-S` switches and these switch-arguments that we use to define the floating-point precision with the `getopts` command. Using `getopts` for command-line parsing is the simplest method. It sure beats trying to program all of the possibilities inside the shell script. The first thing to note about `getopts` is that this command does not care *what* is on the command line! `getopts` is interested in only command switches, which must begin with a hyphen (`-`), such as `-s` and `-S` for this shell script. Let's look at the `getopts` code segment and see how it works:

```
# Parse the command-line arguments to find the scale value, if present.

while getopts ":s:S:" ARGUMENT
do
    case $ARGUMENT in
         s|S) SCALE=$OPTARG
              ;;
          \?) # Because we may have negative numbers we need
              # to test to see if the ARGUMENT that begins with a
              # hyphen (-) is a number, and not an invalid switch!!!

              for TST_ARG in $*
              do
                 if [[ $(echo $TST_ARG | cut -c1) = '-' ]] \
                    && [ $TST_ARG != '-s' -a $TST_ARG != '-S' ]
                 then
                    case $TST_ARG in
                    +([-0-9])) : # No-op, do nothing
                               ;;
                    +([-0-9].[0-9]))
                               : # No-op, do nothing
                               ;;
                    +([-.0-9])) : # No-op, do nothing
                               ;;
                    *) echo "\nERROR: $TST_ARG is an invalid argument\n"
                       usage
                       exit 1
                       ;;
                    esac
                 fi
              done
    esac
done
```

A `getopts` statement starts with a `while` loop. To define valid command-line switches for a shell script, you add the list of characters that you want to use for command-line switches just after the `while getopts` part of the `while` statement.

It is a good practice to enclose the list of command-line switches in double quotes (`"list"`). The next thing that you need to notice is the use of the colons (`:`) in the list of valid switches. The placement and usage of the colons is important. Specifically, if the list *starts* with a colon, then any undefined command-line switch that is located will be assigned the question mark (`?`) character. The question mark character is then assigned to the `ARGUMENT` variable (which can actually be any variable name). Whenever the `?` is matched it is a good idea to `exit` the script or send an error message to the user, and show the user the correct usage of the shell script before exiting. This ability to catch usage errors is what makes `getopts` a very nice and powerful tool to use.

But in our case when we encounter the `?`, we may just have a negative number! Therefore, any time we encounter a hyphen (`-`) on the command line, we need to test for a negative number before we tell the user that the input is invalid. This piece of code is in the `case` statement after the `?`.

The other colon (`:`) used in the list specifies that the switch character that appears immediately *before* the colon requires a switch-argument. Looking at the following `getopts` example statement may help to clarify the colon usage:

```
while getopts ":s:S:rtg:" ARGUMENT
```

In this `getopts` statement the list begins with a colon, so any command-line switch other than `-s`, `-S`, `-r`, `-t`, and `-g` will cause the `ARGUMENT` variable to be assigned the `?` character, indicating a usage error. When any *defined* command-line argument is located on the command line it is assigned to the `ARGUMENT` variable (you can use any variable name here). When any *undefined* command-line switch is located, and the valid switch list *begins* with a colon, the question mark character is assigned to the `ARGUMENT` variable. If the switch list does *not* begin with a colon, the undefined switch is ignored. In our shell script we do not want to ignore any invalid command-line argument but we also do not want a negative number to be considered invalid input. This is where we do the extra test on the command line.

Looking at each of the individually defined switches in the previous example, `-s` and `-S` each require a switch-argument. The `-r`, `-t`, and `-g` switches do *not* have an argument because they do not have a colon after them in the definition list. When a switch is encountered that requires a switch-argument, the switch-argument is assigned to a variable called `OPTARG`. In our case the switch-argument to `-s` or `-S` is the value of the scale for precision floating-point arithmetic, so we make the following assignment: `SCALE=$OPTARG` in the `case` statement inside the `while` loop. As with the `float_add.ksh` shell script, the scale does not give the results that you expect. The use of the scale is in this shell script as a learning experience and you will see expected results in the following shell scripts in this chapter.

Just remember when using `getopts` to parse command-line arguments for valid switches that `getopts` could not care less what is on the command line. It is up to you to verify that all of the data that you use is valid for your particular purpose. This is why we make so many tests of the data that the user inputs on the command line.

Building a Math Statement String for bc

Next we move on to the end of the shell script where we build the math statement for the `bc` command. In building the math statement that we use in the here document,

we now use the SUBTRACT and MINUS variables in the for loop. Take a look at the code segment listed here to build the math statement:

```
# Build the list of numbers to subtract

SUBTRACT=   # Initialize the SUBTRACT variable to NULL
MINUS=      # Initialize the MINUS variable to NULL

# Loop through each number and build a math statement that
# will subtract the numbers in the list.

for X in $NUM_LIST
do
      # If the number has a + prefix, remove it!
      if [[ $(echo $X | cut -c1) = '+' ]]
      then
           X=$(echo $X | cut -c2-)
      fi

      SUBTRACT="$SUBTRACT $MINUS $X"
      MINUS='-'
done
```

Notice that we initialize the SUBTRACT and MINUS variables to NULL. We do this because on the first loop iteration we do not want a minus sign (-) included. The minus sign is defined within the for loop. The SUBTRACT variable is initialized to NULL because we want to begin with an empty statement string. As we start the for loop, using the valid list of numbers that we so painstakingly verified, we add only the first number in the $NUM_LIST variable. On the second loop iteration, and continuing until all of the numbers in the $NUM_LIST have been exhausted, we add a minus sign to the math statement, followed by the next number in the list. Additionally, we took the extra step of removing any plus sign (+) that may be a prefix to any positive number. This step is required because we do not want the + in the equation, or an error will occur because there will be a – *and* a + between two numbers. During this for loop the entire math statement is assigned to the SUBTRACT variable. The statement is built in the following manner, assuming that we have the following numbers to work with:

```
12  453.766  -223.6  3.145927  22
```

As we build the math statement the following assignments are made to the SUBTRACT variable:

```
SUBTRACT="12"
SUBTRACT="12 - 453.766"
SUBTRACT="12 - 453.766 - -223.6"
SUBTRACT="12 - 453.766 - -223.6 - 3.145927"
SUBTRACT="12 - 453.766 - -223.6 - 3.145927 - 22"
```

Here Document and Presenting the Result

I want to cover a here document one more time because it is important to know what you can and cannot do with this technique. With the math statement created we are

ready to create the here document to add all of the numbers together with the bc utility. Take a look at the here document shown here:

```
# Do the math here by using a here document to supply
# input to the bc command. The difference of the numbers is
# assigned to the DIFFERENCE variable.

DIFFERENCE=$(bc <<EOF
scale=$SCALE
(${SUBTRACT})
EOF)
```

Just like the here document in Listing 13-1, float_add.ksh, this here document label is the EOF character string. The bc command has its input between the starting EOF label and the ending EOF label. The first label starts the here document, and the second EOF label ends the here document. Each line between the two labels is used as input to the bc command. As mentioned earlier, there are a couple of requirements for a here document. The first requirement is that the starting label *must* be preceded by double input redirection (<<EOF). The second requirement is that there are *never* any blank spaces at the beginning of *any* line in the here document. If even one blank space is placed in column one, strange things may begin to happen with the calculation. This is the cause of a lot of frustration when programming here documents. This blank-space problem is one of the most difficult programming errors to find when you are testing, or using, a shell script with a here document.

The final step is to display the result to the user. Listing 13-5 shows the float_subtract.ksh shell script in action.

```
[root:yogi]@/scripts# float_subtract.ksh -s 4  8.09838 2048 65536 42.632

The difference of: 8.09838 - 2048 - 65536 - 42.632

to a scale of 4 is -67618.53362
```

Listing 13-5 float_subtract.ksh shell script in action

The float_subtract.ksh shell script is very similar to the float_add.ksh shell script. Again, notice that the scale had no effect on the result of this calculation because we used 5 significant digits to the right of the decimal point with 8.09838. The 5 decimal places take precedence over the scale value. However, if we had not specified a scale value our answer would be an integer instead of a floating-point number. The man page for bc has more information on using scale. The next three shell scripts have some variations also. With this commonality I am going to deviate and cover some of the different aspects of each of the following scripts and show where the differences lie.

Creating the float_multiply.ksh Shell Script

This time we are going to multiply a list of numbers. Using the same front end, for the most part, this shell script changes the building of the math statement and has a new

here document. I want to cover the technique that we use to scan the command-line arguments to find the nonswitch arguments and their associated switch arguments. What remains after the command-line argument scan should be only a list of numbers, which is assigned to the `NUM_LIST` variable. Of course, we do test each number with regular expressions just as before. Let's look at the `float_multiply.ksh` shell script shown in Listing 13-6 and study the details at the end.

```
#!/usr/bin/ksh
#
# SCRIPT: float_multiply.ksh
# AUTHOR: Randy Michael
# DATE: 02/23/2007
# REV: 1.1.P
#
# PURPOSE: This shell script is used to multiply a list of numbers
#          together. The numbers can be either integers or floating-
#          point numbers. For floating-point numbers the user has
#          the option of specifying a scale of the number of digits to
#          the right of the decimal point. The scale is set by adding
#          a -s or -S followed by an integer number.
#
# EXIT STATUS:
#       0 ==> This script/function exited normally
#       1 ==> Usage or syntax error
#       2 ==> This script/function exited on a trapped signal
#
# REV. LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution
#
############################################################
############## DEFINE VARIABLE HERE ######################
############################################################

SCRIPT_NAME=$(basename $0)  # The name of this shell script
SCALE="0"      # Initialize the scale value to zero
NUM_LIST=      # Initialize the NUM_LIST to NULL
COUNT=0        # Initialize the counter to zero
MAX_COUNT=$#   # Set MAX_COUNT to the total number of
               # command-line arguments


############################################################
################ FUNCTIONS ################################
############################################################
```

Listing 13-6 float_multiply.ksh shell script

```
function usage
{
echo "\nPURPOSE: Multiplies a list of numbers together\n"
echo "USAGE: $SCRIPT_NAME [-s scale_value]  N1 N2...Nn"
echo "\nFor an integer result without any significant decimal places..."
echo "\nEXAMPLE: $SCRIPT_NAME 2048.221 65536 \n"
echo "OR for 4 significant decimal places"
echo "\nEXAMPLE: $SCRIPT_NAME -s 4  8.09838 2048 65536 42.632"
echo "\n\t...EXITING...\n"
}

#########################################################

function exit_trap
{
echo "\n...EXITING on trapped signal...\n"
}

#########################################################
################## START OF MAIN ########################
#########################################################

###### Set a Trap ######

trap 'exit_trap; exit 2' 1 2 3 15

#########################################################

# Check for at least two command-line arguments

if (($# < 2))
then
    echo "\nERROR: Please provide a list of numbers to multiply"
    usage
    exit 1
fi

#########################################################

# Parse the command-line arguments to find the scale value, if present.

while getopts ":s:S:" ARGUMENT
do
    case $ARGUMENT in
         s|S) SCALE=$OPTARG
              ;;
          \?) # Because we may have negative numbers we need
              # to test to see if the ARGUMENT that begins with a
```

Listing 13-6 (*continued*)

```
            # hyphen (-) is a number, and not an invalid switch!!!

            for TST_ARG in $*
            do
               if [[ $(echo $TST_ARG | cut -c1) = '-' ]] \
                  && [ $TST_ARG != '-s' -a $TST_ARG != '-S' ]
               then
                  case $TST_ARG in
                  +([-0-9])) : # No-op, do nothing
                             ;;
                  +([-0-9].[0-9]))
                              : # No-op, do nothing
                              ;;
                  +([-.0-9])) : # No-op, do nothing
                              ;;
                  *) echo "\nERROR: $TST_ARG is an invalid argument\n"
                     usage
                     exit 1
                     ;;
                  esac
               fi
            done
            ;;
    esac
done

#########################################################

# Parse through the command-line arguments and gather a list
# of numbers to multiply together.

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1
     case $TOKEN in
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
          -S${SCALE}) shift
                      ;;
                   *) NUM_LIST="${NUM_LIST} $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done
```

Listing 13-6 (*continued*)

```
#########################################################

# Ensure that the scale is an integer value

case $SCALE in
     +([0-9])) :  # No-Op - Do Nothing
               ;;
           *) echo "\nERROR: Invalid scale - $SCALE - Must be an integer"
               usage
               exit 1
               ;;
esac

#########################################################

# Check each number supplied to ensure that the "numbers"
# are either integers or floating-point numbers.

for NUM in $NUM_LIST
do
case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +([-0-9])) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
     +(+[0-9]|[.][0-9]))
               # Check for a positive floating-point number
               # with a + prefix
               : # No-op, do nothing
               ;;
     +([-0-9]|.[0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +(-.[0-9]))
               # Check for a negative floating-point number
               : # No-op, do nothing
               ;;
     +([+.0-9]))
               # Check for a positive floating-point number
               : # No-op, do nothing
               ;;
```

Listing 13-6 (*continued*)

```
     *) echo "\nERROR: $NUM is NOT a valid number"
        usage
        exit 1
        ;;
     esac
done

#########################################################

# Build the list of numbers to multiply

MULTIPLY=  # Initialize the MULTIPLY variable to NULL
TIMES=     # Initialize the TIMES variable to NULL

# Loop through each number and build a math statement that
# will multiply all of the numbers together.

for X in $NUM_LIST
do
      # If the number has a + prefix, remove it!
      if [[ $(echo $X | cut -c1) = '+' ]]
      then
           X=$(echo $X | cut -c2-)
      fi

      MULTIPLY="$MULTIPLY $TIMES $X"
      TIMES='*'
done

#########################################################

# Do the math here by using a here document to supply
# input to the bc command. The product of the multiplication
# of the numbers is assigned to the PRODUCT variable.

PRODUCT=$(bc <<EOF
scale=$SCALE
$MULTIPLY
EOF)

#########################################################

# Present the result of the multiplication to the user.

echo "\nThe product of: $MULTIPLY"
echo "\nto a scale of $SCALE is ${PRODUCT}\n"
```

Listing 13-6 (*continued*)

As you can see in Listing 13-6, most of the previous two shell scripts have been carried over for use here. Now I want to cover in a little more detail how the scanning of the command-line arguments works when we extract the command switches, and the associated switch-arguments, from the entire list of arguments.

Parsing the Command Line for Valid Numbers

To start the extraction process we use the two previously initialized variables, `COUNT` and `MAX_COUNT`. The `COUNT` variable is incremented during the processing of the `while` loop, and the `MAX_COUNT` variable has been initialized to the value of `$#`, which specifies the total number of command-line arguments given by the user. The `while` loop runs until the `COUNT` variable is greater than or equal to the `MAX_COUNT` variable.

Inside the `while` loop the `COUNT` variable is incremented by one, so on the first loop iteration the `COUNT` equals 1, one, because it was initialized to 0, zero. Next is the `TOKEN` variable. The `TOKEN` variable always points to the `$1` positional parameter throughout the `while` loop execution. Using the current value of the `$1` positional parameter, which is pointed to by the `TOKEN` variable, as the `case` statement argument we test to see if `$TOKEN` points to a known value. The current known values on the command line are the `-s` and `-S` switches that are used to define the scale for floating-point arithmetic, if a scale was given, and the integer value of the `SCALE`. There are only two options for the value of the scale:

```
-s  {Scale Integer}

-S  {Scale Integer}
```

Because these are the only possible scale values (we also allow an uppercase `-S`) for the command line, we can test for this condition easily in a `case` statement. Remember that I said the `$TOKEN` variable always points to the `$1` positional parameter? To move the other positional parameters to the `$1` position we use the **shift** command. The `shift` command alone will shift the `$2` positional parameter to the `$1` position. What if you want to move the `$3` positional parameter to the `$1` position? We have two options: Use two `shift` commands in series, or add an integer as an argument to the `shift` command. Both of the following commands move the `$3` positional parameter to the `$1` position:

```
shift; shift
```

or

```
shift 2
```

Now you may be wondering what happens to the previous `$1`, and in this case `$2`, positional parameter values. Well, anything that is shifted from the `$1` position goes to the bit bucket! But this is the result that we want here.

If the value of the positional parameter in the `$1` position is the `-s` or `-S` switch alone, we `shift` two positions. We do this double `shift` because we know that there should

be an integer value after the `-s` or `-S` switch, which is the integer switch-argument that defines the scale. On the other hand, if the user did *not* place a space between the `-s` or `-S` switch and the switch-argument, we shift only once. Let's say that the user entered either of the following command statements on the command line:

```
[root:yogi]@/scripts# float_multiply.ksh -s 4  8.09838 2048 65536 42.632
```

or

```
[root:yogi]@/scripts# float_multiply.ksh -s4  8.09838 2048 65536 42.632
```

Notice in the first command the user added a space between the switch and the switch-argument (`-s 4`). In this situation our test will see the `-s` as a single argument, so we need to `shift` two places to move past the switch argument, which is `4`. In the second command statement the user did *not* add a space between the switch and the switch argument (`-s4`). This time we shift only one position because the switch and the switch argument are together in the `$1` positional parameter, which is what `$TOKEN` points to.

There is one more thing that I want to point out. On each loop iteration the `COUNT` is incremented by 1, one, as you would expect. But if we `shift` two times, we need to increment the `COUNT` by 1, one, a second time so we do not count past the number of arguments on the command line. This is very important! If you leave out this extra counter incrementation, the shell script errors out. Every little piece of this loop has a reason for being there. Speaking of the loop, please study the `while` loop in the code segment shown in Listing 13-7.

```
# Parse through the command-line arguments and gather a list
# of numbers to multiply together.

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1
     case $TOKEN in
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
          -S${SCALE}) shift
                      ;;
                   *) NUM_LIST="${NUM_LIST} $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done
```

Listing 13-7 Code to parse numbers from the command line

The techniques to build the math statement and to do the calculations with a here document using the `bc` command are changed only slightly. Of course, because we are multiplying a string of numbers instead of adding or subtracting, we changed the build code to add a `*`, instead of a `+` or `-`. The here document is exactly the same except that the result is assigned to the `PRODUCT` variable. Please look closely at the `float_multiply.ksh` shell script shown in Listing 13-6 and study the subtle changes from the previous two shell scripts in Listing 13-1 and Listing 13-3.

The `float_multiply.ksh` shell script is shown in action in Listing 13-8. Notice in this output that the scale setting still has no effect on the output.

```
[root:yogi]@/scripts# float_multiply.ksh -s 4  8.09838 2048 65536 42.632

The product of:   8.09838 * 2048 * 65536 * 42.632

is 46338688867.08584
```

Listing 13-8 float_multiply.ksh shell script in action

In the next section we move on to study division. We had to do some creative engineering to change the previous shell script to work with only two numbers. Keep reading — I think you will pick up a few more pointers.

Creating the float_divide.ksh Shell Script

For the division script we had to do some changes because we are dealing with only two numbers, as opposed to an unknown string of numbers. The `float_divide.ksh` shell script starts out the same as the previous three scripts, with the same variables and a modified `usage` function. The first test is for the correct number of command-line arguments. In this shell script we can handle from two to four arguments, with the option to specify a scale value for precision of floating-point numbers.

In the `getopts` statement we perform the same test to parse out the scale switch, `-s` or `-S`, and the switch-argument. When, however, we get to parsing the entire list of command-line arguments to gather the numbers for the division, we do things a little differently. The `while` loop is the same, with the counter and the `TOKEN` variable always pointing to the `$1` positional parameter, which we use as we `shift` command-line arguments to the `$1` position. It is in the `case` statement that we do our modification. For division we need a *dividend* and a *divisor*, which has the form in a division statement of `((QUOTIENT=$DIVIDEND / $DIVISOR))`. As we parse the command-line arguments we assign the first number to the `DIVIDEND` variable and the second number to the `DIVISOR`. Look at the code segment in Listing 13-9, and we will go into the details at the end.

```
# Parse through the command-line arguments and gather a list
# of numbers to divide.

TOTAL_NUMBERS=0

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1
     case $TOKEN in
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
          -S${SCALE}) shift
                      ;;
                   *) ((TOTAL_NUMBERS = TOTAL_NUMBERS + 1))
                      if ((TOTAL_NUMBERS == 1))
                      then
                           DIVIDEND=$TOKEN
                      elif ((TOTAL_NUMBERS == 2))
                      then
                           DIVISOR=$TOKEN
                      else
                           echo "ERROR: Too many numbers to divide"
                           usage
                           exit 1
                      fi
                      NUM_LIST="$NUM_LIST $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done
```

Listing 13-9 Code to extract the dividend and divisor

Notice the boldface text in the `case` statement in Listing 13-9. When a number is encountered we use a variable called `TOTAL_NUMBERS` to keep track of how many numbers are on the command line. If `$TOTAL_NUMBERS` is equal to 1, one, we assign the value of the `$TOKEN` variable to the `DIVIDEND` variable, the number on the top in a division math statement. When `$TOTAL_NUMBERS` is equal to 2, we assign the value of the `$TOKEN` variable to the `DIVISOR` variable. If the `$TOTAL_NUMBERS` counter variable exceeds 2, we print an error message to the screen, execute the `usage` function, and `exit` the script with a return code of `1`, which is a normal usage error for this shell script.

Notice that we are also keeping the NUM_LIST variable. We use the $NUM_LIST to verify that each ''number'' is actually an integer or a floating-point number by using the regular expressions that we covered previously in this chapter.

Notice in the shell script in Listing 13-10 that we omitted the step of building the math statement. In this script it is not necessary because we have the dividend and divisor captured in the code segment in Listing 13-9. Check out the shell script in Listing 13-10, and pay close attention to the boldface text.

```
#!/usr/bin/ksh
#
# SCRIPT: float_divide.ksh
# AUTHOR: Randy Michael
# DATE: 02/23/2007
# REV: 1.1.A
#
# PURPOSE: This shell script is used to divide two numbers.
#          The numbers can be either integers or floating-point
#          numbers. For floating-point numbers the user has the
#          option to specify a scale of the number of digits to
#          the right of the decimal point. The scale is set by
#          adding a -s or -S followed by an integer number.
#
# EXIT STATUS:
#       0 ==> This script exited normally
#       1 ==> Usage or syntax error
#       2 ==> This script exited on a trapped signal
#
# REV. LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution
#
############################################################
############### DEFINE VARIABLE HERE #####################
############################################################

SCRIPT_NAME=`basename $0`
SCALE="0"       # Initialize the scale value to zero
NUM_LIST=       # Initialize the NUM_LIST to NULL
COUNT=0         # Initialize the counter to zero
MAX_COUNT=$#    # Set MAX_COUNT to the total number of
                # command-line arguments

############################################################
################ FUNCTIONS #################################
############################################################
```

Listing 13-10 float_divide.ksh shell script

```
function usage
{
echo "\nPURPOSE: Divides two numbers\n"
echo "USAGE: $SCRIPT_NAME [-s scale_value]  N1 N2"
echo "\nFor an integer result without any significant decimal places..."
echo "\nEXAMPLE: $SCRIPT_NAME 2048.221 65536 \n"
echo "OR for 4 significant decimal places"
echo "\nEXAMPLE: $SCRIPT_NAME -s 4  2048.221 65536"
echo "\n\t...EXITING...\n"
}

#########################################################

function exit_trap
{
        echo "\n...EXITING on trapped signal...\n"
}

#########################################################
################ START OF MAIN ##########################
#########################################################

###### Set a Trap ######

trap 'exit_trap; exit 2' 1 2 3 15

########################

# Check for at least two command-line arguments
# and not more than four

if (($# < 2))
then
        echo "\nERROR: Too few command line arguments"
        usage
        exit 1

elif (($# > 4))
then
        echo "\nERROR: Too many command line arguments"
        usage
        exit 1
fi

# Parse the command-line arguments to find the scale value, if present.

while getopts ":s:S:" ARGUMENT
do
```

Listing 13-10 (*continued*)

```
    case $ARGUMENT in
         s|S) SCALE=$OPTARG
              ;;
          \?) # Because we may have negative numbers we need
              # to test to see if the ARGUMENT that begins with a
              # hyphen (-) is a number, and not an invalid switch!!!

              for TST_ARG in $*
              do
                 if [[ $(echo $TST_ARG | cut -c1) = '-' ]] \
                    && [ $TST_ARG != '-s' -a $TST_ARG != '-S' ]
                 then
                    case $TST_ARG in
                    +([-0-9])) : # No-op, do nothing
                               ;;
                    +([-0-9].[0-9]))
                               : # No-op, do nothing
                               ;;
                    +([-.0-9])) : # No-op, do nothing
                               ;;
                    *) echo "\nERROR: $TST_ARG is an invalid argument\n"
                       usage
                       exit 1
                       ;;
                    esac
                 fi
              done
              ;;
    esac
done

#########################################################

# Parse through the command-line arguments and gather a list
# of numbers to divide.

TOTAL_NUMBERS=0

while ((COUNT < MAX_COUNT))
do
     ((COUNT = COUNT + 1))
     TOKEN=$1
     case $TOKEN in
               -s|-S) shift 2
                      ((COUNT = COUNT + 1))
                      ;;
          -s${SCALE}) shift
                      ;;
```

Listing 13-10 (*continued*)

```
          -S${SCALE}) shift
                      ;;
                   *) ((TOTAL_NUMBERS = TOTAL_NUMBERS + 1))
                      if ((TOTAL_NUMBERS == 1))
                      then
                           DIVIDEND=$TOKEN
                      elif ((TOTAL_NUMBERS == 2))
                      then
                           DIVISOR=$TOKEN
                      else
                           echo "ERROR: Too many numbers to divide"
                           usage
                           exit 1
                      fi
                      NUM_LIST="$NUM_LIST $TOKEN"
                      ((COUNT < MAX_COUNT)) && shift
                      ;;
     esac
done

#########################################################

# Ensure that the scale is an integer value

case $SCALE in
     +([0-9])) :  # No-op - Do Nothing
               ;;
     *) echo "\nERROR: Invalid scale - $SCALE - Must be an integer"
               usage
               exit 1
               ;;
esac

#########################################################

# Check each number supplied to ensure that the "numbers"
# are either integers or floating-point numbers.

for NUM in $NUM_LIST
do
     case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +([-0-9])) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
```

Listing 13-10 (*continued*)

```
                # Check for a positive floating-point number
                : # No-op, do nothing
                ;;
      +(+[0-9]|[.][0-9]))
                # Check for a positive floating-point number
                # with a + prefix
                : # No-op, do nothing
                ;;
      +([-0-9]|.[0-9]))
                # Check for a negative floating-point number
                : # No-op, do nothing
                ;;
      +(-.[0-9]))
                # Check for a negative floating-point number
                : # No-op, do nothing
                ;;
      +([+.0-9]))
                # Check for a positive floating-point number
                : # No-op, do nothing
                ;;
      *) echo "\nERROR: $NUM is NOT a valid number"
         usage
         exit 1
         ;;
      esac
done

############################################################

# Do the math here by using a here document to supply
# input to the bc command. The quotient of the division is
# assigned to the QUOTIENT variable.

QUOTIENT=$(bc <<EOF
scale=$SCALE
$DIVIDEND / $DIVISOR
EOF)

############################################################

# Present the result of the division to the user.

echo "\nThe quotient of: $DIVIDEND / $DIVISOR"
echo "\nto a scale of $SCALE is ${QUOTIENT}\n"
```

Listing 13-10 (*continued*)

Let's look at the here document we use to calculate the `QUOTIENT` using the `bc` utility at the end of Listing 13-10. We already have extracted the dividend and divisor directly from the command line, so we skipped building the math statement. Using command

substitution we use double input redirection with a label (<<EOF), which defines the beginning of a here document, to set the scale of the precision of floating-point numbers and to divide the two numbers. If no scale was given on the command line, the scale is 0, zero, indicating an integer value. The here document ends with the final label (EOF) to end the here document and exit the bc utility, which is an interactive program. The final step is to present the result to the user. In Listing 13-11 you can see the float_divide.ksh shell script in action.

```
[root:yogi]@/scripts# float_divide.ksh -s 6 .3321 -332.889

The quotient of: .3321 / -332.889

to a scale of 6 is -.000997
```

Listing 13-11 float_divide.ksh shell script in action

Notice that the scale worked with the division script because we never used a floating-point number greater than 6 significant digits in our division, therefore we never overrode the scale value. We have completed shell scripts for addition, subtraction, multiplication, and division. I want to present one more variation in the next section.

Creating the float_average.ksh Shell Script

Using the addition shell script from Listing 13-1 we can make a couple of minor modifications and take the average of a series of numbers.

The first addition to Listing 13-1 is the addition of the variable TOTAL_NUMBERS. To average a list of numbers, we need to know how many numbers are in the list so that we can divide the SUM by the total number of numbers. The counter is added in the sanity check of the $NUM_LIST numbers, where we are ensuring that the numbers are either integers or floating-point numbers. This modification is shown in Listing 13-12.

```
TOTAL_NUMBERS=0

for NUM in $NUM_LIST
do
     ((TOTAL_NUMBERS = TOTAL_NUMBERS + 1))
     case $NUM in
     +([0-9])) # Check for an integer
               : # No-op, do nothing.
               ;;
     +([-0-9])) # Check for a negative whole number
               : # No-op, do nothing
               ;;
     +([0-9]|[.][0-9]))
               # Check for a positive floating-point number
```

Listing 13-12 Code segment to keep a running total of numbers

```
                : # No-op, do nothing
                ;;
     +(+[0-9]|[.][0-9]))
                # Check for a positive floating-point number
                # with a + prefix
                : # No-op, do nothing
                ;;
     +([-0-9]|.[0-9]))
                # Check for a negative floating-point number
                : # No-op, do nothing
                ;;
     +(-.[0-9]))
                # Check for a negative floating-point number
                : # No-op, do nothing
                ;;
     +([+.0-9]))
                # Check for a positive floating-point number
                : # No-op, do nothing
                ;;
     *) echo "\nERROR: $NUM is NOT a valid number"
        usage
        exit 1
        ;;
     esac

done
```

Listing 13-12 (*continued*)

The two lines of modification are highlighted in boldface text in Listing 13-12. The only other modifications are with the here document, where we added a division to the `$ADD` by the `$TOTAL_NUMBERS`, and the code to present the result to the user. This code modification is shown in Listing 13-13.

```
# Do the math with a here document for the bc command

AVERAGE=$(bc <<EOF
scale=$SCALE
(${ADD}) / $TOTAL_NUMBERS
EOF)

# Present the result to the user

echo "\nThe average of: $(echo $ADD | sed s/+//g)"
echo "\nto a scale of $SCALE is ${AVERAGE}\n"
```

Listing 13-13 Code segment to average a list of numbers

In Listing 13-13 notice how the averaging of the numbers is done. In the `float_add.ksh` script in listing 13.1 an addition math statement was created and assigned to the `ADD` variable. Now we use this `ADD` variable as input to the `bc` command in the here document and divide the result of the addition by the total number of numbers given on the command line, `$TOTAL_NUMBERS`. The result is an average of the numbers.

In the next step we present the result to the user. Notice the `sed` statement that is in boldface text. This `sed` statement is replacing every occurrence of the plus sign (+) with a blank space. The result is a list of the numbers only. We could have just as easily used the `$NUM_LIST` variable, but I wanted to slip a `sed` statement into this chapter somewhere. The `float_average.ksh` shell script is shown in action in Listing 13-14.

```
[root:yogi]@/scripts# float_average.ksh -s 8 .22389 65 -32.778 -.221
The average of: .22389  65  -32.778  -.221

to a scale of 8 is 8.05622250
```

Listing 13-14 float_average.ksh shell script in action

The `float_average.ksh` shell script listing is shown in Listing 13-15.

```
#!/usr/bin/ksh
#
# SCRIPT: float_aaverage.ksh
# AUTHOR: Randy Michael
# DATE: 03/01/2007
# REV: 1.1.A
#
# PURPOSE: This script is used to average a list of
#   floating-point numbers.
#
# EXIT STATUS:
#       0 ==> This script completed without error
#       1 ==> Usage error
#       2 ==> This script exited on a trapped signal
#
# REV. LIST:
#
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to debug without any command execution

SCRIPT_NAME=`basename $0`
ARG1="$1"
ARG2="$2"
ARG_LIST="$*"
```

Listing 13-15 float_average.ksh shell script

```
TOTAL_TOKENS="$#"
SCALE="0"

#########################################################
################ FUNCTIONS ##############################
#########################################################

function usage
{
  echo "\n\n"
  echo "Numbers to average...\n"
  echo "USAGE: $SCRIPT_NAME [-s scale_value]  N1 N2...N#"
  echo "\nFor an integer result without any significant decimal
places..."
  echo "\nEXAMPLE: $SCRIPT_NAME 2048.221 65536 \n"
  echo "OR for 4 significant decimal places"
  echo "\nEXAMPLE: $SCRIPT_NAME -s 4  8.09838 2048 65536 42.632\n"
  echo "Try again...EXITING...\n"
}
#########################################################
function exit_trap
{
echo "\n...EXITING on trapped signal...\n"
}

#########################################################
################ START OF MAIN ##########################
#########################################################

###### Set a Trap ######

trap 'exit_trap; exit 2' 1 2 3 15

########################

if [ $# -lt 2 ]
then
    echo "\nIncorrect number of command auguments...Nothing to
average..."
    usage
    exit 1
fi

if [ $ARG1 = "-s" ] || [ $ARG1 = "-S" ]
then
    echo $ARG2 | grep [[:digit:]] >/dev/null 2>&1
    if [ $? -ne "0" ]
    then
```

Listing 13-15 (*continued*)

```
        echo "\nERROR: Invalid argument - $ARG2 ... Must be
    an integer...\n"
        usage
        exit 1
    fi
    echo $ARG2 | grep "\." >/dev/null 2>&1
    if [ $? -ne "0" ]
    then
        SCALE="$ARG2"
        NUM_LIST='echo $ARG_LIST | cut -f 3- -d " "'
        (( TOTAL_TOKENS = $TOTAL_TOKENS - 2 ))
    else
        echo "\nERROR: Invalid scale - $ARG2 ... Scale must \
    be an integer...\n"
        usage
        exit 1
    fi
else
    NUM_LIST=$ARG_LIST
fi

for TOKEN in $NUM_LIST
do
    echo $TOKEN | grep [[:digit:]] >/dev/null 2>&1
    RC=$?
    case $RC in
    0) cat /dev/null
       ;;
    *) echo "\n$TOKEN is not a number...Invalid argument list"
       usage
       exit 1
       ;;
    esac
done


# Build the list of numbers to add for averaging...

ADD=""
PLUS=""
for X in $NUM_LIST
do
    ADD="$ADD $PLUS $X"
    PLUS="+"
done

# Do the math here
```

Listing 13-15 (*continued*)

```
AVERAGE=`bc <<EOF
scale=$SCALE
(${ADD}) / $TOTAL_TOKENS
EOF`

echo "\n${AVERAGE}\n"
```

Listing 13-15 (*continued*)

Well, that about does it for our `bc` utility fun. Play around with `bc`; it is a pretty powerful tool that does some very complex arithmetic.

Other Options to Consider

As always, these scripts can be improved, just as any shell script can be improved. As you saw in each of the shell scripts in this chapter, we did a lot of tests to verify the integrity of the data the user entered on the command line. You may be able to combine some of these tests, but I still like to separate each piece so that whoever comes along in the future can follow the shell script easily. Sure, some of these can be done in three lines of code, but this does not allow for data verification, and the user would have to rely on the cryptic system error messages that do not always tell *where* the data error is located.

Creating More Functions

As an exercise for this chapter, replace each of the data tests with functions. This is easy to do! All that is required is that the function must be defined before it can be used. So, put these new functions at the top of the shell scripts in the `DEFINE FUNCTIONS HERE` section. When you extract a code segment from the main body of the shell script, make a comment to yourself that ''XYZ Function goes here.'' Then use one of the following techniques to make the code segment into a function:

```
function my_new_function_name
{
Place Code Segment Here
}
```

or

```
my_new_function_name ()
{
Place Code Segment Here
}
```

Both techniques produce the same result, but I prefer the first method because it is more intuitive to new shell programmers. Remember where the scope of your variables can be seen. A variable in the main body of the shell script is a *global* variable, which can be seen by all functions. A variable inside of a function has limited scope and can be seen in the function and any function that the current function calls, but not in the calling shell script. There are techniques that we have covered in this book to get around these scope limitations, so I hope you have read the whole book. Experiment! That is how you learn.

I hope you enjoyed studying this chapter. Please explore the other options that are available in the `bc` command; you will be surprised by what you can do.

Summary

We have covered a lot of material in this chapter. I hope that you will now find that math is not difficult in a shell script and that it can be done to the precision required. The `bc` command is very powerful, and we only touched the surface of the ability of `bc` here. For more information on `bc` look at the `man` page, **man bc**.

In the next chapter we are moving on to changing numbers between number bases. We start with the basics and move to a shell script that converts any number in any number base to any other number base. See you in the next chapter!

Lab Assignments

1. Utilize an `expect` script to interact with the `bc` utility to add, subtract, multiply, divide, and average floating-point numbers.
2. Rewrite all five shell scripts in this chapter to utilize functions in the testing of the user-inputted numbers.

CHAPTER 14

Number Base Conversions

On many occasions in computer science you need to convert numbers between different number bases. For example, you may need to translate a hexadecimal number into an octal representation, or if you are a software developer you may want to license the software you create for a specific machine. One way of creating a machine-specific license key is to use the IP address of the machine to create a hexadecimal character string, which will allow the software to execute only on that specific machine. The first example here is a common occurrence, but the latter one is a little more obscure.

In this chapter we are going to present some number base conversion techniques and also show how to create a shell script that produces a license key, as in our second example. Converting between number bases is very straightforward, and we are going to go through each step. Before we can write a shell script we need the correct command syntax. In this case we add setting up the proper environment for the system to do all of the hard work automatically.

Syntax

By far, the easiest way to convert a number from one base to another is to use the **typeset** command with the `-ibase` Korn shell option, specifying a valid shell-supported base between base 2 and base 36. Bash and Bourne shells do not support this particular `typeset` command notation. The `typeset` command is used a lot in this book, mostly to force a character string to uppercase or lowercase and to classify a variable as an integer value. This time we are adding to the integer setting, specified by `typeset -i VAR_NAME`, by adding the number base that the variable is to maintain. For example, if the variable `BASE_16_NUM` is to always contain a hexadecimal number, the next command will set the variable's environment:

```
typeset -i16 BASE_16_NUM
```

After the BASE_16_NUM variable is typeset to base 16, any value assigned to this variable is automatically converted to hexadecimal. We can also typeset a variable *after* a number has been assigned. This applies not only to base-10 numbers, but also to *any* base number up to the system and shell limit, which is at least base 36. Let's look at some examples of converting between bases.

To quickly convert any supported base number (base 2 through base 36) to base 10, use the following mathematical notation:

```
echo $((base#number))
```

For example, the following command converts the base-16 number fe18a4 to its base-10 equivalent:

```
[root@yogi:/scripts]> echo $((16#fe18a4))
16652452
```

Using both of these techniques, we can convert between any number bases.

Example 1: Converting from Base 10 to Base 16

```
[root@yogi:/scripts]> typeset -i16 BASE_16_NUM
[root@yogi:/scripts]> BASE_16_NUM=47295
[root@yogi:/scripts]> echo $BASE_16_NUM

16#b8bf
```

Notice the output in Example 1. The output starts out by setting the number base that is represented, which is base 16 here. The string after the pound sign (#) is the hexadecimal number, b8bf. Next we want to convert from base 8, octal, to base 16, hexadecimal. We use the same technique, except this time we must specify the number base of the octal number in the assignment, as shown in Example 1.

Example 2: Converting from Base 8 to Base 16

```
[root@yogi:/scripts]> typeset -i16 BASE_16_NUM
[root@yogi:/scripts]> BASE_16_NUM=8#472521
[root@yogi:/scripts]> echo $BASE_16_NUM

16#735c9
```

In Example 2 notice that we assigned the octal number 472521 to the BASE_16_NUM variable by specifying the number base followed by the base-8 number, BASE_16_NUM=8#472521. When this base-8 number is assigned to the BASE_16_NUM variable it is automatically converted to base 16. As you can see, the system can do the hard work for us.

In UNIX, there is never just one way to accomplish a task, and number base conversions are no exception. We can also use the **printf** command to convert between

number bases. The `printf` command accepts base-10 integer values and converts the number to the specified number base. The following options are available:

- **o** — Accepts a base-10 integer and prints the number in octal
- **x** — Accepts a base-10 integer and prints the number in hexadecimal

Let's look at two examples of using the `printf` command.

NOTE **By default, the `printf` command does not produce a line-feed on some operating systems. Notice the trailing `echo` command that produces the final line-feed.**

Example 3: Converting Base 10 to Octal

```
[root@yogi:/scripts]> printf %o 20398; echo

47656
```

In Example 3 notice the added percent sign (`%`) before the `printf` command option. This `%` tells the `printf` command that the following lowercase `o` is a number base conversion to octal.

Example 4: Converting Base 10 to Hexadecimal

```
[root@yogi:/scripts]> printf %x 20398; echo

4fae
```

Although not as flexible as the `typeset` command, the `printf` command allows you to do base conversions from base 10 to base 8 and base 16. I like the extra flexibility of the `typeset` command, so this is the conversion method that we are going to use most of the time in this chapter.

Scripting the Solution

The most common number base conversion that computer-science people use is conversions between base 2, 8, 10, and 16. We want to be able to convert back and forth between these, and other, bases in this chapter. To do this conversion we are going to create five shell scripts to show the flexibility, and use, of number base conversions. The following shell scripts are covered:

- Base 2 (binary) to base 16 (hexadecimal) shell script
- Base 10 (decimal) to base 16 (hexadecimal) shell script
- Script to create a software key based on the hexadecimal representation of an IP address

- Command-line script to translate between *any* number base between 2 and 36
- Interactive script to translate between *any* number base between 2 and 36

We have a lot to cover in this chapter, but these shell scripts are not too difficult to follow. I hope you pick up a few tips and techniques in this chapter, as well as the whole book.

Base 2 (Binary) to Base 16 (Hexadecimal) Shell Script

This is the first conversion that most computer-science students learn in school. It is easy enough to do this conversion with a pencil and paper, but, hey, we want *automation*! This shell script to convert from binary to hexadecimal uses the `typeset` technique, as all of these scripts use. You know the basic principle of the conversion, so let's present the shell script and cover the details at the end. The `equate_base_2_to_16.ksh` shell script is shown in Listing 14-1.

```
#!/usr/bin/ksh
#
# SCRIPT: equate_base_2_to_16.ksh
# AUTHOR: Randy Michael
# DATE: 07/07/2007
# REV: 1.2.P
#
# PURPOSE: This script is used to convert a base 2 number
#          to a base 16 hexadecimal representation.
#          This script expects that a base 2 number
#          is supplied as a single argument.
#
# EXIT CODES:
#               0 - Normal script execution
#               1 - Usage error
#
# REV LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check command syntax without any execution
#
################################################
# DEFINE FILES AND VARIABLES HERE
################################################

SCRIPT_NAME=`basename $0`

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
```

Listing 14-1 equate_base_2_to_16.ksh shell script listing

```
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

################################################
# DEFINE FUNCTIONS HERE
################################################

function usage
{
echo "\nUSAGE: $SCRIPT_NAME {base 2 number}"
echo "\nEXAMPLE: $SCRIPT_NAME 1100101101"
echo "\nWill return the hexadecimal base 16 number 32d"
echo "\n\t ...EXITING...\n"
}

################################################
# BEGINNING OF MAIN
################################################

# Check for a single command-line argument

if (($# != 1))
then
        echo "\nERROR: A base 2 number must be supplied..."
        usage
        exit 1
fi

# Check that this single command-line argument is a binary number!

case $1 in
+([0-1])) BASE_2_NUM=$1
          ;;
       *) echo "\nERROR: $1 is NOT a base 2 number"
          usage
          exit 1
          ;;
esac

# Assign the base 2 number to the BASE_16_NUM variable

BASE_16_NUM=2#$BASE_2_NUM
```

Listing 14-1 (*continued*)

```
# Now typeset the BASE_16_NUM variable to base 16.
# This step converts the base 2 number to a base 16 number.

typeset -i16 BASE_16_NUM

# Display the resulting base 16 representation

echo $BASE_16_NUM
```

Listing 14-1 (*continued*)

In Listing 14-1 all of the real work is done with three commands. The rest of the code is for testing the user input and providing the correct usage message when an error is detected. Two tests are performed on the user input. First, the number of command-line arguments is checked to ensure that exactly one argument is supplied on the command line. The second test is to ensure that the single command-line argument is a binary number. Let's look at these two tests.

The `$#` shell variable shows the total number of command-line arguments, with the executing command/shell-script's filename in the `$0` position, and the single command-line argument represented by the positional parameter `$1`. For this shell script the value `$#` shell variable must be equal to `1`, one. This test is done using the mathematical test shown here:

```
if (($# != 1))
then
        echo "\nERROR: A base 2 number must be supplied..."
        usage
        exit 1
fi
```

The second test is to ensure that a base 2 number is given on the command line. For this test we use a good ole regular expression. You have to love the simplicity of making this type of test. Because a binary number can consist only of 0, zero, or 1, one, it is an easy test with a regular expression. The idea is to specify a valid range of *characters* that can make up a binary number. The tests for decimal and hexadecimal are similar. The regular expression that we use is used in the `case` statement shown here:

```
case $1 in
+([0-1])) BASE_2_NUM=$1
          ;;
       *) echo "\nERROR: $1 is NOT a base 2 number"
          usage
          exit 1
          ;;
esac
```

The regular expression shown here has the form `+([0-1])` and is used as a test for the specified valid range of numbers 0 through 1. If the range is valid, we assign the

binary number to the BASE_2_NUM variable. We will look at more regular expressions later in this chapter.

When we are satisfied that we have valid data we are ready to do the number base conversion. The first step is to assign the binary number that was supplied on the command line to the BASE_16_NUM variable. Notice that thus far we have not typeset any of the variables, so the variable can contain *any character string*. It is *how* we assign the binary number to the BASE_16_NUM variable that is important. When the binary value is assigned to the variable the current number base is specified, as shown here:

```
BASE_16_NUM=2#$BASE_2_NUM
```

Notice in this assignment that the BASE_2_NUM variable is preceded by the number base, which is base 2 in this case. This allows for the number to be assigned to the BASE_16_NUM as a base 2 number. The base translation takes place in the next step where we typeset the variable to base 16, as shown here:

```
typeset -i16 BASE_16_NUM
```

With the BASE_16_NUM variable typeset to base 16, specified by the -i16 argument, the binary number is translated to hexadecimal. We could just as easily typeset the BASE_16_NUM variable at the top of the shell script, but it really does not matter.

Base 10 (Decimal) to Base 16 (Hexadecimal) Shell Script

This shell script is very similar to the shell script in the previous section. We are really changing just the tests and the conversion values. Other than these few changes the two shell scripts are identical. Again, I want to present the shell script and cover the details at the end. The equate_base_10_to_16.ksh shell script is shown in Listing 14-2.

```
#!/usr/bin/ksh
#
# SCRIPT: equate_base_10_to_16.ksh
# AUTHOR: Randy Michael
# DATE: 07/07/2007
# REV: 1.2.P
#
# PURPOSE: This script is used to convert a base 10 number
#          to a base 16 hexadecimal representation.
#          This script expects that a base 10 number
#          is supplied as a single argument.
#
# EXIT CODES:
#               0 - Normal script execution
#               1 - Usage error
#
# REV LIST:
```

Listing 14-2 equate_base_10_to_16.ksh shell script listing

```
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check command syntax without any execution
#
#
################################################
# DEFINE FILES AND VARIABLES HERE
################################################

SCRIPT_NAME=`basename $0`

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

################################################
# DEFINE FUNCTIONS HERE
################################################
function usage
{
echo "\nUSAGE: $SCRIPT_NAME {base 10 number}"
echo "\nEXAMPLE: $SCRIPT_NAME 694"
echo "\nWill return the hexadecimal number 2b6"
echo "\n\t...EXITING...\n"
}

################################################
# BEGINNING OF MAIN
################################################

# Check for a single command-line argument

if (($# != 1))
then
        echo "\nERROR: A base 10 number must be supplied..."
        usage
        exit 1
fi

# Check that this single command-line argument is a base 10 number!
case $1 in
```

Listing 14-2 (*continued*)

```
+([0-9])) BASE_10_NUM=$1
          ;;
       *) echo "\nERROR: $1 is NOT a base 10 number"
          usage
          exit 1
          ;;
esac

# Assign the base 10 number to the BASE_16_NUM variable

BASE_16_NUM=10#$BASE_10_NUM

# NOTE: Since base 10 is implied by default,
# the 10# may be omitted as a prefix. Both notations
# are supported

# Now typeset the BASE_16_NUM variable to base 16.
# This step converts the base 10 number to a base 16 number.

typeset -i16 BASE_16_NUM

# Display the resulting base 16 number representation

echo $BASE_16_NUM

# This following code is optional. It removes the number base
# prefix. This may be helpful if using this script with
# other programs and scripts.
# Set up the correct awk usage. Solaris
needs to
# use nawk instead of awk.
#
# case $(uname) in
# SunOS) AWK="nawk"
# ;;
# *) AWK="awk"
# ;;
# esac
#
# Strip out the base prefix and the pound sign (#). (Optional)
#
# echo $BASE_16_NUM | grep -q "#"
#
# if (($? == 0))
# then
#        echo $BASE_16_NUM | $AWK -F '#' '{print $2}'
# else
#        echo $BASE_16_NUM
# fi
```

Listing 14-2 (*continued*)

In Listing 14-2 we have a few things to point out. First, notice the `usage` function and how we use the extracted name of the shell script directly from the system, specified by `SCRIPT_NAME='basename $0'`. This is command substitution using *back tics*, which are located in the upper-left corner of a standard keyboard under the ESC key. Using this technique is equivalent to using the *dollar parentheses* method, specified by `$(command)`, as we use in most chapters in this book. Notice in the assignment that the `basename $0` command holds the name of the shell script. We always want to query the system for a script name in the main body of the shell script, before it is used in a `usage` function. If we use the `basename $0` command in a function, the response would be the name of the *function*, not the name of the shell script. We never want to hard-code the script name, because someone may change the name of the shell script in the future.

The next thing that I want to point out is the change made to the regular expression. Before, we were testing for a binary number, which can consist of only 0 and 1. This time we are testing for a decimal number, which can consist of only numbers 0 through 9. The new regular expression is shown here:

```
case $1 in
+([0-9])) BASE_10_NUM=$1
          ;;
       *) echo "\nERROR: $1 is NOT a base 10 number"
          usage
          exit 1
          ;;
esac
```

In this `case` statement we are testing the `ARG[1]` variable, represented by the `$1` positional parameter. This regular expression will assign `$1` to the `BASE_10_NUM` variable only if the characters are numbers between 0 and 9. If any other character is found in this character string, an `ERROR` message is displayed and the `usage` function is called before the script exits with a return code of `1`, one.

In the assignment of the base 10 number to the `BASE_16_NUM` variable, notice the change in the variable assignment as shown here:

```
BASE_16_NUM=10#$BASE_10_NUM
```

Notice that the `$BASE_10_NUM` variable is preceded by number base representation, `10#`. Because this is a decimal number we really did not need to do this because base 10 is implied, but to be consistent it was added.

The last thing that I want to point out is the optional code at the end of the shell script in Listing 14-2. If you are using this shell script with other programs or shell scripts to produce number base conversions, this optional code strips out the number base prefix. Look at the code segment shown here:

```
# Strip out the base prefix and the pound sign (#). (Optional)
#
# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.
#
# case $(uname) in
# SunOS) AWK="nawk"
```

```
#       ;;
#    *) AWK="awk"
#       ;;
#esac
#
# echo $BASE_16_NUM | grep -q "#"
#
# if (($? == 0))
# then
#       echo $BASE_16_NUM | $AWK -F '#' '{print $2}'
# else
#       echo $BASE_16_NUM
# fi
```

This code is commented out, but let's look at what it does. The purpose is to remove the base number prefix and leave only the number alone, which implies that you must have some built-in logic to know the number base in which the number is represented. The first step is to test for the existence of a pound sign (#). We do this by printing the variable with the `echo` command and piping the output to a `grep` statement, using the quiet option `-q`. This command option does not produce any output to the screen, but we test the return code to see if a pattern match was made. If the return code is 0, zero, then a match was made and there is a pound sign in the string. Because we want to display everything *after* the pound sign (#) we use this pound sign as a field separator. To split the string and leave only the number, which will be in the second field now, we can use either **cut** or **awk**. Let's use `awk` for a change of pace. To do field separation with `awk`, we use the `-F` switch, followed by the character(s) that represents a separation of the fields, which is the `#` here. Then we just print the second field, specified by the `$2` positional parameter, and we are left with the number alone. If you use this optional code segment, always remember to keep track of the current number base and comment out the `echo` statement that precedes this code block.

Script to Create a Software Key Based on the Hexadecimal Representation of an IP Address

With the techniques learned in the last two shell scripts let's actually do something that is useful. In this section we are going to create a shell script that will create a software license key based on the IP address of the machine. To tie the license key to the machine and the software we are going to convert each set of numbers in the machine's IP address from decimal to hexadecimal. Then we are going to combine all of the hexadecimal numbers together to make a license key string. This is pretty primitive, but it is a good example for using base conversions. Again, let's look at the code and go through the details at the end. The `mk_swkey.ksh` shell script is shown in Listing 14-3.

```
#!/usr/bin/ksh
#
# SCRIPT: mk_swkey.ksh
# AUTHOR: Randy Michael
```

Listing 14-3 mk_swkey.ksh shell script

```
# DATE: 07/07/2007
# REV: 1.2.P
#
# PURPOSE: This script is used to create a software
#          license key based on the IP address of the
#          system that this shell script is executed on.
#          The system is queried for the system's IP
#          address. The IP address is stripped of the
#          dots (.), and each number is converted to
#          hexadecimal. Then each hex string is combined
#          into a single hex string, which is the software
#          license key.
#
# REV LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check command syntax without any execution
#
#################################################
# DEFINE FILES AND VARIABLES HERE
#################################################

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) AWK="nawk"
       ;;
    *) AWK="awk"
       ;;
esac

#################################################
# DEFINE FUNCTIONS HERE
#################################################
function convert_base_10_to_16
{
```

Listing 14-3 (*continued*)

```
# set -x # Uncomment to debug this function

typeset -i16 BASE_16_NUM

BASE_10_NUM=$1

BASE_16_NUM=$((10#${BASE_10_NUM}))
# Strip the number base prefix from the hexadecimal
# number. This prefix is not needed here.

echo $BASE_16_NUM | grep -q '#'
if (($? == 0))
then
        echo $BASE_16_NUM | awk -F '#' '{print $2}'
else
        echo $BASE_16_NUM
fi
}

################################################
# BEGINNING OF MAIN
################################################

# Query the system for the IP address using the "host $(hostname)"
# command substitution.

IP=$(host $(hostname) | awk '{print $3}' | awk -F ',' '{print $1}')

# Field delimit the IP address on the dots (.) and assign each
# number to a separate variable in a "while read" loop.

echo $IP | $AWK -F '.' '{print $1, $2, $3, $4}'\
| while read a b c d junk
do
     # Convert each of the numbers in the IP address
     # into hexadecimal by calling the "convert_base_10_to 16"
     # function.

     FIRST=$(convert_base_10_to_16 $a)
     SECOND=$(convert_base_10_to_16 $b)
     THIRD=$(convert_base_10_to_16 $c)
     FORTH=$(convert_base_10_to_16 $d)
done

# Combine all of the hexadecimal strings into a single
# hexadecimal string, which represents the software key.

echo "${FIRST}${SECOND}${THIRD}${FORTH}"
```

Listing 14-3 (*continued*)

In the script in Listing 14-3 we are actually doing something useful — at least, if you license your own software this script is useful. To start this shell script off we converted the base-10-to-base-16 code into a function called `convert_base_10_to_16`. This allows us to call the function four times, one for each piece of the IP address. In this function I want you to notice that we `typeset` the `BASE_16_NUM` variable to base 16 at the top of the function, as opposed to the bottom in the previous shell script. It does not make any difference *where* it is set as long as it is set before the value is returned to the main body of the shell script, or displayed.

Also, the optional code segment that was commented out on Listing 14-2 is now used in this shell script. In this case we know that we are converting to a hexadecimal number, and we do not want the number base prefix to appear in the software license key. We use the following code segment to remove the prefix from the output:

```
# Strip the number base prefix from the hexadecimal
# number. This prefix is not needed here.

echo $BASE_16_NUM | grep -q '#'
if (($? == 0))
then
        echo $BASE_16_NUM | $AWK -F '#' '{print $2}'
else
        echo $BASE_16_NUM
fi
```

Notice the silent execution of the `grep` command using the `-q` command switch. Then, if a pound sign is found, the `awk` statement uses the `#` as a field delimiter by specifying the `-F '#'` switch, and then the second field is extracted. This is the value that is returned back to the main body of the shell script from the conversion function.

At the `BEGINNING_OF_MAIN` we start out by querying the system for the system's IP address using the following command:

```
IP=$(host $(hostname) | awk '{print $3}' | awk -F ',' '{print $1}')
```

Let's step through each part of this command. On my system I pulled an IP address out of the air for this demonstration. On the `yogi` machine the command substitution `host $(hostname)` results in the following output:

```
[root:yogi]@/scripts# host $(hostname)
yogi is 163.155.204.42,
```

From this output you can see that the IP address is located in the third field, `163.155.204.42,`. Notice that I have an extra comma (`,`) tacked on to the end of the IP address, which we do not want included. After we extract the third field from the command output we pipe this result to an `awk` statement (the `cut` command will do the same thing). In the `awk` part of the statement we set the field delimiter to the comma (`,`) that we want to get rid of, using the `-F ','` notation. Now that the string

is field-delimited on the comma we just extract the first field, which is the IP address alone. This result is then assigned to the `IP` variable using command substitution.

Now that we have the whole IP address we can chop it up into a series of four numbers. Once we have four individual numbers we can convert each of the decimal numbers into their hexadecimal equivalent. To separate the IP address into separate individual numbers we can use `cut`, `sed`, or `awk`. For consistency let's keep using `awk`. This time we field-delimit the string, which is an IP address, using the dots (`.`) and then use the `print` argument for the `awk` command to print each of the four fields. At this point we are left with the following four numbers:

```
163 155 204 42
```

Now we have some numbers to work with. Because we want to work on each number individually, we pipe this output to a `while read` loop and assign each of the four numbers to a separate variable. Then, inside of the loop, we convert each decimal number into hexadecimal. The entire command statement is shown here:

```
echo $IP | $AWK -F '.' '{print $1, $2, $3, $4}' | while read a b c d junk
```

Notice the final variable at the end of the `while` statement, `junk`. I added this as a catchall for anything that may be tacked on to the previous pipe outputs. It does not matter if there is anything to capture, but if there are ''extra'' fields the `junk` variable will catch everything remaining in the output. Other than this, each of the four fields is stored in the variables `a`, `b`, `c`, and `d`.

Inside of the `while read` loop we call the conversion function four times, once for each variable, as shown here:

```
FIRST=$(convert_base_10_to_16 $a)
SECOND=$(convert_base_10_to_16 $b)
THIRD=$(convert_base_10_to_16 $c)
FOURTH=$(convert_base_10_to_16 $d)
```

The result of these four function calls is the assignment of the hexadecimal values to four new variables, `FIRST`, `SECOND`, `THIRD`, and `FOURTH`. Now that we have the hexadecimal values all we need to do is combine the hex strings into a single string. The combination is shown here:

```
echo "${FIRST}${SECOND}${THIRD}${FOURTH}"
```

The resulting output from the IP address that I pulled out of the air for temporary use (163.155.204.42) is shown next:

```
[root:yogi]@/scripts# ./mk_swkey.ksh
a39bcc2a
```

This hexadecimal string is the software license that is tied to the IP address.

Script to Translate between Any Number Base

So far we have been working in a restricted environment with limited ability to switch between number bases. This script will convert *any* number to *any* number base within the limits of the system. The base conversion's availability is to base 36 at least, and some systems may go higher. I am not sure what you would do with a base-36 number, but you can make one if you want to.

In this script we rely on two command-line switches, each requiring an argument, and the ''number'' to convert. The two switches are `-f {Starting Number Base, or From:}` and `-t {Ending Number Base, or To:}`. These two parameters tell the shell script what number base we are converting from and what number base we want to convert the number *to*, which is where the `-f` and `-t` command-line switches came from. This is another shell script that needs to be presented first, and we will cover the details at the end. The `equate_any_base.ksh` shell script is shown in Listing 14-4.

```
#!/usr/bin/ksh
#
# SCRIPT: equate_any_base.ksh
# AUTHOR: Randy Michael
# DATE: 07/07/2007
# REV: 1.2.P
#
# PURPOSE: This script is used to convert a number to any
#          supported number base, which is at least base 36.
#          This script requires that two command-line
#          arguments and the "number" to be converted
#          are present on the command line. An example
#          number base conversion is shown here:
#
#          equate_any_base.ksh -f16 -t2 e245c
#          2#1110001001000l011100
#
#          This example converts the base 16 number, e245c, to
#          the base 2 equivalent, 2#1110001001000l011100.
#          The 2#, which precedes the binary number, shows
#          the base of the number represented.
#
# EXIT CODES:
#               0 - Normal script execution
#               1 - Usage error
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check syntax without any execution
#
```

Listing 14-4 equate_any_base.ksh shell script

```
################################################
# DEFINE FILES AND VARIABLES HERE
################################################

SCRIPT_NAME=$(basename $0)
COUNT=0
MAX_COUNT=$#

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

################################################
# DEFINE FUNCTIONS HERE
################################################

function usage
{
echo "\n\t***USAGE ERROR***"
echo "\nPURPOSE: This script converts between number bases"
echo "\nUSAGE: $SCRIPT_NAME -f{From base#} -t{To base#} NUMBER"
echo "\nEXAMPLE: $SCRIPT_NAME -f16 -t10 fc23"
echo "\nWill convert the base 16 number fc23 to its"
echo "decimal equivalent base 10 number 64547"
echo "\n\t ...EXITING...\n"
}

################################################
# CHECK COMMAND-LINE ARGUMENTS HERE
################################################

# The maximum number of command-line arguments is five
# and the minimum number is three.

if (($# > 5))
then
        echo "\nERROR: Too many command-line arguments\n"
        usage
        exit 1
elif (($# < 3))
then
        echo "\nERROR: Too few command-line arguments\n"
```

Listing 14-4 (*continued*)

```
        usage
        exit 1
fi

# Check to see if the command-line switches are present

echo $* | grep -q '\-f' || (usage; exit 1)
echo $* | grep -q '\-t' || (usage; exit 1)

# Use getopts to parse the command-line arguments

while getopts ":f:t:" ARGUMENT
do
  case $ARGUMENT in
     f) START_BASE="$OPTARG"
        ;;
     t) END_BASE="$OPTARG"
        ;;
    \?) usage
        exit 1
        ;;
  esac
done

# Ensure that the START_BASE and END_BASE variables
# are not NULL.

if [ -z "$START_BASE" ] || [ "$START_BASE" = '' ] \
   || [ -z "$END_BASE" ] || [ "$END_BASE" = '' ]
then
     echo "\nERROR: Base number conversion fields are empty\n"
     usage
     exit 1
fi

# Ensure that the START_BASE and END_BASE variables
# have integer values for the number base conversion.

case $START_BASE in
+([0-9])) : # Do nothing - Colon is a no-op.
           ;;
        *) echo "\nERROR: $START_BASE is not an integer value"
           usage
           exit 1
           ;;
esac

case $END_BASE in
```

Listing 14-4 (*continued*)

```
+([0-9])) : # Do nothing - Colon is a no-op.
            ;;
         *) echo "\nERROR: $END_BASE is not an integer value"
            usage
            exit 1
            ;;
esac

################################################
# BEGINNING OF MAIN
################################################

# Begin by finding the BASE_NUM to be converted.

# Count from 1 to the max number of command-line arguments

while ((COUNT < MAX_COUNT))
do
   ((COUNT == COUNT + 1))
   TOKEN=$1
   case $TOKEN in
      -f) shift; shift
          ((COUNT == COUNT + 1))
          ;;
      -f${START_BASE}) shift
          ;;
      -t) shift; shift
          ((COUNT == COUNT + 1))
          ;;
      -t${END_BASE}) shift
             ;;
      *) BASE_NUM=$TOKEN
         break
         ;;
   esac
done

# Typeset the RESULT variable to the target number base

typeset -i$END_BASE RESULT

# Assign the BASE_NUM variable to the RESULT variable
# and add the starting number base with a pound sign (#)
# as a prefix for the conversion to take place.

# NOTE: If an invalid number is entered a system error
# will be displayed. An example is inputting 1114400 as
# a binary number, which is invalid for a binary number.
```

Listing 14-4 (*continued*)

```
RESULT="${START_BASE}#${BASE_NUM}"

# Display the result to the user or calling program.

echo "$RESULT"

# End of script...
```

Listing 14-4 (*continued*)

Please stay with me here! This script in Listing 14-4 is really not as difficult as it looks. Because we are requiring the user to provide command-line arguments we need to do a lot of testing to ensure that we have good data to work with. We also need to give the user good and informative feedback if a usage error is detected. Remember: always let the user know what is going on. Keeping the user informed is just good script writing!

Let's start at the top of the `equate_any_base.ksh` shell script and work our way through the details. The first thing we do is to define three variables. The `$SCRIPT_NAME` variable points to the name of this shell script. We need to query the system for this script name for two reasons. First, the name of the script may change in the future; second, the `SCRIPT_NAME` variable is used in the `usage` function. If we had executed the `basename $0` command inside of the `usage` function we would get `usage` instead of the name of the shell script. This is an important point to make. We need to know where the scope lies when referring to positional parameters, `$0` in this case. When we refer to positional parameters in the main body of a shell script, the positional parameters are command-line arguments, including the name of the shell script. When we refer to positional parameters inside of a function, the scope of the positional parameters lies with the arguments supplied to the function, not the shell script. In either case, the name of the shell script, or function, can be referenced by the `basename $0` command.

The next two variable definitions, `COUNT=0` and `MAX_COUNT=$#`, are to be used to parse through each of the shell script's command-line arguments, where `$#` represents the total number of command-line arguments of the shell script. We will go into more detail on these two variables a little later.

In the next section we define any functions that we need for this shell script. For this shell script we need just a `usage` function. If you look at this `usage` function, though, we have a good deal of information to describe how to use the shell script in Listing 14-4. We state the purpose of the shell script followed by the `USAGE` statement. Then we supply an example of using the shell script. This really helps users who are not familiar with running this script.

As I stated before, we need to do a lot of checking because we are relying on the user to supply command-line arguments for defining the execution behavior. We are going to do seven independent tests to ensure that the data we receive is good data that we can work with.

The first two tests are to ensure that we have the correct number of command-line arguments. For the `equate_any_base.ksh` shell script the user may supply as few

as three arguments and as many as five arguments. This variation may sound a little strange, but when we go to the **getopts** command it will be intuitively obvious. For testing the number of arguments we just use an `if...then...elif...fi` structure where we test the `$#` shell parameter to make sure that the value is not greater than five and is not less than three, as shown here:

```
if (($# > 5))
then
        echo "\nERROR: Too many command-line arguments\n"
        usage
        exit 1
elif (($# < 3))
then
        echo "\nERROR: Too few command-line arguments\n"
        usage
        exit 1
fi
```

Using getopts to Parse the Command Line

Now we get to use `getopts` to parse through each command-line switch and its arguments. The `getopts` command recognizes a command switch as any character that is preceded by a hyphen (`-`) — for example, `-f` and `-t`. The `getopts` command really does not care *what* is on the command line, unless it is a command switch or its argument. Let's look at a couple of examples of command-line arguments so I can clear the mud.

Example 5: Correct Usage of the equate_any_base.ksh Shell Script

```
[root:yogi]@/scripts# ./equate_any_base.ksh -f 2 -t16 10110011110101
```

Notice in Example 5 the use of the two command switches, `-f 2` and `-t16`. Both of these are valid because `getopts` does not care if there is a space or no space between the switch and the switch-argument, and the order of appearance does not matter either. As you can see in Example 5, we can have as few as three command-line arguments if no spaces are used, or as many as five if both command switches have a space between the command switch and the switch-argument.

Example 6: Incorrect Usage of the equate_any_base.ksh Shell Script

```
[root:yogi]@/scripts# ./equate_any_base.ksh -i -f 2 -t 16 10110011110101
```

In Example 6 we have an error condition in two different ways. The first error is that there are six command-line arguments given to the `equate_any_base.ksh` shell script. The second error is that there is an undefined command switch, **-i**, given on the command line. This is a good place to go through using `getopts` to parse a defined set of command-line switches and arguments.

The purpose of the `getopts` command is to process command-line arguments and check for valid options. The `getopts` command is used with a `while` loop and has an enclosed `case` statement to let you take action for each correct and incorrect argument found on the command line. We can define command-line switches to require an argument, or the switch can be defined as a standalone command switch. The order of the switch does not matter, but if the switch is defined to require an argument, the switch-argument must follow the switch, either with or without a space. When `getopts` finds a switch that requires an argument, the argument is always assigned to a variable called `OPTARG`. This variable allows you to assign the switch-argument value to a useful variable name to use in the shell script. Let's look at the `getopts` definition that is used in this shell script:

```
while getopts ':f:t:' ARGUMENT
do
  case $ARGUMENT in
     f) START_BASE="$OPTARG"
        ;;
     t) END_BASE="$OPTARG"
        ;;
     \?) usage
        exit 1
        ;;
  esac
done
```

There are two parts to the `getopts` definition. The first is the `while` loop that contains the `getopts` statement, and the second is the `case` statement that allows you to do something when a valid or invalid switch is found. In the `while` loop we have defined two valid command switches, `-f` and `-t`. When you define these you do not add the hyphen (`-`) in the case statement, but it is required on the command line. Notice the colons (`:`) in the definitions. The beginning colon specifies that when an undefined switch is found — for example, `-i` — then the invalid switch is matched with the question mark (`?`) in the `case` statement. In our case we always run the `usage` function and immediately `exit` the shell script with a return code of 1, one. Also notice that we *escaped* the `?` with a backslash (`\?`). By escaping the `?` character (`\?`), we can use the `?` as a regular character without any special meaning or function.

When a colon (`:`) is present *after* a switch definition, it means that the switch must have an argument associated with it. If the switch definition does *not* have a colon after it, the switch has no argument. For example, the statement `getopts ":t:f:i"` defines `-t` and `-f` as command-line switches that require an argument and `-i` as a switch that has no argument associated with it.

When a switch is found, either defined or undefined, it is assigned to the `ARGUMENT` variable (you can use any variable name here), which is used by the `case` statement. For defined variables we need a match in the `case` statement, but for undefined switches the `ARGUMENT` is assigned `?` *if* the `getopts` definition begins with a colon (`:`). Additionally, when a defined switch is found that requires an argument, the argument to the switch is assigned to the `OPTARG` variable (you cannot change this

variable name) during the current loop iteration. This is the mechanism that we use to get our *from* and *to* number base definitions, START_BASE and END_BASE, for the equate_any_base.ksh shell script.

Continuing with the Script

As I stated before, getopts does not care what is on the command line if it is not a command switch or a switch argument. So, we need more sanity checks. The next test is to ensure that both -f and -t command-line switches are present on the command line as arguments. We must also check to ensure that the START_BASE and END_BASE variables are not empty and also make sure that the values are integers. We can do all of these sanity checks with the code segment in Listing 14-5.

```
# Check to see if the command-line switches are present

echo $* | grep -q '\-f' || (usage; exit 1)
echo $* | grep -q '\-t' || (usage; exit 1)

# Use getopts to parse the command-line arguments

while getopts ":f:t:" ARGUMENT
do
  case $ARGUMENT in
     f) START_BASE="$OPTARG"
        ;;
     t) END_BASE="$OPTARG"
        ;;
    \?) usage
        exit 1
        ;;
  esac
done

# Ensure that the START_BASE and END_BASE variables
# are not NULL.

if [ -z "$START_BASE" ] || [ "$START_BASE" = '' ] \
   || [ -z "$END_BASE" ] || [ "$END_BASE" = '' ]
then
     echo "\nERROR: Base number conversion fields are empty\n"
     usage
     exit 1
fi

# Ensure that the START_BASE and END_BASE variables
# have integer values for the number base conversion.
```

Listing 14-5 Code segment to verify number base variables

```
case $START_BASE in
+([0-9])) : # Do nothing - Colon is a no-op.
           ;;
        *) echo "\nERROR: $START_BASE is not an integer value"
           usage
           exit 1
           ;;
esac

case $END_BASE in
+([0-9])) : # Do nothing - Colon is a no-op.
           ;;
        *) echo "\nERROR: $END_BASE is not an integer value"
           usage
           exit 1
           ;;
esac
```

Listing 14-5 (*continued*)

Starting at the top in Listing 14-5, we first check to ensure that both `-f` and `-t` are present as command-line arguments. Next the `getopts` statement parses the command line and populates the `START_BASE` and `END_BASE` variables. After `getopts` we test the `START_BASE` and `END_BASE` variables to ensure that they are not NULL. When you do have NULL value tests always remember to use double quotes (`"$VAR_NAME"`) around the variable names, or you will get an error if they are actually empty, or NULL. This is one of those hard-to-find errors that can take a long time to track down.

In the next two `case` statements we use a regular expression to ensure that the `$START_BASE` and `$END_BASE` variables are pointing to integer values. If either one of these variables is not an integer, we give the user an informative error message, show the correct usage by running the `usage` function, and `exit` the shell script with a return code of 1, one.

Beginning of Main

At this point we have confirmed that the data that was entered on the command line is valid, so let's do our number base conversion. Because we have all of the command switches and switch-arguments on the command line, we actually need to *find* the ''number'' that is to be converted between bases. To find our number to convert we need to scan all of the command-line arguments, starting with the argument at `$1` and continuing until the number is found, or until the last argument, which is pointed to by the `$#` shell variable.

Scanning the command-line arguments and trying to find the ''number'' is a little tricky. First, the ''number'' may be in any valid number base that the system supports, so we may have alphanumeric characters. But we do have one thing going for us: we know the command switches and the integer values of the `$START_BASE` and `$END_BASE` variables. We still need to consider that there may or may not be spaces between the command switches and the switch-arguments. Let's think about this a

minute. If a single command-line argument is one of the command switches, we know that the user placed a space between the command switch and the switch-argument. On the other hand, if a single command-line argument is a command-line switch *and* its switch-argument, we know that the user does *not* place a space between the command switch and the switch-argument. By using this logic we can use a simple `case` statement to test for these conditions. When we get to a command-line argument that does not fit this logic test, we have found the ''number'' that we are looking for.

Look at the code segment in Listing 14-6, and we will go into a little more detail at the end.

```
# Count from 1 to the max number of command-line arguments

while ((COUNT  < MAX_COUNT))
do
   ((COUNT == COUNT + 1))
   TOKEN=$1
   case $TOKEN in
      -f) shift; shift
          ((COUNT == COUNT + 1))
             ;;
      -f${START_BASE}) shift
             ;;
      -t) shift; shift
          ((COUNT == COUNT + 1))
             ;;
      -t${END_BASE}) shift
             ;;
      *) BASE_NUM=$TOKEN
         break
         ;;
   esac
done
```

Listing 14-6 Code segment to parse the command line

Remember that at the beginning of the shell script we defined the variables `COUNT=0` and `MAX_COUNT=$#`. Now we get a chance to use them. I also want to introduce the **shift** command. This Korn shell built-in allows us to always reference the `$1` command-line argument to access *any* argument on the command line. To go to the next command-line argument we use the `shift` command to make the next argument, which is `$2` here, shift over to the `$1` position parameter. If we want to `shift` more than one position we can either execute multiple `shift` commands or just add an integer value to the `shift` command to indicate how many positions that we want to shift to the `$1` position. Both of the following commands shift positional parameters two positions to the `$1` argument:

```
shift; shift

shift 2
```

The idea in our `case` statement is to do *one* `shift` if a command-line switch *with* its switch-argument is found at `$1` and to `shift` *two* positions if a command-line switch is found alone. We start with a `while` loop and increment a counter by one. Then we use the `TOKEN` variable to always grab the value in the `$1` position. We make the test to check for a command-line switch alone or a command-line switch plus its switch argument. If the `$1` positional parameter contains either of these, we `shift` accordingly. If the test is not matched, we have found the number that we are looking for. So, this is really not that difficult a test when you know what the goal is.

When we have found the ''number,'' which is assigned to the `BASE_NUM` variable, we are ready to do the conversion between number bases. We do the conversion as we did in the previous shell scripts in this chapter, except that this time we use the variable assignments of the `START_BASE` and `END_BASE` variables as number bases to start at and to end with, as shown in the next command statement:

```
RESULT="${START_BASE}#${BASE_NUM}"
```

Let's assume that the `$START_BASE` variable points to the integer 2, and the `$BASE_NUM` variable points to the binary number 1101101011. Then the following command statement is equivalent to the preceding statement:

```
RESULT="2#1101101011"
```

The next step is to `typeset` the `BASE_TO` variable to the target number base. This is also accomplished using the previously defined variable `END_BASE`, as shown here:

```
typeset -i$END_BASE RESULT
```

Now let's assume that the target number base, `$END_BASE`, is 16. The following command statement is equivalent to the preceding variable statement:

```
typeset -i16 RESULT
```

The only thing left to do is print the result to the screen. You can use `echo`, `print`, or `printf` to display the result. I still like to use `echo`, so this is the final line of the shell script:

```
echo $RESULT
```

An Easy, Interactive Script to Convert Between Bases

The script is Listing 14-7 is a simple, interactive shell script that prompts the user for the input number in any base between base 2 and base 36. It then prompts the user for the number base to convert the number to. Study the `chg_base.ksh` shell script in Listing 14-7 and we will step through the script at the end.

```
#!/bin/ksh
#
# SCRIPT: chg_base.ksh
# AUTHOR: Randy Michael
# DATE: 10/4/2007
# REV: 1.1.A
#
# PURPOSE: This script converts numbers between base
# 2 through base 36. The user is prompted for input.
#
# NOTE: Numbers are in the following format:
#
#     base#number
#
# EXAMPLE:  16#264bf
#
#########################################
# DEFINE FILES AND VARIABLES HERE
#########################################

# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) AWK="nawk"
       ;;
    *) AWK="awk"
       ;;
esac

# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac

#########################################
# BEGINNING OF MAIN
#########################################

# Prompt the user for an input number with base
```

Listing 14-7 chg_base.ksh shell script

```
echo "\nInput the number to convert in the following format:

Format: base#number

Example: 16#264BF \n"

read ibase_num

# Extract the base from the ibase_num variable

ibase=$(echo $ibase_num | $AWK -F '#' '{print $1}')

# Test to ensure the input base is an integer

case $ibase in
  [0-9]*) : # do nothing
          ;;
       *) echo "\nERROR: $ibase is not a valid number for input base\n"
          exit 1
          ;;
esac

# Test to ensure the input base is between 2 and 36

if (( ibase < 2 || ibase > 36 ))
then
    echo "\nERROR: Input base must be between 2 and 36\n"
    exit 1
fi

# Ask the user for the output base

echo "\nWhat base do you want to convert $ibase_num to?
NOTE: base 2 through 36 are valid\n"
echo "Output base: \c"
read obase

# Test to ensure the output base is an integer

case $obase in
  [0-9]*) : # do nothing
          ;;
       *) echo "\nERROR: $obase is not a valid number\n"
          exit 1
          ;;
esac

# Test to ensure the output base is between 2 and 36
```

Listing 14-7 (*continued*)

```
if (( obase < 2 || obase > 36 ))
then
    echo "\nERROR: Output base must be between 2 and 36\n"
    exit 1
fi

# Save the input number before changing the base

in_base_num=$ibase_num

# Convert the input number to the desired output base

typeset -i$obase ibase_num

# Assign the output base number to an appropriate variable name

obase_num=$ibase_num

# Display the result

echo "\nInput number $in_base_num is equivalent to $obase_num\n"
```

Listing 14-7 (*continued*)

The key to the `chg_base.ksh` shell script in Listing 14-7 is that both the input and output numbers are represented in *base#number* notation as we have previously done, unless, of course, it is a base-10 number. Base 10 is implied by default, so the *base#* part is not displayed, nor is it required as input. The script accepts both notations.

Starting from the top of the `chg_base.ksh` shell script in Listing 14-7, we first set up the correct `awk` command usage. If we use `awk -F` to define a field delimiter on Solaris, this command will fail. For Solaris, we must use `nawk` in place of `awk`. The following code segment sets up the correct command usage:

```
# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) AWK="nawk"
       ;;
    *) AWK="awk"
       ;;
esac
```

Next we need to query the system for the executing `$SHELL`, so we use the correct syntax when using the `echo` command with backslash operators, such as `\n`, `\c`, `\b`, and so on when executing in different shells. Many Linux distributions will execute in a Bash shell even though we specify Korn shell on the very first line of the script. Bash shell requires the use of the `echo -e` switch to enable the backslash operators. Korn shell, by default, recognizes the backslash operators. Listing 14-8 shows the `case` statement

to alias the `echo` command to `echo -e` if the executing shell is `*/bin/Bash`. Now, when we need to use the `echo` command, we are assured it will display text correctly.

```
# Set up the correct echo command usage. Many Linux
# distributions will execute in Bash even if the
# script specifies Korn shell. Bash shell requires
# we use echo -e when we use \n, \c, etc.

case $SHELL in
*/bin/Bash) alias echo="echo -e"
            ;;
esac
```

Listing 14-8 case statement to set proper `echo` usage

With the correct usage set for the `echo` command, we now just prompt the user for the input number, specifying the `base#number` format. Next we extract the number base from the input number and test for an integer with the regular expression `+([0-9])` in a `case` statement.

NOTE **Bash shell does not support the regular expression `+([0-9])`.**

Next we ensure that the number base value is between the shell-supported values base 2 through base 36.

We next prompt the user for the base to convert the input number to using the `read OBASE` statement. Then we perform tests to ensure `$OBASE` is an integer and the value is greater than 1 and less than 37.

With these tests complete, we are ready to do the number base conversion, but first we save the input number to the `in_base_num` variable. Next, using the `typeset` command, the number base conversion is done, as shown here:

```
typeset -i$obase ibase_num
```

We then assign the new base to a more appropriate variable:

```
obase_num=$ibase_num
```

Then display the result to the user:

```
$ECHO "\nInput number $in_base_num is equivalent to $obase_num\n"
```

To see the `chg_base.ksh` shell script in action, check out Listing 14-9.

```
[root:yogi]@/scripts# ./chg_base.ksh


Input the number to convert in the following format:


Format: base#number


Example: 16#264BF


8#72544100474


What base do you want to convert 8#72544100474 to?

NOTE: base 2 through 36 are valid


Output base: 2


Input number 8#72544100474 is equivalent to
2#11101010110010000100000100111100


[root:yogi]@/scripts# ./chg_base.ksh


Input the number to convert in the following format:
```

Listing 14-9 chg_base.ksh shell script in action

```
base#number

Example: 16#264BF


22#1ahk3df3b


What base do you want to convert 22#1ahk3df3b to?
NOTE: base 2 through 36 are valid


Output base: 10


Input number 22#1ahk3df3b is equivalent to 81850831953


[root:yogi]@/scripts#
```

Listing 14-9 (*continued*)

Listing 14-9 gives two examples of using the interactive `chg_base.ksh` shell script. Notice that an output in base 10, by default, does not show the base in `base#number` notation because base 10 is implied. If you enter a base 10 number as an input number, you can omit the `10#` part of the number, because base 10 is, again, implied by default. The script supports both methods of notation for base 10.

Using the bc Utility for Number Base Conversions

So far in this chapter we have been doing everything in Korn shell. The reason is simple: Bash does not support the `typeset -ibase VAR` notation for number base conversions. Another reason is that Bash does not support the regular expression `+([0-9])` that we use to test for an integer. We can still convert number bases in Bash shell, however, by using the `bc` utility — the calculator program we studied in Chapter 13, ''Floating-Point Math and the bc Utility.'' Testing for the integer? We will use a different technique.

The `bc` utility uses two internal variables to define input and output number bases: `ibase` and `obase`. In both cases `bc` converts the number to decimal. So, to convert between bases, we must first convert to decimal and then convert to the desired output base. Additionally, `bc` only supports number bases between base 2 and base 16.

The chg_base_bc.Bash shell script in Listing 14-10 uses the same framework as the chg_base.ksh shell script in Listing 14-7. Study the chg_base_bc.Bash shell script in Listing 14-10 and we will cover the details at the end.

```
#!/bin/Bash
#
# SCRIPT: chg_base_bc.Bash
# AUTHOR: Randy Michael
# DATE: 10/4/2007
# REV: 1.1.A
#
# PURPOSE: This script converts numbers between base
# 2 through base 16 using the bc utility. The user
# is prompted for input.
#
# NOTE: Numbers are in the following format:
#
#     base#number
#
# EXAMPLE:  16#264bf
#
#########################################
# DEFINE FILES AND VARIABLES HERE
#########################################

# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) AWK="nawk"
       ;;
    *) AWK="awk"
       ;;
esac

#########################################
# BEGINNING OF MAIN
#########################################

# Prompt the user for an input number with base

echo -e "\nInput the number to convert in the following format:

Format: base#number

Example: 16#264BF \n"

read IBASE_NUM
```

Listing 14-10 chg_base_bc.Bash shell script

```
# Extract the base and the number from the ibase_num variable

IBASE=$(echo $IBASE_NUM | $AWK -F '#' '{print $1}')
INUMBER=$(echo $IBASE_NUM | $AWK -F '#' '{print $2}')

# Test to ensure the input base is between 2 and 16

if (( IBASE < 2 || IBASE > 16 ))
then
    echo -e "\nERROR: Input base must be between 2 and 16\n"
    exit 1
fi

# The bc utility requires all number bases greater
# than 10 use uppercase characters for all
# non-numeric character numbers, i.e. hex numbers.
# We use the tr command to uppercase all lowercase
# characters.

if (( IBASE > 10 ))
then
    INUMBER=$(echo $INUMBER | tr '[a-z]' '[A-Z]')
fi

# Ask the user for the output base

echo -e "\nWhat base do you want to convert $IBASE_NUM to?
NOTE: base 2 through 16 are valid\n"
echo -e "Output base: \c"
read OBASE

# Test to ensure the output base is an integer

case $OBASE in
  [0-9]*) : # do nothing
          ;;
       *) echo -e "\nERROR: $obase is not a valid number\n"
          exit 1
          ;;
esac

# Test to ensure the output base is between 2 and 16

if (( OBASE < 2 || OBASE > 16 ))
then
    echo -e "\nERROR: Output base must be between 2 and 16\n"
    exit 1
fi
```

Listing 14-10 (*continued*)

```
# Save the input number before changing the base

IN_BASE_NUM=$IBASE_NUM

# Convert the input number to decimal

if (( IBASE != 10 ))
then
    DEC_EQUIV=$(echo "ibase=$IBASE; $INUMBER" | bc)
fi

# Convert the number to the desired output base

RESULT=$(echo "obase=$OBASE; $DEC_EQUIV" | bc)

# Display the result

echo -e "\nInput number $IN_BASE_NUM is equivalent to \
${OBASE}#${RESULT}\n"
```

Listing 14-10 (*continued*)

We start the `chg_base_bc.Bash` shell script in Listing 14-10 by defining the correct `awk` command usage. If the UNIX flavor is Solaris, we need to use `nawk` instead of `awk` because `awk` in Solaris does not support the following `awk -F` syntax, denoted here in boldface text:

```
awk -F : '{print $1}'
```

To get around this little problem, we use `gawk` instead of `awk`. The following `case` statement sets up the correct `awk` usage:

```
# Set up the correct awk usage. Solaris needs to
# use nawk instead of awk.

case $(uname) in
SunOS) AWK="nawk"
       ;;
    *) AWK="awk"
       ;;
esac
```

Now when we use the `$AWK` variable, the correct `awk` command will execute.

At `BEGINNING OF MAIN`, we ask the user for an input number using the specific format `base#number`. The base is the number base of the input number and the number part is the number specified in the number base — for example, `16#264BF`. However, for this script we are expecting the `base#number` notation even for base 10 input numbers.

The next step is to split the number the user entered into two parts: the base part and the number part. This data extraction is shown here:

```
# Extract the base and the number from the ibase_num variable

IBASE=$(echo $IBASE_NUM | $AWK -F '#' '{print $1}')
INUMBER=$(echo $IBASE_NUM | $AWK -F '#' '{print $2}')
```

Notice here that we use the variable `$AWK` to execute the correct `awk` command based on the UNIX flavor we discovered earlier.

With the two parts of the input number we next verify that the input base is an integer. Remember that Bash shell does not support the regular expression `+([0-9)` to test for an integer. Instead, we can test for the input base to be between base 2 and base 16. If we find a base value out of this range, we show the user a usage error and exit — but we still test for a valid value. The test for a valid input number base is shown here:

```
# Test to ensure the input base is between 2 and 16

if (( IBASE < 2 || IBASE > 16 ))
then
    echo -e "\nERROR: Input base must be between 2 and 16\n"
    exit 1
fi
```

After verifying that the input base is in a valid range, we need to uppercase all non-numeric characters in input numbers that are in a base greater than 10, such as hexadecimal numbers. We do this using the **tr** command. We can use the `tr` command to both uppercase and lowercase text. The uppercase conversion is shown here:

```
# The bc utility requires all number bases greater
# than 10 use uppercase characters for all
# non-numeric character numbers, i.e. hex numbers.
# We use the tr command to uppercase all lowercase
# characters.

if (( IBASE > 10 ))
then
    INUMBER=$(echo $INUMBER | tr '[a-z]' '[A-Z]')
fi
```

This `tr` command changes all lowercase characters in `$INUMBER` to uppercase characters. If we had wanted to make all uppercase characters lowercase, we would have swapped the `'[a-z]' '[A-Z]'` with `'[A-Z]' '[a-z]'`, as shown here:

```
INUMBER=$(echo $INUMBER | tr '[A-Z]' '[a-z]')
```

NOTE **The single quotes around the square brackets are required.**

Now that we have all the tests complete and we have ensured that any lowercase characters are converted to uppercase characters, we ask the user for the desired output base. Again, we must test the user input to ensure the base is between 2 and 16. This test of the output base is shown here:

```
# Test to ensure the output base is between 2 and 16

if (( OBASE < 2 || OBASE > 16 ))
then
    echo -e "\nERROR: Output base must be between 2 and 16\n"
    exit 1
fi
```

If the base is out of range, we show the user a usage error and exit.

Now come the actual conversions. We first must convert the number to decimal before we convert the number to the desired output base. The following `bc` command statement converts the input base number to base-10 conversion:

```
# Convert the input number to decimal

if (( IBASE != 10 ))
then
    DEC_EQUIV=$(echo "ibase=$IBASE; $INUMBER" | bc)
fi
```

Of course, if the input base is already base 10, this conversion is not necessary.

With the input number now represented in base 10, we can use `bc` to convert the number to the desired output base, as shown here:

```
# Convert the number to the desired output base

RESULT=$(echo "obase=$OBASE; $DEC_EQUIV" | bc)
```

The only thing we are doing is to `echo` the data that `bc` requires and then piping this output into the `bc` utility.

The `chg_base_bc.Bash` shell script is shown in action in Listing 14-11.

```
[root:yogi.tampabay.rr.com]@/scripts# ./chg_base_bc.Bash

Input the number to convert in the following format:

Format: base#number

Example: 16#264BF

16#264bf
```

Listing 14-11 chg_base_bc.Bash shell script in action

```
What base do you want to convert 16#264bf to?
NOTE: base 2 through 16 are valid

Output base: 8

Input number 16#264bf is equivalent to 8#462277

[root:yogi.tampabay.rr.com]@/scripts#
```

Listing 14-11 (*continued*)

The `bc` utility is a very powerful tool and can handle some very complex arithmetic. For more information, see the `bc` manual page, `man bc`, and look back at Chapter 13.

Other Options to Consider

As with all of the scripts in this book, we can always make some changes to any shell script to improve it or to customize the script to fit a particular need.

Software Key Shell Script

To make a software key more complicated, you can hide the hexadecimal representation of the IP address within some pseudo-random numbers, which we studied in Chapters 10, ''Process Monitoring and Enabling Pre-Processing, Startup, and Post-Processing Events,'' and 11, ''Pseudo-Random Number and Data Generation.'' As an example, add five computer-generated pseudo-random numbers as both a prefix and a suffix to the hexadecimal IP address representation. Then to verify the license key in your software program, you can extract the hex IP address from the string. There are several techniques to do this verification, and I am going to leave the details up to you as a little project.

Summary

We went through a lot of variations in this chapter, but we did hit the scripts from different angles. Number base conversion can be used for many purposes, and we wrote one script that takes advantage of the translation. Software keys are usually more complicated than this script example, but I think you get the basic idea.

In the next chapter we are going to create a shell script I like to call `hgrep`, or *highlighted* `grep`. This script uses the same command syntax as `grep` but displays the entire text with the matching pattern highlighted in reverse video. See you in the next chapter!

Lab Assignments

1. Write an Expect script to automate the `chg_base.ksh` shell script in Listing 14-7. The expect script should use two command-line arguments: one for the input number, and the second for the output number base for conversion.
2. Write an Expect script to automate the `chg_base_bc.Bash` shell script in Listing 14-10. The Expect script should use two command-line arguments: one for the input number, and the second for the output number base for conversion.

CHAPTER 15

hgrep: Highlighted grep Script

Ever want to find text in a large file easily? The larger the text file, the more you will appreciate this shell script. We can use reverse video in shell scripts for more than just making pretty menus. What about highlighting text in a file or in a command's output? In this chapter we are going to show an example of using reverse video in a shell script that works similarly to the **grep** command. Instead of displaying the line(s) that match the pattern, we are going to display the entire file, or command output, with the matched pattern highlighted in reverse video. I like to call this **hgrep**.

In the process of creating this shell script, an initial test script was developed that ended up being very complicated. It started by grepping each line for the specified pattern. If the pattern was found in the line, then a scan of the line, character by character, was started to locate the exact pattern in the line for highlighting, then we grepped again for the pattern in remaining lines of text, and so on. This initial code had quite a few problems, other than the complicated nature of the script, caused by UNIX special characters making the output do some very interesting things when scanning shell script code. Regular text files worked fine, but the script was *very* slow to execute.

Then there was the revelation that the **sed** command should somehow be able to handle the pattern matching — and do so a lot faster than parsing the file with a shell script. A shell script is really not meant to work on a file line-by-line and *character by character*; it can be done, but this is what Perl is for! The problem to resolve using `sed` was how to add in the highlighting control within a `sed` command statement. After thinking about using `sed` and command substitution for a while, I had a working script in about 15 minutes (we might have a record!), and the following is what I came up with.

NOTE **Since the time I wrote this script for the first edition of *Mastering Unix Shell Scripting* in 2001, the GNU `more` command now has this capability. Type `more filename`, then search by pressing the / key and typing the search**

pattern followed by Enter. The search will take you to the first occurrence of the pattern and highlight in reverse video, this, and every, pattern match in the file. To shell script a solution, follow along.

Reverse Video Control

There are two commands that control reverse video: **tput smso** turns *soft* reverse video on, and **tput rmso** turns highlighting back off. The `tput` command has many other options to control the terminal (see Table 15-1 later in this chapter), but **tput sgr0** (sgr-zero) will turn every `tput` option off. To highlight text, we turn reverse video on, print whatever we want highlighted, and then turn reverse video off. We can also save this output, with the highlighted text, in a file. To display the file with highlighted text, we can use **pg**, or **page**, and on some operating systems **more** will work. The `more` command did not work on either AIX or HP-UX operating systems. Instead, the `more` command displayed the characters that make up the *escape sequence* for the highlighted text, not the highlighted text itself. You would see the same result using the `vi` editor. On Solaris both commands displayed the highlighted text, but not all operating systems have the `pg` and `page` commands.

There is one common mistake that will prevent this shell script from working: not double quoting the variables — for example, `"$STRING"`. The double quotes have no effect on a single-word pattern match, but for multiword string patterns, where there is white space, the variables *must* be double quoted or standard error will produce command usage errors within the script. The errors are due to the fact that each word that makes up the string pattern will be interpreted as a separate argument instead of one entity when the double quotes are present. The double quotes are very important when working with string variables containing white space. Forgetting the double quotes is a very hard error to find when troubleshooting code!

The `sed` command is next. Remember the basic `sed` syntax that we use in this book:

```
sed s/current_string/new_string/g $FILENAME
```

In our script, we want to use the `sed` command statement to redirect output to a file, and then use `pg`, `page`, or `more` to display the file:

```
sed s/current_string/new_string/g $FILENAME > $OUTPUT_FILE

pg $OUTPUT_FILE
   --verse--
more $OUTPUT_FILE
```

To add in the reverse video piece, we have to do some command substitution within the `sed` statement itself using the `tput` commands — this is the part that had to be worked out. Where we specify the `new_string` we will add in the control for reverse video using command substitution, one to turn highlighting on and one to turn it back

off. When the command substitution is added, our `sed` statement will look like the following:

```
sed s/current_string/$(tput smso)new_string$(tput rmso)/g
```

In our case, the `current_string` and `new_string` will be the same because we only want to highlight existing text without changing it. We also want the string to be assigned to a variable, as in the next command:

```
sed s/"$STRING"/$(tput smso)"$STRING"$(tput rmso)/g
```

Notice the double quotes around the string variable, `"$STRING"`. Just another reminder: do not forget to add the double quotes around variables with white space!

As an experiment using command substitution, try this next command statement on any UNIX machine:

```
sed s/`hostname`/$(tput smso)`hostname`$(tput rmso)/g /etc/hosts
```

In the preceding command statement, notice that we used both types of command substitution, enclosing the command within back tics, `` `command` ``, and the dollar parentheses method, `$(command)`. The statement will **cat** the `/etc/hosts` file and highlight the machine's `hostname` in reverse video each time it appears in the file. Now try the same command, but this time pipe the command to `more`. Try the same command again using `pg` and `page` instead of `more`, if your machine supports the `page` commands. If your machine does not have the `pg` command, the `more` command should work. If your operating system has both `pg` and `more`, notice that using `more` may not display the string pattern in reverse video — it will display the characters that make up the *escape sequence* that the `tput` commands create, but Solaris is an exception. We will need to consider this when we display the result on different operating systems.

To make this script have the same look and feel as the `grep` command, we want to be able to supply input via a file, as a command-line argument, or as standard input from a command pipe. When supplying a filename to the script as a command-line argument, we need to ensure that the file exists, its size is greater than zero bytes, it is readable by this script, and the string pattern is matched in the file. We could leave out the last step, but if the pattern is not in the file it would be nice to let the user know. If we are getting input from standard input instead of a file specified as an argument — for example, `cat /etc/hosts | hgrep.Bash `hostname`` — we need to check for the string pattern in the output file instead of the input file. Then we can still inform the user if the pattern is not found.

Building the hgrep.Bash Shell Script

Now that we have the basic command syntax, let's build the `hgrep.Bash` shell script. There are two types of input for this script: file input and standard input. For the file input we need to do some sanity checks so that we don't get standard error

messages from the system. We also want to give the user some feedback if there is something that will cause an error using the specified file as input — for example, the file does not exist or is not readable by the script because of file permissions. The command syntax using the `hgrep.Bash` script should be the same as the `grep` command, which is:

```
grep  pattern  [filename]
```

By looking at this we can determine that we will sanity-check the file only when we have two command-line arguments; otherwise, we are using piped-in standard input, which implies that we check the file only when `$#` is equal to `2`. We begin with checking the command-line arguments and making assignments of the arguments to variables:

```
if (( $# != 1 ))
then
     # Input coming from standard input

     PATTERN="$1" # Pattern to highlight
     FILENAME=    # Assign NULL to FILENAME

elif (( $# != 2 ))
then
     # Input coming from $FILENAME file

     PATTERN="$1"  # Pattern to highlight
     FILENAME="$2" # File to use as input
else
     # Incorrect number of command-line arguments

     usage
     exit 1
fi
```

We should now have enough to get us started. If we have a single command-line argument, we assign `$1` to `PATTERN` and assign the `FILENAME` variable a NULL value. If there are two command-line arguments, we assign `$1` to `PATTERN` and `$2` to `FILENAME`. If we have zero or more than two arguments, we display the `usage` message and exit with a return code of `1`, one. The function for correct usage is listed here. Notice we add the `-e` switch to the `echo` command, enabling the backslash cursor controls, since this is a Bash shell script.

```
function usage
{
echo -e "\nUSAGE: $SCRIPT_NAME  pattern  [filename]\n"
}
```

Follow through the `hgrep.Bash` script in Listing 15-1, and the process will be explained at the end of the shell script. Note that this is a Bash script, but it will run in Bourne or Korn shells. Just declare your favorite shell.

```
#!/bin/Bash
#
# SCRIPT: hgrep.Bash
# AUTHOR: Randy Michael
# DATE: 07/09/2007
# REV 3.0
#
# PLATFORM: Not Platform Dependent
#
# PURPOSE: This script is used to highlight text in a file.
#    Given a text string and a file the script will search
#    the file for the specified string pattern and highlight
#    each occurrence. For standard input the script pages a
#    temporary file which has the string text highlighted.
#
# REV LIST:
#
# set -x   # Uncomment to debug
# set -n   # Uncomment to check script syntax without execution
#
# EXIT CODES:
#       0 ==> Script exited normally
#       1 ==> Usage error
#       2 ==> Input File Error
#       3 ==> Pattern not found in the file
#
# REV LIST:
#    03/12/2001 - Randy Michael - Sr. Sys. Admin.
#    Added code to just exit if the string is not in
#    the target file.
#
#    03/13/2001 - Randy Michael - Sr. Sys. Admin.
#    Added code to ensure the target file is a readable
#    "regular" non-zero file.
#
#    03/13/2001 - Randy Michael - Sr. Sys. Admin.
#    Added code to highlight the text string and filename
#    in the error and information messages.
#
#    08-22-2001 - Randy Michael - Sr. Sys. Admin
#    Changed the code to allow this script to accept standard
#    input from a pipe. This makes the script work more like the
#    grep command
#
#    7/02/2007 - Randy Michael - Sr. Sys. Admin
#    Converted this script to Bash shell.
#
```

Listing 15-1 hgrep.Bash shell script

```
###############################################
#     DEFINE FILES AND VARIABLES HERE
###############################################

SCRIPT_NAME=$(basename $0)
OUTPUT_FILE="/tmp/highlightfile.out"
>$OUTPUT_FILE

###############################################
#     DEFINE FUNCTIONS HERE
###############################################

function usage
{
echo -e "\nUSAGE: $SCRIPT_NAME  pattern  [filename]\n"
}

###############################################
#         CHECK COMMAND SYNTAX
###############################################

# Input coming from standard input

if (( $# == 1 ))
then
     # Input coming from standard input

     PATTERN="$1" # Pattern to highlight
     FILENAME=    # Assign NULL to FILENAME

elif (( $# == 2 ))
then
     # Input coming from $FILENAME file

     PATTERN="$1"  # Pattern to highlight
     FILENAME="$2" # File to use as input

     # Does the file exist as a "regular" file?

     if [ ! -f "$FILENAME" ]
     then
        echo -e "\nERROR: $FILENAME does not exist...\n"
        usage
        exit 2
     fi

     # Is the file empty?
```

Listing 15-1 (*continued*)

```
      if [ ! -s "$FILENAME" ]
      then
         echo -e "\nERROR: \c"
         tput smso
         echo -e "$FILENAME\c"
         tput sgr0
         echo -e " file size is zero...nothing to search\n"
         usage
         exit 2
      fi

      # Is the file readable by this script?

      if [ ! -r "$FILENAME" ]
      then
         echo -e "\nERROR: \c"
         tput smso
         echo -e "${FILENAME}\c"
         tput sgr0
         echo -e " is not readable to this program...\n"
         usage
         exit 2
      fi

      # Is the pattern anywhere in the file?

      grep -q "$PATTERN" "$FILENAME"
      if (( $? != 0 ))
      then
         echo -e "\nSORRY: The string \c"
         tput smso
         echo -e "${PATTERN}\c"
         tput sgr0
         echo -e " was not found in \\c"
         tput smso
         echo -e "${FILENAME}\c"
         tput sgr0
         echo -e "\n\n....EXITING...\n"
         exit 3
      fi
else
      # Incorrect number of command-line arguments
      usage
      exit 1
fi

###############################################
#       BEGINNING OF MAIN
```

Listing 15-1 (*continued*)

```
###############################################

# There is no $FILENAME if we get input from a pipe...

if [[ ! -z "$FILENAME" && "$FILENAME" != '' ]]
then
    # Using $FILENAME as input

    case $(uname) in
    AIX|HP-UX)
      # This is a fancy "pg" command.  It acts similar to the
      # "more" command but instead of showing the percentage
      # displayed it shows the page number of the file

      sed s/"${PATTERN}"/$(tput smso)"${PATTERN}"$(tput sgr0)/g \
      "$FILENAME"  | pg -csn -p"Page %d:"
      exit 0
      ;;
    *)
      sed s/"${PATTERN}"/$(tput smso)"${PATTERN}"$(tput sgr0)/g \
      "$FILENAME" | more
      exit 0
      ;;
    esac
else
     # Input is from standard input...
     sed s/"${PATTERN}"/$(tput smso)"${PATTERN}"$(tput sgr0)/g \
         > $OUTPUT_FILE

     # Is the pattern anywhere in the file?
     grep -q "$PATTERN" $OUTPUT_FILE
     if (( $? != 0 ))
     then
        echo -e "\nERROR: The string \c"
        tput smso
        echo -e "${PATTERN}\c"
        tput sgr0
        echo -e " was not found in standard input\c"
        echo -e "\n\n....EXITING...\n"
        exit 3
     fi
fi

# Check the operating system; on AIX and HP-UX we need to
# use the "pg", or "page" command.  The "more" command does
# not work to highlight the text; it will only show the
# characters that make up the escape sequence.  All
# other operating system usr the "more" command.
```

Listing 15-1 (*continued*)

```
case $(uname) in
AIX|HP-UX)

     # This is a fancy "pg" command.  It acts similar to the
     # "more" command but instead of showing the percentage
     # displayed it shows the page number of the file

     cat $OUTPUT_FILE | pg -csn -p"Page %d:"
   ;;
*)
     cat $OUTPUT_FILE | more
   ;;
esac
```

Listing 15-1 (*continued*)

In the shell script in Listing 15-1 we first check for the correct number of command-line arguments; either one or two arguments are valid. Otherwise, the script `usage` message is displayed, and the script will exit with a return code of `1`. If we have the correct number of arguments, we assign the arguments to variables. If we have two command-line arguments, an input file is specified in `$2` — at least it is supposed to be a file. We need to do some sanity checking on this second command-line argument by first checking to see that the file exists as a regular file. We do not want to do anything with the file if it is a block or character special file, a directory, or any other *nonregular* file. Next we make sure that the file is not empty. Then we ensure that the script can read the file, and finally, we `grep` for the pattern in the file to see if we have anything to highlight. If all the tests are passed, we can proceed.

By checking if the `$FILENAME` variable is null, or empty, we know which type of input we are dealing with. A null or empty `$FILENAME` variable means we use standard input, which is input from a pipe in this case. If `$FILENAME` is not null, we have a file specified as input to the script on the command line.

The difference in handling an input file versus standard input is that we will directly read an input file, perform the `sed` substitution, and display the file one page at a time. Otherwise, the input is already coming in from a pipe directly into the `sed` statement and we capture this `sed` output in a temporary file specified by the `$OUTPUT_FILE` variable. It's that simple!

We have one more check before displaying the output. We need to `grep` for `"$PATTERN"` in the `$FILENAME` or `$OUTPUT_FILE` to see if it exists. If not, we display a *string not found* message and exit.

The output display is interesting because the `more` command will not work on HP-UX or AIX to display the highlighted text. For HP-UX and AIX we use `pg` instead of `more`. To determine which flavor of UNIX we are running, we use the **uname** command in a `case` statement. If the OS is either AIX or HP-UX, we use a *fancy* `pg` command, which has output that appears similar to the `more` output. Using `pg -csn -p"Page %d:"` will display the page number of the file, whereas `more` displays the percentage of the file. All other UNIX flavors will use `more` to display the output file.

The script in Listing 15-1 is a good example of how a little ingenuity can greatly simplify a challenge. We sometimes make things more complicated than they need to be, as in my initial test script that parsed through the file line-by-line and character by character, searching for the pattern. We live and learn!

Other Options to Consider

As with every script there is room for improvement or customization, however you want to look at it.

Other Options for the tput Command

The only `tput` command option that we worked with was the `tput smso` command, which is used to turn on highlighting. The `tput` command has many other options to control terminal display. In our example we did a highlight of not only the text but also the surrounding *block* for *each* character. We could also highlight only the text piece, double video the entire text block, or underline with other options — for example, we could have underlined bold text. The `tput` command is fun to play with. The short list of command options is shown in Table 15-1.

Table 15-1 Options for the tput Command

TPUT BELL	RINGS THE BELL
`tput blink`	Starts blinking mode
`tput bold`	Starts double intensity (much brighter than reverse video)
`tput civis`	Turns off the cursor
`tput cnorm`	Makes the cursor normal again
`tput cr`	Sends a carriage to the terminal
`tput cvvis`	Makes the cursor very bright
`tput dim`	Starts one-half intensity mode
`tput ed`	Clears to the end of the display
`tput el`	Clears to the end of the line
`tput flash`	Sends a visible bell (good for sending a flash to someone's screen)
`tput invis`	Starts invisible text mode
`tput prot`	Starts protected mode
`tput rc`	Restores the last saved cursor position (paved by `tput sc`)

(*continued*)

Table 15-1 (*continued*)

TPUT BELL	RINGS THE BELL
`tput rev`	Begins reverse video mode (bright!)
`tput rmso`	Ends the standout mode (reverses `tput smso`)
`tput rmul`	Ends the underline (underscore) mode
`tput sc`	Saves the cursor position
`tput sgr0`	Turns off all video modes
`tput smso`	Starts the standout mode (soft reverse video we used in this chapter)
`tput smul`	Starts the underline (underscore) mode

Table 15-1 is only an abbreviated listing of the `tput` command options. As you can see, we can do a lot with the text on the screen. Use your imagination, and play around with the commands.

Summary

In this chapter we introduced using reverse video to highlight text within our output. We also showed how to do command substitution inside a `sed` command statement. There are many more options for the `tput` command to control the terminal; for example, we could have underlined the matching pattern. The nice thing about the `tput` command is that it will let you mix things up, too.

In the next chapter, we are going to study some techniques to monitor one or more processes, with options to wait for processing to start or stop execution, or both. We also allow for pre- and post-events to be defined for the process. I hope you gained some knowledge in this chapter, and every chapter! Please review the lab assignments.

Lab Assignments

1. Modify the `hgrep.Bash` shell script in Listing 15-1 to blink/flash matching patterns on the screen.
2. Modify the `hgrep.Bash` shell script in Listing 15-1 to process standard input directly, without relying on a temporary file for internal script tests and processing. (Hint: Include required tests in one statement.)
3. Count the occurrences of pattern matches and give the end user this feedback. How you give this feedback is up to you.

CHAPTER 16

Monitoring Processes and Applications

The most critical part of any business is ensuring that applications continue to run without error. In this chapter, we are going to look at several techniques for monitoring applications and critical processes that the applications rely on. The problem with trying to write this chapter is that there are so many applications in the corporate world that the techniques to monitor them vary widely.

From the lowest level, we can **ping** the machine to see if it is up. A `ping`, though, is not an operating system response, but rather a machine response that only confirms that the network adapter is configured. Then again, if the machine is in the DMZ, `ping` is probably disabled at the router. At a higher level, we can look at the processes that are required for the application to run properly, but this too does not completely confirm, 100 percent, that the application is working properly. The only way to ensure the application is working properly is to interact with the application. As an example, if we have a database that the application requires we can do a simple SQL query to ensure that the database is working properly. For interactive applications, we can try to use a *here* document or an `expect` script to log in to the application, or server, and maybe even perform a small task. Applications work differently, so solutions to ensure that the application is up and running properly will vary widely.

We are going to look at monitoring local processes, remote monitoring using OpenSSH (`ssh`) or Remote Shell (`rsh`), checking for active Oracle databases, and using an **expect** script to log in remotely and execute one or more commands. We will check an application URL and HTTP server status, and finally use **egrep** to monitor a group of processes to give notification when they have all completed execution in this chapter.

Monitoring Local Processes

Above pinging a host machine, the most common application monitoring technique is to look for the critical processes that are required for the application to work properly.

This is also a good practice when we have a flaky application that has a process that dies intermittently.

The basic technique is to use the `ps -ef | grep target_process | grep -v grep` command syntax. If you have more than one required process, this command statement needs to be executed for each of the processes individually for an accurate result. We can also build an `egrep` statement of PIDs and monitor all of the processes at once. However, we do not want to use `egrep` in place of **grep** in some cases. If `egrep` is used, we can get a positive result if *any* of the processes are currently running. For example, if we lose a critical HTTP process, and any of the other ''targeted'' processes are still running, we will get a false positive that everything is okay if we use `egrep` to search all of the processes at once. We use `egrep` when we want to monitor for all processes to *end execution*, not to ensure all process are running.

The key to making this technique work is to find a *unique* string pattern that represents the target process. The PID is no good if you are not sure if your PID is the parent or child process, because the process may have a child or parent process that has the same PID somewhere in the `ps -ef` output. Finding a unique string pattern that works with the `grep` command is key. This command is easily tested using the following command syntax, from the command line:

```
ps -ef | grep Appserver | grep -v grep
```

This command statement assumes that we are looking for a process called `Appserver`. Notice that we always pipe (|) the last pipe's output to `| grep -v grep`. This last `grep` on `grep` is needed so that the system will not report on the `grep Appserver` process. In the process table each part of the command statement that has a pipe will have a separate PID.

Then there is another thing to consider if this command is executed in a shell script. The shell script name may show up in the `grep` output, depending on how the shell script is written. To get around this little problem, we need to query the system to capture the shell script's filename and add a third `grep` to the `ps -ef` command statement using the following syntax:

```
SCRIPT_NAME=$(basename $0)

ps -ef | grep target_process | grep -v grep | grep -v $SCRIPT_NAME
```

Now we have a command that will work if, *and only if*, a unique character string can be found that separates the target process from all other processes. This usually takes a few tries for each application that we want to monitor.

In Listing 16-1 we have a code segment from a shell script that monitors an application service, using a unique character string. This particular application service is defined by the `APPSVC` variable. If this service is not currently running, there is an attempt to restart the application service and an email is sent to my text pager and my regular email account. Follow the code segment in Listing 16-1.

```
#########################################################
#   DEFINE FILES AND VARIABLES HERE
#########################################################

APPSVC="/usr/local/sbin/appstrt_u1"
MAILLIST="1234567890@mypage.provider.abc randy@my.domain.com"
MAILFILE="/tmp/mailfile.out"
TIMESTAMP=$(date +%m%d%y%H%M%S)
APPS_LOG="/usr/local/log/appsvc.log"
[ -s $APP_LOG ] || touch $APP_LOG

#########################################################
#   BEGINNING OF MAIN
#########################################################

# Check to see if the APPSVC process(es) is/are running

APPSVC_COUNT=$(ps -ef | grep "$APPSVC" | grep -v grep \
                      | grep -v $SCRIPT_NAME | wc -l)

# If the count is zero then we need to attempt to restart the service

if (( $APPSVC_COUNT == 0 ))
then
     # Need to attempt an Application server restart.
     echo "Attempting Restart: $APPSVC" > $MAILFILE
     # Send email notification
     mailx -r rmichael@my.domain.com -s "App Down" $MAILLIST < $MAILFILE
     # Make a log entry
     echo "ERROR: $TIMESTAMP - Appsvc DOWN - Attempting Restart $APPSVC" \
           >> $APP_LOG
     # Make another log entry
     echo "STARTING APPLICATION SERVER - $TIMESTAMP" >>$APPS_LOG

     # Attempt the restart!!!
     su - appsvc -c '/usr/local/sbin/appsvc start 2>&1' >> $APP_LOG
fi
```

Listing 16-1 Code segment to monitor an application process

In the code segment in Listing 16-1, notice that we defined a unique string for the process, which in this case is the fully qualified pathname to the `APPSVC` variable. Because this application server can have multiple instances running at the same time, we need to get a count of how many of these processes are running. If the process count is 0, zero, a restart of the application server is attempted.

During the restart effort an email notification is sent to reflect that the application service is down and the script is attempting a restart. This information is also logged in the `$APP_LOG` file *before* the restart command. Notice the restart command at the end of the script segment. This monitoring script is executed from the `root` cron table every 10 minutes. Because the script is running as `root` it is easy to use the **su** (switch user) command to execute a single command as the `appsvc` user for the restart. If you are not familiar with this technique, study the syntax in Listing 16-1 and the `man` page for the `su` command.

Remote Monitoring with Secure Shell and Remote Shell

In the previous section we studied a ''local'' shell script. No one said, though, that you could not run this same script from a remote machine. This is where Remote Shell and Open Secure Shell (OpenSSH) come into play.

Open Secure Shell is a freeware encryption replacement for `telnet`, `ftp`, and `rsh`, for the most part. Every place I have worked over the past four years has disabled `rsh`, `telnet`, and `ftp`as a result of SOX audits. These commands are a security risk because communication is not encrypted and, with a sniffer or a `tcpdump`, usernames and passwords can be seen in plain text. When we use the `ssh` command, we establish a connection between two machines, and a secure *tunnel* allows encrypted communication between two *trusted* machines. Using `ssh` we can log in to another trusted machine in the network, we can copy files between the machines with `scp` and `sftp` in an encrypted state, and we can run commands on a remote trusted machine. You can download OpenSSH at `http://www.openssh.com`.

To establish *password-free* encrypted connections, an encryption key pair must be created on both machines. This encryption key is located on both machines in the user's `$HOME/.ssh` directory. All of the details to set up the password-free encrypted connections are shown in great detail in the `ssh` manual page (**man ssh**).

Of course, you can script it, too! The `keyit` script, shown in Listing 16-2, takes care of the task of adding the public key to the `authorized_keys` file.

```
#!/usr/bin/ksh
#
# SCRIPT: keyit
# AUTHOR: Randy Michael
# DATE: 7/31/2007
# REV: 1.0
# PLATFORM: Not platform dependent
# REQUIREMENTS: OpenSSH
#
# PURPOSE: This script is used to set up
# encryption keypairs between two hosts.
```

Listing 16-2 keyit shell script

```
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check script syntax
#        # without any execution. Do not
#        # forget to add the comment back,
#        # or the script will never execute.
#
# USAGE:  keyit remote_host username
#
########################################
# DEFINE FILES AND VARIABLES HERE
########################################

RHOST=$1
THIS_USER=$2
THIS_SCRIPT=$(basename $0)
THIS_HOST=$(hostname)

########################################
# DEFINE FUNCTIONS HERE
########################################

usage ()
{
echo "\nUSAGE: $THIS_SCRIPT \
remote_host username\n"
}

########################################

success_message ()
{
KTYPE=$1
echo "\nSUCCESS: $KTYPE key pairs configured for $THIS_USER on $RHOST"
echo "\n$THIS_USER should no longer require an SSH password on $RHOST"
echo "when logging in directly, however, using the ssh commands:\n"
echo "\tssh -l $THIS_USER $RHOST\nAND\n\tssh ${THIS_USER}@${RHOST}"
echo "\nWHILE LOGGED IN LOCALLY AS ANOTHER USER will still not work"
echo "without a valid user password\n"
}

########################################

failure_message ()
{
echo "\nERROR: Setting up the $KEYTYPE key pairs failed"
echo "Ensure that OpenSSH is installed and running"
```

Listing 16-2 (*continued*)

```
echo "on both hosts. Then ensure that the user has"
echo "a .ssh directory in their \$HOME directory."
echo "See the man page on ssh and ssh-keygen"
echo "for more details and manual setup\n"
}

#######################################

keyit_dsa ()
{
# Append the local public key to the same user's
# authorized_users file

cat ~${THIS_USER}/.ssh/id_dsa.pub | ssh ${THIS_USER}@$RHOST \
"cat >> ~${THIS_USER}/.ssh/authorized_keys"

if (( $? == 0 ))
then
    success_message dsa
else
    failure_message
fi
}

#######################################

keyit_rsa ()
{
# Append the local public key to the same user's
# authorized_users file

cat ~${THIS_USER}/.ssh/id_rsa.pub | ssh ${THIS_USER}@$RHOST \
"cat >> ~${THIS_USER}/.ssh/authorized_keys"

if (( $? == 0 ))
then
    success_message rsa
else
    failure_message
fi
}

#######################################
# BEGINNING OF MAIN
#######################################

# Ensure the user $THIS_USER exists on the local system
```

Listing 16-2 (*continued*)

```
if ! $(/usr/bin/id $THIS_USER >/dev/null 2>&1)
then
    echo "\nERROR: $THIS_USER is not a valid user on $THIS_HOST\n"
    usage
    exit 1
fi

# Ensure ssh is installed locally

if [[ ! -x /usr/bin/ssh && ! -x /usr/local/bin/ssh ]]
then
    echo "\nERROR: SSH does not appear to be installed on this machine"
    echo "This script requires SSH...Exiting...\n"
    usage
    exit 2
fi

# Check for proper usage

if ! [ $2 ]
then
   usage
   exit 1
fi

# Ping the remote host 1 ping

if ! $(ping -c1 $RHOST >/dev/null 2>&1)
then
    echo "\nERROR: $RHOST is not pingable...Exiting...\n"
    exit 2
fi

# Set up the key pairs for the configured key(s)

SET=0

if [ -s ~$THIS_USER/.ssh/id_dsa.pub ]
then
   keyit_dsa
   SET=1
fi

if [ -s ~$THIS_USER/.ssh/id_rsa.pub ]
then
   keyit_rsa
   SET=2
fi
```

Listing 16-2 (*continued*)

```
if (( SET == 0 ))
then
   echo "\nERROR: SSH public key is not set for $THIS_USER..."
   echo "\nTo Configure Run: ssh-keygen -t type"
   echo "Where type is rsa or dsa encryption\n"
   echo "Would you like to set up the keys now? (y/n): \c"
   read REPLY
   case $REPLY in
   y|Y) if $(id $THIS_USER >/dev/null 2>&1)
        then
           echo "\nEncryption Type: (dsa or rsa?): \c"
           read KEYTYPE
           case "$KEYTYPE" in
           +([d|D][s|S][a|A])) KEYTYPE=dsa
              ;;
           +([r|R][s|S][a|A])) KEYTYPE=rsa
              ;;
           *) echo "\nERROR: Invalid entry...Exiting..."
              exit 1
              ;;
           esac
          echo "\nAccept the defaults and do not enter a passphrase...\n"
           su - $THIS_USER "-c ssh-keygen -t $KEYTYPE"
           if (( $? == 0 ))
           then
              echo "\nSuccess, keying $THIS_USER on $RHOST\n"
              keyit_${KEYTYPE} $KEYTYPE
           fi
        else
           echo "\nERROR: $THIS_USER username does not exist\n"
        fi
       ;;
     *) # Do nothing
        :  # A colon, :, is a "no-op"
        ;;
   esac
fi

########################################
# END OF KEYIT SCRIPT
########################################
```

Listing 16-2 (*continued*)

Let's look at a couple of examples of using `ssh`. The first example, shown in Listing 16-3, shows a simple login without the key pair created.

```
# ssh randy@dino
The authenticity of host 'dino (10.10.10.6)' can't be established.
RSA key fingerprint is c5:19:37:b9:59:ad:3a:18:6b:45:57:2d:ab:b8:df:bb.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'dino (10.10.10.6)' (RSA) to
the list of known hosts.
randy@dino's password:
Last unsuccessful login: Tue Jul 2 13:58:18 EDT 2006 on
/dev/pts/24 from bambam
Last login: Wed Aug  7 10:28:00 EDT 2006 on /dev/pts/18 from bambam

*******************************************************************************
*
*
*  Welcome to dino!
*
*
*  Please see the README file in /usr/lpp/bos for information
pertinent to this release of the operating system
*
*
*
*******************************************************************************
*****************[YOU HAVE NEW MAIL]
[randy@dino] $
```

Listing 16-3 Sample Secure Shell login

Notice in Listing 16-3 that the login to `dino` required a password, which indicates that the systems do not have the encryption key pairs set up. This does get a bit annoying when you are trying to run a command on a remote machine using an `ssh` tunnel. With the key pairs created on both machines we can monitor remote machines using encryption, and no password is required. As an example, suppose we need to check the filesystem usage on `dino` and we are logged into `yogi`. By adding the command that we want to execute on `dino` to the end of the `ssh` login statement, we establish a trusted connection between the two machines, and the command executes on the remote machine with standard output going to the local machine. Of course, this is equivalent to a remote shell, `rsh`, except that the information is encrypted using `ssh` in place of `rsh`. A simple example of this technique is shown in Listing 16-4.

```
[randy@yogi] ssh randy@dino df -k

Filesystem    1024-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4           196608     66180   67%     2330     3% /
```

Listing 16-4 Example of running a remote command

```
/dev/hd2          1441792    488152   67%    29024     9% /usr
/dev/hd9var       2162688   1508508   31%      868     1% /var
/dev/hd3           131072    106508   19%      361     2% /tmp
/dev/hd1           589824    235556   61%    15123    11% /home
/dev/local_lv      393216     81384   80%     2971     4% /usr/local
/dev/oracle_lvx   1507328    307388   80%     5008     2% /oracle
/dev/arch_lvx    13631488   8983464   35%       44     1% /oradata
```

Listing 16-4 (*continued*)

Notice in the output in Listing 16-4 that there was no prompt for a password, and that the result was presented back to the local terminal. Once the key pairs are set up, you can do remote monitoring with ease. The `keyit` script is a handy tool to keep around. Let's move on to Oracle now.

Checking for Active Oracle Databases

I wanted to add a couple of examples of interacting with an application in this chapter, and I picked an Oracle database as the example using a SQL+database query, and using **autoexpect** to automate logging in to a remote machine. First the Oracle database tests. We will look at three steps to check the Oracle database status. The first step is to list all of the Oracle instances defined in the `/etc/oratab` file. This file is colon-separated (`:`) with the Oracle instance name(s) in the first field, `$1`. The function shown in Listing 16-4 first checks to see if a `/etc/oratab` file exists. If the file is not found, a notification message is displayed on the user's terminal and the function returns a `3` for a return code. Otherwise, the `/etc/oratab` file is parsed to find the Oracle instance name(s). Removing all of the lines in the file that begin with comments, specified by beginning with a hash mark (`#`), is done using a **sed** statement in combination with the `^#` notation. Removing the comment lines is easy using the `sed` statement, as shown here with a `/etc/hosts` file as an example:

```
cat /etc/hosts | sed /^#/d > /etc/hosts.without_beginning_comments
```

The output of the preceding command shows all the IP address and hostname entries, except that the commented-out lines have been removed. The `^#` is the key to finding the commented lines, which translates to *begins with a* `#`.

We could have used `grep -v ^#` just as easily as the previous `sed` statement. I wanted to mix it up a little bit.

Check out the function in Listing 16-5 to see how we use this technique to parse the Oracle instances from the `/etc/oratab` file.

```
function show_oratab_instances
{
if [ ! -f "$ORATAB" ]
then
     echo "\nOracle instance file $ORATAB does not exist\n"
```

Listing 16-5 show_oratab_instances function

```
     return 3
else
     cat $ORATAB | sed /^#/d | awk -F: '{print $1}'
fi
}
```

Listing 16-5 (*continued*)

The output of the `show_oratab_instances` function in Listing 16-5 is a list of all of the Oracle instances defined on the system. We have already removed the lines that are comments; next comes the **awk** statement that extracts the first field, specified by `awk -F: '{print $1}'`. In this `awk` statement, the `-F:` specifies that the line is field separated by colons (`:`). Once we know the field separator, we just extract the first field (`$1`), which is the Oracle instance name.

NOTE **The Solaris implementation of `awk` does not support specifying a field delimiter using `awk -F :` type notation. For Solaris you must use `nawk` (new `awk`) instead of `awk`. If you add the following code segment at the top of a shell script that uses this notation the `alias` will take care of the problem:**

```
case $(uname) in
SunOS) alias awk=nawk
            ;;
esac
```

Now we are going to use the same function shown in Listing 16-5 to get the status of all of the defined Oracle instances by checking for the process for each instance. This technique is shown in Listing 16-6.

```
function show_all_instances_status
{
for INSTANCE in $(show_oratab_instances)
do
     ps -ef | grep ora | grep $INSTANCE | grep -v grep >/dev/null 2>&1
     if (($? != 0))
     then
          echo "\n$INSTANCE is NOT currently running $(date)\n"
     else
          echo "\n$INSTANCE is currently running OK $(date)\n"
     fi
done
}
```

Listing 16-6 show_all_instances_status function

Notice in Listing 16-6 that we use the function from Listing 16-5 to get the list of Oracle instances to query the system for. If you do this, remember the `show_oratab_instances` function must be defined in the script before the `show_all_instances_status` function is used. *Define it before you use it*. In this case, all we are doing is

using the `ps -ef` command again. This time we narrow down the list with a `grep` on the string `ora`. This output is piped (`|`) to another `grep` statement, where we are looking for the instance name for the current loop iteration, specified by `$INSTANCE`. Of course, we need to strip out any `grep` processes from the output, so we add one more `grep -v grep`. If the return code of the entire `ps -ef` statement is 0, zero, then the instance is running; if the return is anything other than 0, zero, the instance is not running, specified by the `if (($? ! = 0))` test.

We are still looking at the process level. I have seen cases when the instance processes are running, but I still could not log in to the database. For a final test we need to do an actual SQL query of the database to interact with Oracle. This just needs to be a very simple query to prove that we can interact with the database and get data back.

To actually query the Oracle database we can use a simple SQL+statement, as shown in Listing 16-7. This two-line SQL script is used in the function `simple_SQL_query`, shown in Listing 16-8 using the **sqlplus** command.

```
select * from user_users;
exit
```

Listing 16-7 my_sql_query.sql SQL script

As you can see in Listing 16-7, this is not much of a query, but it is all that we need. This SQL script, `my_sql_query.sql`, is used in the `sqlplus` function in Listing 16-8. Notice in this function, `simple_SQL_query`, that the `sqlplus` command statement requires a username, password, and an Oracle SID name to work. This file should have file permission to limit read access for security. See the function code in Listing 16-8.

```
function simple_SQL_query
{
USER=oracle
PASSWD=oracle
SID=yogidb

sqlplus ${USER}/${PASSWD}@$SID @my_sql_query.sql
}
```

Listing 16-8 simple_SQL_query function

The function shown in Listing 16-8 can be shortened further, *if* you are logged in to the system as the `oracle` user or executing a script as the `oracle` user. If these conditions are met, you can run a simpler version of the previous `sqlplus`, as shown in Listing 16-9, with the output of the query; however, the Oracle Listener is not tested as in the previous `sqlplus` statement in Listing 16-8. The `sqlplus` command in Listing 16-9 should be run on the local machine.

```
 [oracle@yogi] sqlplus / @/usr/local/bin/mysql_query.sql

SQL*Plus: Release 8.1.7.0.0 - Production on Wed Aug 7 16:07:30 2007

(c) Copyright 2000 Oracle Corporation.  All rights reserved.


Connected to:
Oracle8i Enterprise Edition Release 8.1.7.4.0 - Production
With the Partitioning option
JServer Release 8.1.7.4.0 - Production


USERNAME                          USER_ID ACCOUNT_STATUS
------------------------------ ---------- --------------------------
LOCK_DATE   EXPIRY_DATE DEFAULT_TABLESPACE
----------- ----------- ------------------------------
TEMPORARY_TABLESPACE           CREATED     INITIAL_RSRC_CONSUMER_GROUP
------------------------------ ----------- ------------------------
EXTERNAL_NAME
----------------------------------------------------------------
OPS$ORACLE                             940 OPEN
                        USERS
TEMP                           18-APR-2007



Disconnected from Oracle8i Enterprise Edition Release
8.1.7.4.0 - Production
With the Partitioning option
JServer Release 8.1.7.4.0 - Production
```

Listing 16-9 Example of a SQL+Oracle query

This is about as simple as it gets! You can check the return code from the `sqlplus` command shown in Listing 16-9. If it is zero, the query worked. If the return code is nonzero, the query failed and the database should be considered down. In any case, the Database Administrator needs to be notified of this condition.

Using autoexpect to Create an expect Script

As we saw in Chapter 8, ''Automating Interactive Programs with Expect and Autoexpect,'' an expect script enables us to automate interaction with machines and applications. Now here's your miracle: we can automate *creating* the `expect` script by using `autoexpect`. After starting an `autoexpect` session, all your interaction, and system responses, are saved in a file. The default filename is `script.exp`, so you

need to change the filename. The trick is to *not make a typo*! You cannot even use the backspace key because this keystroke too is saved. To show how this works, follow along through Listing 16-10. The task is to log in to a remote machine and run the `who` and `w` commands, and then log out. To begin, enter **autoexpect**, then, *without making a mistake*, interact with the application or system. When you are finished, press the Ctrl+D key sequence to exit the `autoexpect` session, and save the file as `script.exp`.

```
#!/usr/bin/expect -f
#
# This Expect script was generated by autoexpect on Tue
Jul 31 04:46:35 2007
# Expect and autoexpect were both written by Don Libes, NIST.
#
# Note that autoexpect does not guarantee a working script.  It
# necessarily has to guess about certain things.  Two reasons a script
# might fail are as follows:
#
# 1) timing - A surprising number of programs (rn, ksh, zsh, telnet,
# etc.) and devices discard or ignore keystrokes that arrive "too
# quickly" after prompts.  If you find your new script hanging up at
# one spot, try adding a short sleep just before the previous send.
# Setting "force_conservative" to 1 (see below) makes Expect do this
# automatically - pausing briefly before sending each character.  This
# pacifies every program I know of.  The -c flag makes the script do
# this in the first place.  The -C flag allows you to define a
# character to toggle this mode off and on.

set force_conservative 0  ;# set to 1 to force conservative mode even if
                      ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
             sleep .1
             exp_send -s -- $arg
     }
}

#
# 2) differing output - Some programs produce different output each time
# they run.  The "date" command is an obvious example.  Another is
# ftp, if it produces throughput statistics at the end of a file
# transfer.  If this causes a problem, delete these patterns or replace
# them with wildcards.  An alternative is to use the -p flag (for
# "prompt") which makes Expect only look for the last line of output
# (i.e., the prompt).  The -P flag allows you to define a character to
# toggle this mode off and on.
#
```

Listing 16-10 script.exp

```
# Read the man page for more info.
#
# -Don


set timeout -1
spawn $env(SHELL)
match_max 100000
expect -exact " \]0;root@localhost:/scripts
\[?1034h\[root@localhost scripts\]# "
send -- "telnet yogi\r"
expect -exact "telnet yogi\r
Trying 192.168.1.101...\r\r
Connected to yogi.\r\r
Escape character is '^\]'.\r\r
\r
\r
telnet (yogi.tampabay.rr.com)\r
\r\r
\r\r
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\r
\r
\rAIX Version 5\r
\r(C) Copyrights by IBM and by others 1982, 2000, 2005.\r
\rlogin: "
send -- "randy\r"
```

Listing 16-10 (*continued*)

```
expect -exact "randy\r
randy's Password: "
send -- "abc123\r"
expect -exact "\r
*******************************************************
**********************\r
*
*\r
*
*\r
*  Welcome to AIX Version 5.3!
*\r
*
*\r
*
*\r
*  Please see the README file in /usr/lpp/bos for
information pertinent to  *\r
*  this release of the AIX Operating System.
*\r
*
*\r
*
*\r
*******************************************************
**********************\r
Last unsuccessful login: Sun Jul 29 00:23:33 EDT 2007
on /dev/pts/1 from 192.168.1.102\r
Last login: Sun Jul 29 00:24:26 EDT 2007 on /dev/pts/1
from 192.168.1.102\r
\r
randy@/home/randy # "
send -- "who\r"
expect -exact "who\r
root         pts/0       Jul 26 05:19     (yogi)           \r
randy        pts/1       Jul 29 00:26     (192.168.1.102) \r
randy@/home/randy # "
send -- "w\r"
expect -exact "w\r
  12:26AM   up 2 days,  23:52,  2 users,  load average: 0.03, 0.06, 0.05\r
User     tty          login@       idle      JCPU      PCPU what\r
root     pts/0       Thu05AM      22:20        25         1 -ksh\r
randy    pts/1       12:26AM          0         0         0 w\r
randy@/home/randy # "
send -- "exit\r"
expect -exact "exit\r
Connection closed by foreign host.\r\r"
expect eof
```

Listing 16-10 (*continued*)

When you first look at the result, it's a bit overwhelming. Not to worry, we are going to drop about 90 percent of this file in the bit bucket. The trick with `expect` is *not to expect too much*. The lines of code we are interested in are highlighted in bold text in Listing 16-10.

Now we just need to `send` commands and `expect` a known reply. Follow through the shortened version of this `expect` script, as shown in Listing 16-11.

```
#!/usr/bin/expect -f
#

set force_conservative 0  ;# set to 1 to force conservative mode even if
                      ;# script wasn't run conservatively originally
if {$force_conservative} {
     set send_slow {1 .1}
     proc send {ignore arg} {
             sleep .1
             exp_send -s -- $arg
     }
}

set timeout -1
spawn $env(SHELL)
match_max 100000
send -- "telnet yogi\r"
expect "\rlogin: "
send -- "randy\r"
expect -exact "randy\r
randy's Password: "
send -- "abc123\r"
expect "randy@/home/randy # "
send -- "who\n"
expect "randy@/home/randy # "
send -- "w\r"
expect "randy@/home/randy # "
send -- "exit\r"
expect -exact "exit\r
Connection closed by foreign host.\r\r"
send -- "\r"
expect eof
```

Listing 16-11 expect script to remotely execute the who and w commands

The first thing to notice about Listing 16-11 is that we omitted the `-exact` switch on most of the `expect` statements. What we *expect* is just the command-line prompt. So, if you set the same `PS1` environment variable on all your machines, you will have the same prompt, as long as the host name is not part of the prompt. You can also set the `PS1` here in the `expect` script. You should use whatever prompt the server or application gives you if you do not set it in the `expect` script. I always have to

play around with `expect` a bit when I remove the unneeded replies. The output of executing the `expect` script in Listing 16-11 is shown in Listing 16-12.

```
[root@booboo scripts]# ./login_remotely.exp
spawn /bin/Bash
telnet yogi
[root@booboo scripts]# telnet yogi
Trying 192.168.1.101...
Connected to yogi.
Escape character is '^]'.
telnet (yogi.tampabay.rr.com)




AIX Version 5


(C) Copyrights by IBM and by others 1982, 2000, 2006.

login: randy
randy's Password:

*******************************************************************
*                                                                 *
*                                                                 *
*  Welcome to AIX Version 5.1!                                    *
*                                                                 *
*                                                                 *
*  Please see the README file in /usr/lpp/bos for
information pertinent to    *
*  this release of the AIX Operating System.                      *
*                                                                 *
*                                                                 *
*******************************************************************
Last unsuccessful login: Sun Jul 29 00:23:33 EDT 2007
on /dev/pts/1 from 192.168.1.102
Last login: Sun Jul 29 00:38:02 EDT 2007 on /dev/pts/1
from 192.168.1.102

randy@/home/randy # who
who
 root         pts/0       Jul 30 01:07     (192.168.1.100)
 randy        pts/1       Jul 30 04:15     (192.168.1.102)
randy@/home/randy # w
w
```

Listing 16-12 expect script to execute remote who and w commands in action

```
  04:15AM   up 4 days,   3:42,  2 users,  load average: 0.16, 0.05, 0.04
User     tty          login@       idle      JCPU      PCPU what
root     pts/0       01:07AM         40        17         1 -ksh
randy    pts/1       04:15AM          0         0         0 w
randy@/home/randy # exit
exit
Connection closed by foreign host.
[root@booboo scripts]#
[root@booboo scripts]# exit
exit
Script done on Wed 01 Aug 2007 08:35:54 AM EDT
```

Listing 16-12 (*continued*)

Play around with `expect` and `autoexpect` by first trying it with FTP. For more details on `expect`, study Chapter 8.

Checking if the HTTP Server/Application Is Working

Some applications use a web browser interface. For this type of application we can use a command-line browser, such as **linx**, to attempt to reach a specific URL, which in turn should bring up the specified application web page. The function shown in Listing 16-13 utilizes the `linx` command-line browser to check both the HTTP server and the web page presented by the specified URL, which is passed to the function in the `$1` argument.

```
check_HTTP_server ()
{
LINX="/usr/local/bin/lynx"  # Define the location of the linx program
URL=$1                      # Capture the target URL in the $1 position
URLFILE=/tmp/HTTP.$$        # Define a file to hold the URL output

#########################################

$LINX "$URL" > $URLFILE     # Attempt to reach the target URL

if (($? != 0))              # If the URL is unreachable - No Connection
then
     echo "\n$URL - Unable to connect\n"
     cat $URLFILE
else                        # Else the URL was found

     while read VER RC STATUS  # This while loop is fed from the bottom
                               # after the "done" using input redirection
     do
```

Listing 16-13 check_HTTP_server function

```
            case $RC in        # Check the return code in the $URLFILE

            200|401|301|302)   # These are valid return codes!

                               echo "\nHTTP Server is OK\n"
                               ;;
                           *)  # Anything else is not a valid return code

                               echo "\nERROR: HTTP Server Error\n"
                               ;;
            esac

      done < $URLFILE
fi

rm -f $URLFILE
}
```

Listing 16-13 (*continued*)

This is a nice function for checking the status of a web server and also to see if an application URL is accessible. You should test this function against doing the same task manually using a graphical browser. This has been tested on an application front-end, and it works as expected; however, a good test is recommended before implementing this, or any other code, in this book. You know all about the disclaimer stuff. (I am really not even here writing this book, or so the disclaimer says.)

What about Waiting for Something to Complete Executing?

If you are waiting on some processes to finish execution, `egrep` is a good option — for example, if you are running several backups, or **rsync** sessions, and you want to be notified when the processing is complete. One method is to execute the commands in the background, and save the PID of the last background process using the shell variable `$!`. The code snippet in Listing 16-14 builds an `egrep` statement using the saved PIDs.

```
EGREP_LIST=
THISPID=
# We have 7 filesystems to copy
for N in 1 2 3 4 5 6 7
do
   # Run each rsync session in the background
    rsync -avz /dba/oradata/data_0${N}/
```

Listing 16-14 Using egrep to monitor processes

```
$MACHINE:/dba/oradata/data_0${N} &
    THIS_PID=$!     # Save the last PID
    # Build an egrep list of PIDs
    if [ -z "$EGREP_LIST" ]
    then
         EGREP_LIST="$THIS_PID"
    else
        EGREP_LIST="${EGREP_LIST}|${THIS_PID}"
    fi
done

sleep 10  # Sleep a few seconds to let the process complete.

echo "\nRsync is running: -- [Start time: $date].\c"

REMAINING_PROC=$(ps -ef | grep "$EGREP_LIST" | grep -v grep \
                | awk '{print $2}' | wc -l)

# Print a dot every 60 seconds for feedback to the user

until (( $REMAING_PROC == 0 ))
do
      REMAINING_PROC=$(ps -ef | grep "$EGREP_LIST" | grep -v grep \
                      | awk '{print $1}' | wc -l)
      echo ".\c"
      sleep 60
done

echo "\nCOMPLETE: Rsync copies completed $(date)\n"
```

Listing 16-14 (*continued*)

This code in Listing 16-14 starts seven `rsync` copy sessions in the background, specified by ending the `rsync` commands with an `&`, ampersand. Next we save the last background PID using the `THIS_PID=$!` variable assignment. As we gather each background PID, we build an `egrep` statement. We sleep for 10 seconds to let the `rsync` sessions start up, and then we start monitoring all the processes at once using `egrep`. When the process ID count reaches zero, we display the completion to the end user.

Other Things to Consider

As with any code that is written, it can always be improved. Each of the functions and code segments presented in this chapter are just that, code segments. When you are monitoring applications, code like this is only one part of a much bigger shell script, or at least it should be. The monitoring should start at the lowest level, which is sending a `ping` to the application host to ensure that the machine is powered on and booted. Then we apply more layers as we try to build a script that will allow us to debug the

problem. I have presented only a few ideas; it is your job to work out the details for your environment.

Proper echo Usage

Also remember the proper shell usage of `echo` when we use the backslash operators:

```
echo "\nHello World\n"
```

- For Bourne and Bash shell — `echo -e "\nHello World\n"`
- For Korn shell — `echo "\nHello World\n"`

Application APIs and SNMP Traps

Most enterprise management tools come with application programming interfaces (APIs) for the more common commercial applications; however, we sometimes must write shell scripts to fill in the gaps. This is where SNMP traps come in. Because the enterprise management tool *should* support SNMP traps, the APIs allow the application to be monitored using the SNMP MIB definitions on both the management server and the client system.

When an enterprise management tool supports SNMP traps, you can usually write your own shell scripts that can use the tool's MIB and SNMP definitions to get the message out from your own shell scripts. As an example, the command shown here utilizes a well-known monitoring tool's SNMP and MIB data to allow a trap to be sent:

```
/usr/local/bin/trapclient $MON_HOST $MIB_NUM $TRAP_NUM $TRAP_TEXT
```

In this command the `MON_HOST` variable represents the enterprise management workstation. The `MIB_NUM` variable represents the specific code for the MIB parameter. The `TRAP_NUM` variable represents the specific trap code to send, and the `TRAP_TEXT` is the text that is sent with the trap. This type of usage varies depending on the monitoring tool that you are using. At any rate, there are techniques that allow you to write shell scripts to send traps. The methods vary, but the basic syntax remains the same for SNMP.

Summary

This is one of those chapters where it is useless to write a bunch of shell scripts. I tried to show some of the techniques of monitoring applications and application processes, but the details are too varied to cover in a single chapter. I have laid down a specific process that you can utilize to build a very nice tool to monitor your systems and applications. Always start with a `ping`! If the box is unpingable, your first job is to get the machine booted or to call hardware support.

In the next steps you have several options, including interacting with the application, as we did with an SQL+query of an Oracle database and the `expect` scripts. We also covered monitoring specific processes that are a little flaky and die every once in a while. I have two applications that I have to monitor this way, and I have not had even one phone call since I put this tool in place. The key is to keep the business in business, and the best way to do that is to be very proactive. This is where good monitoring and control shell scripts make you look like gold.

Remember: no one *ever* notices an application except when it is down!

In the next chapter we will cover monitoring a system for full filesystems. Methods covered include a typical percentage method to the number of megabytes free, for very large filesystems. Chapter 17, ''Filesystem Monitoring,'' ends with a shell script that does auto detection using the filesystem size to set the monitoring method.

Lab Assignments

1. Write an `expect` script to log in to a remote machine and run the `keyit` script so that you have the `ssh` encryption key pairs configured in both directions. You should be able to `ssh` between machines without a password.
2. Rewrite the `keyit` shell script using `expect`.
3. If you have an application to monitor, write a shell script to tackle the task.

PART

III

Scripts for Systems Administrators

CHAPTER 17

Filesystem Monitoring

The most common monitoring task is monitoring for full filesystems. On different flavors of UNIX the monitoring techniques are the same, but the commands and fields in the output vary slightly. This difference is due to the fact that command syntax and the output columns vary depending on the UNIX system.

We are going to step through the entire process of building a script to monitor filesystem usage and show the philosophy behind the techniques used. In scripting this solution we will cover six monitoring techniques, starting with the most basic monitoring — percentage of space used in each filesystem.

The next part will build on this original base code and add *exceptions* capability allowing an override of the script's set threshold for a filesystem to be considered full. The third part will deal with *large filesystems*, which are typically considered to be a filesystems larger than 2 gigabytes, 2 GB. This script modification will use the megabytes (MB)-of-free-space technique.

The fourth part will add exception capability to the MB-of-free-space method. The fifth part in this series combines both the percentage-of-used-space and MB-of-free-space techniques with an added *auto-detect* feature to decide how to monitor each filesystem. Regular filesystems will be monitored with percent used and large filesystems as MB of free space, and, of course, with the exception capability. The sixth and final script will allow the filesystem monitoring script to run on AIX, Linux, HP-UX, OpenBSD, or Solaris without any further modification.

Syntax

Our first task, as usual, is to get the required command syntax. For this initial example, we are going to monitor an AIX system. (HP-UX, Linux, OpenBSD, and Solaris will be covered later.) The command syntax to look at the filesystems in kilobytes, KB, or 1024-byte blocks, is `df -k` in AIX.

Let's take a look at the output of the `df -k` command on an AIX 5L machine:

```
Filesystem    1024-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4            32768     16376   51%     1663    11% /
/dev/hd2          1212416     57592   96%    36386    13% /usr
/dev/hd9var         53248     30824   43%      540     5% /var
/dev/hd3           106496     99932    7%      135     1% /tmp
/dev/hd1             4096      3916    5%       25     3% /home
/proc                   -         -    -        -     -  /proc
/dev/hd10opt       638976     24456   97%    15457    10% /opt
/dev/scripts_lv    102400     95264    7%      435     2% /scripts
/dev/cd0           656756         0  100%   328378   100% /cdrom
```

The fields in the command output that we are concerned about are column 1, the `Filesystem` device; column 4, the `%Used`; and `Mounted on` in column 7. There are at least two reasons that we want both the filesystem device and the mount point. The first reason is to know if it is an NFS mounted filesystem. This first column will show the NFS server name as part of the device definition if it is NFS mounted. The second reason is that we will not want to monitor a mounted CD/DVD-ROM. A CD/DVD-ROM will always show that it is 100 percent used because it is mounted as read-only and you cannot write to it (I know, CD-RW/DVD-RW drives, but these are still not the norm in most business environments, and because we are not trying to write to this type of device, we will ignore it).

As you can see in the bottom row of the preceding output, the `/cdrom` mount point does indeed show that it is 100 percent utilized. We want to omit this from the output along with the column heading at the top line. The first step is to show everything except for the column headings. We can use the following syntax:

```
df -k | tail +2
```

This delivers the following output without the column headings:

```
/dev/hd4            32768     16376   51%     1663    11% /
/dev/hd2          1212416     57592   96%    36386    13% /usr
/dev/hd9var         53248     30824   43%      540     5% /var
/dev/hd3           106496     99932    7%      135     1% /tmp
/dev/hd1             4096      3916    5%       25     3% /home
/proc                   -         -    -        -     -  /proc
/dev/hd10opt       638976     24456   97%    15457    10% /opt
/dev/scripts_lv    102400     95264    7%      435     2% /scripts
/dev/cd0           656756         0  100%   328378   100% /cdrom
```

This output looks a bit better, but we still have a couple of things we are not interested in. The `/cdrom` is at 100 percent all of the time, and the `/proc` mount point has no values, just hyphens. The `/proc` filesystem is new to AIX 5L (it used to be hidden), and because it has no values, we want to eliminate it from our output. Notice the device, in column 1, for the CD-ROM is `/dev/cd0`. This is what we want to use

as a tag to pattern match on instead of the mount point because it may at some point be mounted somewhere else, for example `/mnt`. We may also have devices `/dev/cd1` and `/dev/cd2`, too, if not now perhaps in the future. This, too, is easy to take care of, though. We can expand on our command statement to exclude both lines from the output with one **egrep** statement, as in the following:

```
df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc'
```

In this statement we used the `egrep` command with a `-v` switch. The `-v` switch means to show everything *except* what it patterned matched on. The `egrep` is used for extended regular expressions; in this case, we want to exclude two rows of output. To save an extra `grep` statement, we use `egrep` and enclose what we are pattern matching on within single tic marks, `' '`, and separate each item in the list with a pipe symbol, `|`. The following two commands are equivalent:

```
df -k | tail +2 | grep -v '/dev/cd[0-9]' | grep -v '/proc'

df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc'
```

Also notice in both statements the pattern match on the CD-ROM devices. The `grep` and `egrep` statements will match devices `/dev/cd0` up through the last device, for example `/dev/cd24`, using `/dev/cd[0-9]` as the pattern match.

Using `egrep` saves a little bit of code, but both commands produce the same output, shown here:

```
/dev/hd4            32768     16376   51%     1663    11% /
/dev/hd2          1212416     57592   96%    36386    13% /usr
/dev/hd9var         53248     30864   43%      539     5% /var
/dev/hd3           106496     99932    7%      134     1% /tmp
/dev/hd1             4096      3916    5%       25     3% /home
/dev/hd10opt       638976     24456   97%    15457    10% /opt
/dev/scripts_lv    102400     95264    7%      435     2% /scripts
```

In this output we have all of the rows of data we are looking for; however, we have some extra columns that we are not interested in. Now let's extract out the columns of interest, 1, 4, and 7. Extracting the columns is easy to do with an **awk** statement. The **cut** command will work, too. Using an `awk` statement is the cleanest method, and the columns are selected using the positional parameters, or columns, `$1, $2, $3, . . . , $n`. As we keep building this command statement, we add in the `awk` part of the command:

```
df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
 | awk '{print $1, $4, $7}'
```

First, notice that we extended our command onto the next line with the backslash character, `\`. This convention helps with the readability of the script. In the `awk` part of the statement, we placed a comma and a space after each field, or positional parameter.

The comma and space are needed to ensure that the fields remain separated by at least one space. This command statement leaves the following output:

```
/dev/hd4 51% /
/dev/hd2 96% /usr
/dev/hd9var 43% /var
/dev/hd3 7% /tmp
/dev/hd1 5% /home
/dev/hd10opt 97% /opt
/dev/scripts_lv 7% /scripts
```

For ease of working with our command output, we can write it to a file and work with the file. In our script we can define a file and point to the file with a variable. The following code will work:

```
WORKFILE="/tmp/df.work"   # df output work file
>$WORKFILE                # Initialize the file to zero size
```

Before we go any further, we also need to decide on a trigger threshold for when a filesystem is considered full, and we want to define a variable for this, too. For our example, we will say that anything over 85 percent is considered a full filesystem, and we will assign this value to the variable `FSMAX`:

```
FSMAX="85"
```

From these definitions we are saying that any monitored filesystem that has used *more than* 85 percent of its capacity is considered *full*. Our next step is to loop through each row of data in our output file. Our working data file is `/tmp/df.work`, which is pointed to by the `$WORKFILE` variable, and we want to compare the second column, the percentage used for each filesystem, to the `$FSMAX` variable, which we initialized to 85. But we still have a problem; the `$WORKFILE` entry still has a `%`, percent sign, and we need an integer value to compare to the `$FSMAX` value. We will take care of this conversion with a **sed** statement. We use `sed` for character substitution and manipulation and, in this case, character removal. The `sed` statement is just before the numerical comparison in a loop that follows. Please study Listing 17-1, and pay close attention to the bold text.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_AIX.ksh
# AUTHOR: Randy Michael
# DATE: 08-22-2007
# REV: 1.1.P
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as "exceeding" the FSMAX value.
```

Listing 17-1 fs_mon_AIX.ksh shell script

```
#     A message is displayed for all "full" filesystems.
#
# REV LIST:
#
# set -n # Uncomment to check script syntax without any execution
# set -x # Uncomment to debug this script
#
##### DEFINE FILES AND VARIABLES HERE ####

FSMAX="85"              # Max. FS percentage value

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
>$OUTFILE               # Initialize to empty
THISHOST=`hostname` # Hostname of this machine

######## START OF MAIN ##############

# Get the data of interest by stripping out /dev/cd#,
# /proc rows and keeping columns 1, 4 and 7

df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
      | awk '{print $1, $4, $7}' > $WORKFILE

# Loop through each line of the file and compare column 2

while read FSDEVICE FSVALUE FSMOUNT
do
      FSVALUE=$(echo $FSVALUE | sed s/\%//g) # Remove the % sign
      typeset -i FSVALUE
      if [ $FSVALUE -gt $FSMAX ]
      then
          echo "$FSDEVICE mounted on $FSMOUNT is ${FSVALUE}%" \
                >> $OUTFILE
      fi
done < $WORKFILE # Feed the while loop from the bottom!!

if [[ -s $OUTFILE ]]
then
      echo "\nFull Filesystem(s) on $THISHOST\n"
      cat $OUTFILE
      print
fi
```

Listing 17-1 (*continued*)

The items highlighted in the script are all important to note. We start with getting the hostname of the machine. We want to know which machine the report is relating to. Next we load the `$WORKFILE` with the filesystem data. Just before the numerical test is made we remove the `%` sign and then typeset the variable, `FSVALUE`, to be an integer. Then we make the over-limit test, and if the filesystem in the current loop iteration has exceeded the threshold of 85 percent, we append a message to the `$OUTFILE`. Notice that the `while` loop is getting its data from the bottom of the loop, after `done`. This is the fastest technique to process a file line by line without using file descriptors. After processing the entire file we test to see if the `$OUTFILE` exists and is greater than zero bytes in size. If it has data, we print an output header, with a newline before and after, and display the `$OUTFILE` file followed by another blank line. In Listing 17-1 we used an assortment of commands to accomplish the same task in a different way — for example, using `VARIABLE=$(command)` and `VARIABLE=`command`` to execute a command and assign the command's output to a variable, and the use of the `echo` and `print` commands. In both instances the result is the same. We again see there is not just one way to accomplish the same task.

We also want to explain how we use `sed` for character substitution. The basic syntax of the `sed` statement is as follows:

```
sed s/current_string/new_string/g [filename]
```

The filename is optional, and we need to use the output from a command, so we are going to use the following `sed` command syntax:

```
command | sed s/current_string/new_string/g
```

When we extend our command and pipe the last pipe's output to the `sed` statement, we get the following:

```
df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
      | awk '{print $1, $4, $7}' | sed s/\%//g
```

The point to notice about the preceding `sed` part of the command statement is that we had to *escape* the `%`, percent sign, with a `\`, backslash. This is because `%` is a special character in UNIX. To remove the special meaning from, or to escape, the function, we use a backslash before the `%` sign. This lets us literally use `%` as a text character as opposed to its system/shell-defined value or function (`%` is the modulo math operator). See Listing 17-2.

```
Full Filesystem(s) on yogi

/dev/hd2 mounted on /usr is 96%
/dev/hd10opt mounted on /opt is 97%
```

Listing 17-2 Full filesystem script in action

This script is okay, but we really are not very concerned about these filesystems being at these current values. The reason is that `/usr` and `/opt`, on AIX, should remain

static in size. The /usr filesystem is where the OS and application code for the system reside, and /opt, new to AIX 5L version 5.1, as a mount point, is where Linux and many GNU programs' code resides. So how can we give an exception to these two filesystems?

Adding Exceptions Capability to Monitoring

The fs_mon_AIX.ksh script is great for what it is written for, but in the real world we always have to make exceptions and we always strive to cover all of the ''gotchas'' when writing shell scripts. Now we are going to add the capability to override the default FSMAX threshold. Because we are going to be able to override the default, it would be really nice to be able to either raise or lower the threshold for individual filesystems.

To accomplish this script tailoring, we need a data file to hold our exceptions. We want to use a data file so that people are not editing the shell script every time a filesystem threshold is to be changed. To make it simple, let's use the file /usr/local/bin/exceptions, and point to the file with the EXCEPTIONS variable. Now that we know the name of the file, we need a format for the data in the $EXCEPTIONS file. A good format for this data file is the /mount_point and a NEW_MAX%. We will also want to ignore any entry that is commented out with a pound sign, #. This may sound like a lot, but it is really not too difficult to modify the script code and add a function to read the exceptions file. Now we can set it up.

The Exceptions File

To set up our exceptions file, we can always use /usr/local/bin, or your favorite place, as a *bin directory*. To keep things nice we can define a bin directory for the script to use. This is a good thing to do in case the files need to be moved for some reason. The declarations are shown here:

```
BINDIR="/usr/local/bin"
EXCEPTIONS="${BINDIR}/exceptions"
```

Notice the curly braces around the BINDIR variable when it is used to define the EXCEPTIONS file. This is always a good thing to do if the variable name will have a character that is not associated with the variable's name, next to the variable name without a space. Otherwise, an error may occur that could be very hard to find! Notice the difference in usage shown here.

```
EXCEPTIONS="$BINDIR/exceptions"
```

versus

```
EXCEPTIONS="${BINDIR}/exceptions"
```

In all of the ways there are to set up exceptions capability, grep seems to come up the most. Please *avoid the grep mistake!* The two fields in the $EXCEPTIONS file are the /mount_point and the NEW_MAX% value. The first instinct is to grep on the /mount_point, but what if /mount_point is root, /? If you grep on /, and the / entry is not the first entry in the exceptions file, you will get a pattern match on the wrong entry, and thus use the wrong $NEW_MAX% in deciding if the / mount point is full. In fact, if you grep on / in the exceptions file, you will get a match on the first entry in the file every time. Listing 17-3 shows some *wrong code* that made this very grep mistake.

```
while read FSDEVICE FSVALUE FSMOUNT
do
     # Strip out the % sign if it exists
     FSVALUE=$(echo $FSVALUE | sed s/\%//g) # Remove the % sign
     if [[ -s $EXCEPTIONS ]] # Do we have a non-empty file?
     then # Found it!
        # Look for the current $FSMOUNT value in the file
              #WRONG CODE, DON'T MAKE THIS MISTAKE USING grep!!
        cat $EXCEPTIONS | grep -v "^#" | grep $FSMOUNT \
                        | read FSNAME NEW_MAX
        if [ $? -eq 0 ] # Found it!
        then
            if [[ $FSNAME = $FSMOUNT ]] # Sanity check
            then
                 NEW_MAX=$(echo $NEW_MAX | sed s/\%//g)
                 if [ $FSVALUE -gt $NEW_MAX ] # Use the new $NEW_MAX
                 then
                     echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                             >> $OUTFILE
                 fi
            elif [ $FSVALUE -gt $FSMAX ] # Not in $EXCEPTIONS file
            then
                 echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                       >> $OUTFILE
            fi
        fi
     else # No exceptions file...use script default
             if [ $FSVALUE -gt $FSMAX ]
             then
                  echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                        >> $OUTFILE
             fi
     fi
done < $WORKFILE
```

Listing 17-3 The wrong way to use grep

The code in Listing 17-3 really looks as if it should work, and it does *some of the time*! To get around the error that grep introduces, we need to just set up a function that will look for an exact match for each entry in the exceptions file.

Now let's look at this new technique. We want to write two functions: one to load the $EXCEPTIONS file data without the comment lines (the lines beginning with a #) while omitting all blank lines into a data file, and one to search through the exceptions file data and perform the tests.

This is a simple one-line function to load the $EXCEPTIONS file data into the $DATA_EXCEPTIONS file:

```
function load_EXCEPTIONS_file
{
# Ignore any line that begins with a pound sign, #
# and also remove all blank lines

cat $EXCEPTIONS |  grep -v "^#" | sed /^$/d > $DATA_EXCEPTIONS
}
```

In the preceding function, we use the ^, caret character, along with grep -v to ignore any line beginning with a #, pound sign. We also use the ^$ with the sed statement to remove any blank lines and then redirect output to a data file, which is pointed to by the $DATA_EXCEPTIONS variable. After we have the exceptions file data loaded, we have the following check_exceptions function that will look in the $DATA_EXCEPTIONS file for the current mount point and, if found, will check the $NEW_MAX value to the system's reported percent-used value. The function will present back to the script a return code relating to the result of the test.

```
function check_exceptions
{
# set -x # Uncomment to debug this function

while read FSNAME NEW_MAX # Feeding data from Bottom of Loop!!!
do
        if [[ $FSNAME = $FSMOUNT ]] # Correct /mount_point?
        then    # Get rid of the % sign, if it exists!
                NEW_MAX=$(echo $NEW_MAX | sed s/\%//g)

                if [ $FSVALUE -gt $NEW_MAX ]
                then #  Over Limit...Return a "0", zero
                        return 0 # FOUND OVER LIMIT - Return 0
                else #  Found in the file but is within limits
                        return 2 # Found OK
                fi
        fi

done < $DATA_EXCEPTIONS # Feed from the bottom of the loop!!

return 1 # Not found in File
}
```

This check_exceptions function is called during each loop iteration in the main script and returns a 0, zero, if the /mount_point is found to exceed the NEW_MAX%. It

will return a 2 if the mount point was found to be okay in the exceptions data file, and return a 1, one, if the mount point was not found in the $DATA_EXCEPTIONS file. There are plenty of comments throughout this new script, so feel free to follow through and pick up a few pointers — pay particular attention to the bold text in Listing 17-4.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_AIX_except.ksh
# AUTHOR: Randy Michael
# DATE: 08-22-2007
# REV: 2.1.P
#
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as "exceeding" the FSMAX value.
#     A message is displayed for all "full" filesystems.
#
# PLATFORM: AIX
#
# REV LIST:
#         08-23-2007 - Randy Michael
#         Added code to override the default FSMAX script threshold
#         using an "exceptions" file, defined by the $EXCEPTIONS
#         variable, that list /mount_point and NEW_MAX%
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this script
#
##### DEFINE FILES AND VARIABLES HERE ####

FSMAX="85"              # Max. FS percentage value

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
>$OUTFILE               # Initialize to empty
BINDIR="/usr/local/bin" # Local bin directory
THISHOST=`hostname`     # Hostname of this machine

EXCEPTIONS="${BINDIR}/exceptions" # Overrides $FSMAX
DATA_EXCEPTIONS="/tmp/dfdata.out" # Exceptions file w/o #, comments


####### DEFINE FUNCTIONS HERE #####

function load_EXCEPTIONS_file
```

Listing 17-4 fs_mon_AIX_except.ksh shell script

```
{
# Ignore any line that begins with a pound sign, #
# and omit all blank lines

cat $EXCEPTIONS |  grep -v "^#" | sed /^$/d > $DATA_EXCEPTIONS
}

###################################

function check_exceptions
{
# set -x # Uncomment to debug this function

while read FSNAME NEW_MAX # Feeding data from Bottom of Loop!!!
do
        if [[ $FSNAME = $FSMOUNT ]] # Correct /mount_point?
        then    # Get rid of the % sign, if it exists!
                NEW_MAX=$(echo $NEW_MAX | sed s/\%//g)

                if [ $FSVALUE -gt $NEW_MAX ]
                then #  Over Limit...Return a "0", zero
                        return 0 # FOUND OUT OF LIMITS - Return 0
                fi
        fi

done < $DATA_EXCEPTIONS # Feed from the bottom of the loop!!

return 1 # Not found in File
}

#############################################
######## START OF MAIN #############
###################################

# If there is an exceptions file...load it...

[[ -s $EXCEPTIONS ]] && load_EXCEPTIONS_file

# Get the data of interest by stripping out /dev/cd#,
# /proc rows and keeping columns 1, 4, and 7

df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
   | awk '{print $1, $4, $7}' > $WORKFILE

# Loop through each line of the file and compare column 2

while read FSDEVICE FSVALUE FSMOUNT
```

Listing 17-4 (*continued*)

```
do   # Feeding the while loop from the BOTTOM!!

     # Strip out the % sign if it exists
     FSVALUE=$(echo $FSVALUE | sed s/\%//g) # Remove the % sign
     if [[ -s $EXCEPTIONS ]] # Do we have a non-empty file?
     then # Found it!

        # Look for the current $FSMOUNT value in the file
        # using the check_exceptions function defined above.

        check_exceptions
        RC=$? # Get the return code from the function
        if [ $RC -eq 0 ] # Found Exceeded in Exceptions File!!
        then
            echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                 >> $OUTFILE
        elif [ $RC -eq 1 ] # Not found in exceptions, use defaults
        then
             if [ $FSVALUE -gt $FSMAX ] # Use Script Default
             then
                  echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                       >> $OUTFILE
             fi
        fi
     else # No exceptions file use the script default
             if [ $FSVALUE -gt $FSMAX ] # Use Script Default
             then
                  echo "$FSDEVICE mount on $FSMOUNT is ${FSVALUE}%" \
                       >> $OUTFILE
             fi
     fi
done < $WORKFILE # Feed the while loop from the bottom...

# Display output if anything is exceeded...

if [[ -s $OUTFILE ]]
then
      echo "\nFull Filesystem(s) on ${THISHOST}\n"
      cat $OUTFILE
      print
fi
```

Listing 17-4 (*continued*)

Notice in the script that we never acted on the return code `2`. Because the mount point is found to be okay, there is nothing to do except to check the next mount point. The `/usr/local/bin/exceptions` file will look something like the file shown in Listing 17-5.

```
# FILE: "exceptions"
# This file is used to override the $FSMAX
# value in the filesystem monitoring script
# fs_mon_except.ksh.  The syntax to override
# is a /mount-point and a NEW_MAX%:
# EXAMPLE:
# /opt 97
# OR
# /usr 96%
# All lines beginning with a # are ignored as well as
# the % sign, if you want to use one...

/opt 96%
/usr 97
/ 50%
```

Listing 17-5 Example exceptions file

When we execute the `fs_mon_AIX_except.ksh` script, with the exceptions file entries from Listing 17-5, the output looks like the following on `yogi` (see Listing 17-6).

```
Full Filesystem(s) on yogi

/dev/hd4 mount on / is 51%
/dev/hd10opt mount on /opt is 97%
```

Listing 17-6 Full filesystem on yogi script in action

Notice that we added a limit for the root filesystem, `/`, and set it to 50 percent, and also that this root entry is not at the top of the list in the exceptions file shown in Listing 17-5 so we have solved the `grep` problem. You should be able to follow the logic through the preceding code to see that we met all of the goals we set out to accomplish in this section. There are plenty of comments to help you understand each step.

Are we finished? Not by a long shot! What about monitoring large filesystems? Using the percentage of filesystem space used is excellent for regular filesystems, but if you have a 10 GB or 100 GB filesystem and it is at 90 percent, you still have 1 GB or 10 GB of free space, respectively. Even at 99 percent you have 100 MB to 1 GB of space left. For large filesystems we need another monitoring method.

Using the MB-of-Free-Space Method

Sometimes a percentage is just not accurate enough to get the detailed notification that is desired. For these instances, and in the case of large filesystems, we can use `awk` on the `df -k` command output to extract the KB of Free Space field and compare this to a

threshold trigger value, specified in either KB or MB. We are going to modify both of the scripts we have already written to use the KB of Free Space field. Please understand that I could just use `df -m` or `df -g` to specify `df` command output in MB or GB of space. However, if I did that, you would not get a chance to do a little math in a shell script. Just keep these two commands in mind for the Lab Assignments at the end of this chapter.

Remember our previous `df -k` command output:

```
Filesystem    1024-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4            32768     16376   51%     1663    11% /
/dev/hd2          1212416     57592   96%    36386    13% /usr
/dev/hd9var         53248     30824   43%      540     5% /var
/dev/hd3           106496     99932    7%      135     1% /tmp
/dev/hd1             4096      3916    5%       25     3% /home
/proc                   -         -    -        -     -  /proc
/dev/hd10opt       638976     24456   97%    15457    10% /opt
/dev/scripts_lv    102400     95264    7%      435     2% /scripts
/dev/cd0           656756         0  100%   328378   100% /cdrom
```

Instead of the fourth field of the percentage used, we now want to extract the third field with the 1024-blocks, or KB of `Free` space. When someone is working with the script it is best that an easy and familiar measurement is used; the most common is MB of free space. To accomplish this we will need to do a little math, but this is just to have a more familiar measurement to work with. As before, we are going to load the command output into the `$WORKFILE`, but this time we extract columns `$1`, `$3`, and `$7`:

```
df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
   | awk '{print $1, $3, $7}' > $WORKFILE
```

We also need a new threshold variable to use for this method. The `MIN_MB_FREE` variable sounds good. But what is an appropriate value to set the threshold? In this example, we are going to use 50 MB, although it could be any value:

```
MIN_MB_FREE="50MB"
```

Notice that we added `MB` to the value. We will remove this later, but it is a good idea to add the measurement type just so that the ones who follow will know that the threshold is in MB. Remember that the system is reporting in KB, so we have to multiply our 50 MB times 1024 to get the actual value that is equivalent to the system-reported measurement. We also want to strip out the `MB` letters and typeset the `MIN_MB_FREE` variable to be an integer. In the compound statement that follows, we take care of everything except typesetting the variable:

```
(( MIN_MB_FREE = $(echo $MIN_MB_FREE | sed s/MB//g) * 1024 ))
```

The order of execution for this compound command is as follows: First, the innermost `$()` command substitution is executed, which replaces the letters `MB`, if they exist, with

null characters. Next is the evaluation of the math equation and assignment of the result to the MIN_MB_FREE variable. Equating MIN_MB_FREE may seem a little confusing, but remember that the system is reporting in KB so we need to get to the same power of 2 to also report in 1024-byte blocks. Other than these small changes, the script is the same as the original, as shown in Listing 17-7.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_AIX_MBFREE.ksh
# AUTHOR: Randy Michael
# DATE: 08-22-2007
# REV: 1.5.P
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as "exceeding" the FSMAX value.
#     A message is displayed for all "full" filesystems.
#
# REV LIST:
#          Randy Michael - 08-27-2007
#          Changed the code to use MB of free space instead of
#          the %Used method.
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this script
#
##### DEFINE FILES AND VARIABLES HERE ####

MIN_MB_FREE="50MB"     # Min. MB of Free FS Space

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
>$OUTFILE       # Initialize to empty
THISHOST=`hostname`   # Hostname of this machine

######## START OF MAIN ##############

# Get the data of interest by stripping out /dev/cd#,
# /proc rows and keeping columns 1, 4 and 7

df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
   | awk '{print $1, $3, $7}' > $WORKFILE

# Format Variables
(( MIN_MB_FREE = $(echo $MIN_MB_FREE | sed s/MB//g) * 1024 ))

# Loop through each line of the file and compare column 2
```

Listing 17-7 fs_mon_AIX_MBFREE.ksh shell script

```
while read FSDEVICE FSMB_FREE FSMOUNT
do
      FSMB_FREE=$(echo $FSMB_FREE | sed s/MB//g) # Remove the "MB"
      if (( FSMB_FREE < MIN_MB_FREE ))
      then
          (( FS_FREE_OUT = FSMB_FREE / 1000 ))
          echo "$FSDEVICE mounted on $FSMOUNT only has \
      ${FS_FREE_OUT}MB Free" >> $OUTFILE
      fi

done < $WORKFILE  # Feed the while loop from the bottom!!

if [[ -s $OUTFILE ]]
then
      echo "\nFull Filesystem(s) on $THISHOST\n"
      cat $OUTFILE
      print
fi
```

Listing 17-7 (*continued*)

The `fs_mon_AIX_MBFREE.ksh` script in Listing 17-7 is a good start. Listing 17-8 shows this shell script in action.

```
Full Filesystem(s) on yogi

/dev/hd4 mounted on /only has 16MB Free
/dev/hd9var mounted on /var only has 30MB Free
/dev/hd1 mounted on /home only has 3MB Free
/dev/hd10opt mounted on /opt only has 24MB Free
```

Listing 17-8 Shell script in action

This output in Listing 17-8 is padded by less than 1 MB due to the fact that we divided the KB free column by 1,000 for the output, measured in MB. If the exact KB is needed, the division by 1,000 can be omitted. What about giving this script exception capability to raise or lower the threshold, as we did for the percentage technique? We already have the percentage script with the `check_exception` function so that we can modify this script and function to use the same technique of parsing through the `$EXCEPTIONS` file.

Using MB of Free Space with Exceptions

To add exception capability to the `fs_mon_AIX_MBFREE.ksh` shell script, we will again need a function to perform the search of the `$EXCEPTIONS` file, if it exists. This

time we will add some extras. We may have the characters `MB` in our data, so we need to allow for this. We also need to test for null characters, or no data, and remove all blank lines in the exception file. The easiest way to use the function is to supply an appropriate return code back to the calling script. We will set up the function to return `1`, one, if the mount point is found to be out of limits in the `$DATA_EXCEPTIONS` file. It will return `2` if the `/mount_point` is in the exceptions data file but is *not* out of limits. The function will return `3` if the mount point is not found in the exceptions data file. This will allow us to call the function to check the exception file, and based on the return code, we make a decision in the main body of the script.

We already have experience modifying the script to add exception capability, so this should be a breeze, right? When we finish, the exception modification will be intuitively obvious.

Because we are going to parse through the exceptions file, we need to run a sanity check to see if someone made an incorrect entry and placed a colon, `:`, in the file intending to override the limit on an NFS mounted filesystem. This error should never occur if the local mount point is used, but because a tester I know did so, I now check and correct the error, if possible. We just `cut` out the second field using the colon, `:`, as a delimiter. Listing 17-9 shows the modified `check_exceptions` function. Check out the highlighted parts in particular.

```
function check_exceptions
{
# set -x # Uncomment to debug this function

while read FSNAME FSLIMIT
do
    # Do an NFS sanity check
    echo $FSNAME | grep ":" >/dev/null \
         && FSNAME=$(echo $FSNAME | cut -d ":" -f2)

    # Make sure we do not have a null value
    if [[ ! -z "$FSLIMIT" && "$FSLIMIT" != '' ]]
    then
        (( FSLIMIT = $(echo $FSLIMIT | sed s/MB//g) * 1024 ))
        if [[ $FSNAME = $FSMOUNT ]]
        then
            # Get rid of the "MB" if it exists
            FSLIMIT=$(echo $FSLIMIT | sed s/MB//g)
            if (( FSMB_FREE < FSLIMIT ))
            then
                return 1 # Found out of limit
            else
                return 2 # Found OK
            fi
        fi
    fi
```

Listing 17-9 New check_exceptions function

```
done < $DATA_EXCEPTIONS # Feed the loop from the bottom!!!

return 3 # Not found in $EXCEPTIONS file
}
```

Listing 17-9 (*continued*)

A few things to notice in this function are the NFS and null value sanity checks, as well as the way that we feed the `while` loop from the bottom, after the `done` statement. First, the sanity checks are very important to guard against incorrect NFS entries and blank lines, or null data, in the exceptions file. For the NFS colon check we use the double ampersands, `&&`, as opposed to the `if...then...` statement. It works the same but is cleaner in this type of test. The other point is the null value check. We check for both a zero-length variable and null data. The double ampersands, `&&`, are called a logical AND function, and the double pipes, `||`, are a logical OR function. In a logical AND, `&&`, all of the command statements must be true for the return code of the entire statement to be 0, zero. In a logical OR, `||`, at least one statement must be true for the return code to be 0, zero. When a logical OR receives the first true statement in the test list it will immediately exit the test, or command statement, with a return code of 0, zero. Both are good to use, but some people find it hard to follow. Next we test for an empty/null variable:

```
if [[ ! -z "$FSLIMIT" && "$FSLIMIT" != '' ]]
```

Note that in the null sanity check there are double quotes around both of the `$FSLIMIT` variables, `"$FSLIMIT"`. These are required! If you omit the double quotes and the variable is actually null, the test will fail and a shell error message is generated and displayed on the terminal. It never hurts to add double quotes around a variable, and sometimes it is required.

For the `while` loop we go back to our favorite loop structure. Feeding the `while` loop from the bottom, after `done`, is the fastest way to loop through a file line by line without using file descriptors. With the sanity checks complete, we just compare some numbers and give back a return code to the calling shell script. Please pay attention to the boldface code in Listing 17-10.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_AIX_MB_FREE_except.ksh
# AUTHOR: Randy Michael
# DATE: 08-22-2007
# REV: 2.1.P
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as "exceeding" the FSMAX value.
#     A message is displayed for all "full" filesystems.
```

Listing 17-10 fs_mon_AIX_MB_FREE_except.ksh shell script

```
#
# PLATFORM: AIX
#
# REV LIST:
#          Randy Michael - 08-27-2007
#          Changed the code to use MB of free space instead of
#          the %Used method.
#
#          Randy Michael - 08-27-2007
#          Added code to allow you to override the set script default
#          for MIN_MB_FREE of FS Space
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this script
#
##### DEFINE FILES AND VARIABLES HERE ####

MIN_MB_FREE="50MB"     # Min. MB of Free FS Space

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
>$OUTFILE       # Initialize to empty
EXCEPTIONS="/usr/local/bin/exceptions" # Override data file
DATA_EXCEPTIONS="/tmp/dfdata.out" # Exceptions file w/o # rows
THISHOST=`hostname`   # Hostname of this machine

######## DEFINE FUNCTIONS HERE ########

function check_exceptions
{
# set -x # Uncomment to debug this function

while read FSNAME FSLIMIT
do
    # Do an NFS sanity check
    echo $FSNAME | grep ":" >/dev/null \
         && FSNAME=$(echo $FSNAME | cut -d ":" -f2)
    if [[ ! -z "$FSLIMIT" && "$FSLIMIT" != '' ]] # Check for empty/null
    then
        (( FSLIMIT = $(echo $FSLIMIT | sed s/MB//g) * 1024 ))
        if [[ $FSNAME = $FSMOUNT ]]
        then
            # Get rid of the "MB" if it exists
            FSLIMIT=$(echo $FSLIMIT | sed s/MB//g)
            if (( FSMB_FREE < FSLIMIT )) # Numerical Test
            then
                return 1 # Found out of limit
```

Listing 17-10 (*continued*)

```
            else
                return 2 # Found OK
            fi
        fi
    fi
done < $DATA_EXCEPTIONS # Feed the loop from the bottom!!!

return 3 # Not found in $EXCEPTIONS file
}

######## START OF MAIN #############

# Load the $EXCEPTIONS file if it exists

if [[ -s $EXCEPTIONS ]]
then
    # Ignore all lines beginning with a pound sign, #
    # and omit all blank lines

    cat $EXCEPTIONS | grep -v "^#" | sed /^$/d > $DATA_EXCEPTIONS
fi

# Get the data of interest by stripping out /dev/cd#,
# /proc rows and keeping columns 1, 4 and 7

df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
   | awk '{print $1, $3, $7}' > $WORKFILE

# Format Variables for the proper MB value
(( MIN_MB_FREE = $(echo $MIN_MB_FREE | sed s/MB//g) * 1024 ))

# Loop through each line of the file and compare column 2

while read FSDEVICE FSMB_FREE FSMOUNT
do
    if [[ -s $EXCEPTIONS ]]
    then
      check_exceptions
      RC="$?"  # Check the Return Code!
      if (( RC == 1 )) # Found out of exceptions limit
      then
          (( FS_FREE_OUT = $FSMB_FREE / 1000 ))
           echo "$FSDEVICE mounted on $FSMOUNT only has\
 ${FS_FREE_OUT}MB Free" \
               >> $OUTFILE
      elif (( RC == 2 )) # Found in exceptions to be OK
      then # Just a sanity check - We really do nothing here...
           # The colon, :, is a NO-OP operator in KSH
```

Listing 17-10 (*continued*)

```
            : # No-Op - Do Nothing!

        elif (( RC == 3 )) # Not found in the exceptions file
        then
            FSMB_FREE=$(echo $FSMB_FREE | sed s/MB//g) # Remove the "MB"
            if (( FSMB_FREE < MIN_MB_FREE ))
            then
                (( FS_FREE_OUT = FSMB_FREE / 1000 ))
                echo "$FSDEVICE mounted on $FSMOUNT only has\
 ${FS_FREE_OUT}MB Free" >> $OUTFILE
            fi
        fi
      else # No Exceptions file use the script default
        FSMB_FREE=$(echo $FSMB_FREE | sed s/MB//g) # Remove the "MB"
        if (( FSMB_FREE < MIN_MB_FREE ))
        then
            (( FS_FREE_OUT = FSMB_FREE / 1000 ))
            echo "$FSDEVICE mounted on $FSMOUNT only has\
 ${FS_FREE_OUT}MB Free" >> $OUTFILE
        fi
      fi
done < $WORKFILE

if [[ -s $OUTFILE ]]
then
        echo "\nFull Filesystem(s) on $THISHOST\n"
        cat $OUTFILE
        print
fi
```

Listing 17-10 (*continued*)

The script in Listing 17-10 is good, and we have covered all of the bases, right? If you want to stop here, you will be left with an incomplete picture of what we can accomplish. There are several more things to consider, and, of course, there are many more ways to do any of these tasks, and no single one is *correct*. Let's consider mixing the filesystem-percentage-used and the MB-of-free-filesystem-space techniques. With a mechanism to auto-detect the way we select the usage, the filesystem monitoring script could be a much more robust tool — and a *must-have* tool where you have a mix of regular and large filesystems to monitor.

Percentage Used — MB Free and Large Filesystems

Now we're talking! Even if most of your filesystems are large file enabled or are just huge in size, the small ones will still kill you in the end. For a combination of small and large filesystems, we need a mix of both the percent-used and MB-of-free-space

techniques. For this combination to work, we need a way to auto-detect the *correct usage*, which we still need to define. There are different combinations of these auto-detect techniques that can make the monitoring work differently. For the large filesystems we want to use the MB of free space, and for regular filesystems we use the percentage method.

We need to define a *trigger* that allows for this free space versus percentage monitoring transformation. The trigger value will vary by environment, but this example uses 1 GB as the transition point from percentage used to MB of free space. Of course, the value should be more like 4–6 GB, but we need an example. We also need to consider how the `$EXCEPTIONS` file is going to look. Options for the exceptions file are a combined file or two separate files, one for percentage used and one for MB free. The obvious choice is one combined file. What are combined entries to look like? How are we going to handle the wrong entry *type*? The entries need to conform to the specific test type the script is looking for. The best way to handle this is to require that either a `%` or `MB` be added as a suffix to each new entry in the exceptions file. With the `MB` or `%` suffix we could override not only the triggering level, but also the testing method! If an entry has only a number without the suffix, this exceptions file entry will be ignored and the shell script's default values will be used. This suffix method is the most flexible, but it, too, is prone to mistakes in the exceptions file. For the mistakes, we need to test the entries in the exceptions to see that they conform to the standard that we have decided on.

The easiest way to create this new, more robust script is to take large portions of the previous scripts and convert them into functions. We can simply insert the word *function* followed by a function name and enclose the code within curly braces — for example, `function test_function {function_code}`. Or if you prefer the GNU function method, we can use this example: `test_function () {function_code}`. The only difference between the two function methods is that one uses the word *function* to define the function, whereas the other just adds a set of parentheses after the function's name. But adding the parentheses is okay even using the `function` operator. When we use functions, it is easy to set up a logical framework from which to call the functions. It is always easiest to set up the framework first and then fill in the middle. The *logic code* for this script will look like Listing 17-11.

```
load_File_System_data > $WORKFILE
if EXCEPTIONS_FILE exists and is > 0 size
then
    load_EXCEPTIONS_FILE_data
fi
while read $WORKFILE, which has the filesystem data
do
    if EXCEPTIONS data was loaded
    then
         check_exceptions_file
         RC=Get Return code back from function
```

Listing 17-11 Logic code for a large and small filesystem free-space script

```
          case $RC in
             1) Found exceeded by % method
             2) Found out-of-limit by MB Free method
             3) Found OK in exceptions file by a testing method
             4) Not found in exceptions file
          esac
    else # No exceptions file
        Use script defaults to compare
    fi
done

if we have anything out of limits
then
    display_output
fi
```

Listing 17-11 (*continued*)

This is very straightforward and easy to do with functions. From this logical description we already have the main body of the script written. Now we just need to modify the `check_exceptions` function to handle both types of data and create the `load_FS_data`, `load_EXCEPTIONS_data`, and `display_output` functions. For this script we are also going to do things a little differently because this *is* a learning process. As we all know, there are many ways to accomplish the same task in UNIX; shell scripting is a prime example. To make our scripts a little easier to read at a glance, we are going to change how we do numeric test comparisons. We currently use the standard bracketed test functions with the numeric operators, `-lt`, `-le`, `-eq`, `-ne`, `-ge`, and `-gt`:

```
if [ $VAR1 -gt $VAR2 ]
```

We are now going to use the bracketed tests for character strings only and do all of our numerical comparisons with the double parentheses method:

```
if (( VAR1 > VAR2 ))
```

The operators for this method are <, <=, = =, ! =, >=, and >. These test operators are for numerical data only. When we make this small change, it makes the script much easier to follow because we know immediately that we are dealing with either numeric data or a character string, without knowing much at all about the data being tested. Notice that we did *not* reference the variables with a `$` (dollar sign) for the numeric tests. The `$` omission is not the only difference, but it is the most obvious. The `$` is omitted because it is implied that anything that is not numeric is a variable. Other things to look for in this script are compound tests, math and math within tests, the use of curly braces with variables, `$VAR1 MB`, a no-op using a `:` (colon), data validation, error checking, and error notification. These variables are a lot to look for, but you can learn much from studying the script shown in Listing 17-12.

Just remember that all functions must be defined before they can be used! Failure to define functions is the most common mistake when working with them. The second

most common mistake has to do with *scope*. Scope deals with *where* a variable and its value are known to other scripts and functions. *Top level down* is the best way to describe where scope lies. The basic rules say that *all* of a shell script's variables are known to the *internal*, lower-level, functions, but *none* of the function's variables are known to any *higher-calling* script or function, thus the top level down definition. We will cover a method called a co-process of dealing with scope in Chapter 10, ''Process Monitoring and Enabling Pre-Processing, Startup, and Post-Processing Events.''

So, in this script the `check_exceptions` function will use the *global* script's variables, which are known to all of the functions, and the function will, in turn, reply with a return code, as we defined in the logic flow of Listing 17-11. Scope is a very important concept, as is the placement of the function in the script. The comments in this script are extensive, so please study the code and pay particular attention to the boldface text.

NOTE Remember that you have to define a function before you can use it.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_AIX_PC_MBFREE_except.ksh
# AUTHOR: Randy Michael
# DATE: 08-22-2007
# REV: 4.3.P
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as "exceeding" the MAX_PERCENT value.
#     A message is displayed for all "full" filesystems.
#
# PLATFORM: AIX
#
# REV LIST:
#       Randy Michael - 08-27-2007
#       Changed the code to use MB of free space instead of
#       the %Used method.
#
#       Randy Michael - 08-27-2007
#       Added code to allow you to override the set script default
#       for MIN_MB_FREE of FS Space
#
#       Randy Michael - 08-28-2007
#       Changed the code to handle both %Used and MB of Free Space.
#       It does an "auto-detection" but has override capability
#       of both the trigger level and the monitoring method using
#       the exceptions file pointed to by the $EXCEPTIONS variable
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this script
#
```

Listing 17-12 fs_mon_AIX_PC_MBFREE_except.ksh shell script

```
##### DEFINE FILES AND VARIABLES HERE ####

MIN_MB_FREE="100MB"    # Min. MB of Free FS Space
MAX_PERCENT="85%"      # Max. FS percentage value
FSTRIGGER="1000MB"     # Trigger to switch from % Used to MB Free

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
>$OUTFILE               # Initialize to empty
EXCEPTIONS="/usr/local/bin/exceptions" # Override data file
DATA_EXCEPTIONS="/tmp/dfdata.out" # Exceptions file w/o # rows
EXCEPT_FILE="N"         # Assume no $EXCEPTIONS FILE
THISHOST=`hostname`     # Hostname of this machine

###### FORMAT VARIABLES HERE ######

# Both of these variables need to be multiplied by 1024 blocks
(( MIN_MB_FREE = $(echo $MIN_MB_FREE | sed s/MB//g) * 1024 ))
(( FSTRIGGER = $(echo $FSTRIGGER | sed s/MB//g)  * 1024 ))

####### DEFINE FUNCTIONS HERE ########

function check_exceptions
{
# set -x # Uncomment to debug this function

while read FSNAME FSLIMIT
do
    IN_FILE="N"  # If found in file, which test type to use?

    # Do an NFS sanity check and get rid of any ":".
    # If this is found it is actually an error entry
    # but we will try to resolve it.  It will
    # work only if it is an NFS cross mount to the same
    # mount point on both machines.
    echo $FSNAME | grep ':' >/dev/null \
         && FSNAME=$(echo $FSNAME | cut -d ':' -f2)

    # Check for empty and null variable
    if [[ ! -z "$FSLIMIT" && "$FSLIMIT" != '' ]]
    then
        if [[ $FSNAME = $FSMOUNT ]] # Found it!
        then
            # Check for "MB" Characters...Set IN_FILE=MB
          echo $FSLIMIT | grep MB >/dev/null && IN_FILE="MB" \
                && (( FSLIMIT = $(echo $FSLIMIT \
                      | sed s/MB//g) * 1024 ))
```

Listing 17-12 (*continued*)

```
            # check for "%" Character...Set IN_FILE=PC, for %
            echo $FSLIMIT | grep "%" >/dev/null && IN_FILE="PC" \
                 && FSLIMIT=$(echo $FSLIMIT | sed s/\%//g)

            case $IN_FILE in
            MB) # Use Megabytes of free space to test
                # Up-case the characters, if they exist
                FSLIMIT=$(echo $FSLIMIT | tr '[a-z]' '[A-Z]')
                # Get rid of the "MB" if it exists
                FSLIMIT=$(echo $FSLIMIT | sed s/MB//g)
                # Test for blank and null values
                if [[ ! -z $FSLIMIT && $FSLIMIT != '' ]]
                then
                   # Test for a valid filesystem "MB" limit
                   if (( FSLIMIT >= 0 && FSLIMIT < FSSIZE ))
                   then # Check the limit
                      if (( FSMB_FREE < FSLIMIT ))
                      then
                         return 1 # Found out of limit
                                  # using MB Free method
                      else
                         return 3 # Found OK
                      fi
                   else
                     echo "\nERROR: Invalid filesystem MAX for\
$FSMOUNT - $FSLIMIT"
                      echo "       Exceptions file value must be\
less than or"
                      echo "       equal to the size of the filesystem\
measured"
                      echo "       in 1024 bytes\n"
                   fi
                else
                   echo "\nERROR: Null value specified in exceptions\
file"
                   echo "       for the $FSMOUNT mount point.\n"
                fi
                ;;
            PC) # Use the Percent used method to test
                # Strip out the % sign if it exists
                PC_USED=$(echo $PC_USED | sed s/\%//g)
                # Test for blank and null values
                if [[ ! -z $FSLIMIT && $FSLIMIT != '' ]]
                then
                   # Test for a valid percentage, i.e. 0-100
                   if (( FSLIMIT >= 0 && FSLIMIT <= 100 ))
                   then
                      if (( PC_USED > FSLIMIT ))
```

Listing 17-12 (*continued*)

```
                    then
                       return 2 # Found exceeded by % Used method
                    else
                       return 3 # Found OK
                    fi
                 else
                    echo "\nERROR: Invalid percentage for\
 $FSMOUNT - $FSLIMIT"
                    echo "       Exceptions file values must be"
                    echo "       between 0 and 100%\n"
                 fi
              else
                 echo "\nERROR: Null value specified in exceptions"
                 echo "        file for the $FSMOUNT mount point.\n"
              fi
              ;;
           N)  # Test type not specified in exception file, use default

              # Inform the user of the exceptions file error...
              echo "\nERROR: Missing testing type in exceptions file"
              echo "       for the $FSMOUNT mount point.  A \"%\" or"
              echo "       \"MB\" must be a suffix to the numerical"
              echo "       entry.  Using script default values...\n"

              # Method Not Specified - Use Script Defaults
              if (( FSSIZE >= FSTRIGGER ))
              then # This is a "large" filesystem
                  if (( FSMB_FREE < MIN_MB_FREE ))
                  then
                       return 1 # Found out of limit using MB Free
                  else
                       return 3 # Found OK
                  fi
              else # This is a standard filesystem
                  PC_USED=$(echo $PC_USED | sed s/\%//g) #Remove the %
                  FSLIMIT=$(echo $FSLIMIT | sed s/\%//g) #Remove the %
                  if (( PC_USED > FSLIMIT ))
                  then
                      return 2 # Found exceeded by % Used method
                  else
                      return 3 # Found OK
                  fi
              fi
              ;;
           esac
        fi
     fi
done < $DATA_EXCEPTIONS # Feed the loop from the bottom!!!
```

Listing 17-12 (*continued*)

```
return 4 # Not found in $EXCEPTIONS file
}

###################################

function display_output
{
if [[ -s $OUTFILE ]]
then
      echo "\nFull Filesystem(s) on $THISHOST\n"
      cat $OUTFILE
      print
fi
}

###################################

function load_EXCEPTIONS_data
{
# Ignore any line that begins with a pound sign, #
# and omit all blank lines

cat $EXCEPTIONS |  grep -v "^#" | sed /^$/d > $DATA_EXCEPTIONS
}

###################################

function load_FS_data
{
   df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
         | awk '{print $1, $2, $3, $4, $7}' > $WORKFILE
}

###################################
######### START OF MAIN #############
###################################

load_FS_data

# Do we have a nonzero size $EXCEPTIONS file?

if [[ -s $EXCEPTIONS ]]
then # Found a nonempty $EXCEPTIONS file

    load_EXCEPTIONS_data
    EXCEP_FILE="Y"
fi
```

Listing 17-12 (*continued*)

```
while read FSDEVICE FSSIZE FSMB_FREE PC_USED FSMOUNT
do
     if [[ $EXCEP_FILE = "Y" ]]
     then
         check_exceptions
         CE_RC="$?" # Check Exceptions Return Code (CE_RC)

         case $CE_RC in
         1) # Found exceeded in exceptions file by MB Method
            (( FS_FREE_OUT = FSMB_FREE / 1000 ))
            echo "$FSDEVICE mounted on $FSMOUNT has ${FS_FREE_OUT}MB\
 Free" >> $OUTFILE
          ;;
         2) # Found exceeded in exceptions file by %Used method
            echo "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                  >> $OUTFILE
          ;;
         3) # Found OK in exceptions file
            : # NO-OP Do Nothing
          ;;

         4) # Not found in exceptions file - Use Script Default Triggers
            if (( FSSIZE >= FSTRIGGER ))
            then # This is a "large" filesystem
              # Remove the "MB", if it exists
              FSMB_FREE=$(echo $FSMB_FREE | sed s/MB//g)
              typeset -i FSMB_FREE
              if (( FSMB_FREE < MIN_MB_FREE  ))
              then
                (( FS_FREE_OUT = FSMB_FREE / 1000 ))
                echo "$FSDEVICE mounted on $FSMOUNT has\
 ${FS_FREE_OUT}MB Free" >> $OUTFILE
              fi
            else # This is a standard filesystem
                PC_USED=$(echo $PC_USED | sed s/\%//g)
                MAX_PERCENT=$(echo $MAX_PERCENT | sed s/\%//g)
                if (( PC_USED > MAX_PERCENT ))
                then
                    echo "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                          >> $OUTFILE
                fi
            fi
          ;;
         esac
```

Listing 17-12 (*continued*)

```
     else # NO $EXCEPTIONS FILE USE DEFAULT TRIGGER VALUES
          if (( FSSIZE >= FSTRIGGER  ))
          then # This is a "large" filesystem - Use MB Free Method
            FSMB_FREE=$(echo $FSMB_FREE | sed s/MB//g) # Remove the "MB"
            if (( FSMB_FREE < MIN_MB_FREE ))
            then
              (( FS_FREE_OUT = FSMB_FREE / 1000 ))
              echo "$FSDEVICE mounted on $FSMOUNT has\
 ${FS_FREE_OUT}MB Free" >> $OUTFILE
            fi
          else # This is a standard filesystem - Use % Used Method
              PC_USED=$(echo $PC_USED | sed s/\%//g)
              MAX_PERCENT=$(echo $MAX_PERCENT | sed s/\%//g)
              if (( PC_USED > MAX_PERCENT ))
              then
                  echo "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                        >> $OUTFILE
              fi
          fi
     fi
done < $WORKFILE # Feed the while loop from the bottom!!!

display_output

# End of Script
```

Listing 17-12 (*continued*)

In the script shown in Listing 17-12, we made tests to confirm the data's integrity and for mistakes in the exceptions file (of course, we can go only so far with mistakes!). The reason is that we made the exceptions file more complicated to use. Two of my testers consistently had reverse logic on the MB free override option of the script by thinking *greater than* instead of *less than*. From this confusion, a new exceptions file was created that explained what the script is looking for and gave example entries. Of course, all of these lines begin with a pound sign, #, so they are ignored when data is loaded into the `$DATA_EXCEPTIONS` file. Listing 17-13 shows the exceptions file that worked best with the testers.

```
# FILE: "exceptions"
#
# This file is used to override both the default
# trigger value in the filesystem monitoring script
```

Listing 17-13 Example exceptions file

```
# fs_mon_except.ksh, but also allows overriding the
# monitoring technique used, i.e. Max %Used and
# minimum MB of filesystem space.  The syntax to
# override is a /mount-point and a trigger value.
#
# EXAMPLES:
#
# /usr 96%  # Flag anything ABOVE 96%
# OR
# /usr 50MB # Flag anything BELOW 50 Megabytes
#
# All lines beginning with a # are ignored.
#
# NOTE: All Entries MUST have either "MB" or
#       "%" as a suffix!!!  Or else the script
#       defaults are used.  NO SPACES PLEASE!
#
/opt 95%
/ 50%
/usr 70MB
```

Listing 17-13 (*continued*)

The requirement for either `%` or `MB` does help keep the entry mistakes down. In case mistakes are made, the error notifications seemed to get these cleared up very quickly — usually after an initial run.

Are we finished with filesystem monitoring? No way! What about the other four operating systems that we want to monitor? We need to be able to execute this script on AIX, Linux, HP-UX, OpenBSD, and SunOS without the need to change the script on each platform.

Running Filesystem Scripts on AIX, Linux, HP-UX, OpenBSD, and Solaris

Can we run the filesystem scripts on various UNIX flavors? You bet! Running our filesystem monitoring script is very easy because we used functions for most of the script. We are going to use the same script, but instead of hard-coding the loading of the filesystem data, we need to use variables to point to the correct OS syntax and columns of interest. Now we need a new function that will determine which flavor of UNIX we are running. Based on the OS, we set up the command syntax and command

output columns of interest that we want to extract, and load the filesystem data for this particular OS. For OS determination we just use the **uname** command. `uname`, and the `get_OS_info` function, will return the resident operating system, as shown in Table 17-1.

Table 17-1 uname Command and Function Results

OPERATING SYSTEM	COMMAND RESULT	FUNCTION RESULT
Linux	Linux	LINUX
AIX	AIX	AIX
HP-UX	HP-UX	HP-UX
OpenBSD	OpenBSD	OPENBSD
Solaris	SunOS	SUNOS

For the function's output, we want to use all *uppercase* characters, which makes testing much easier. In the following function please notice we use the `typeset` function to ensure that the result is in all uppercase characters:

```
function get_OS_info
{
# For a few commands it is necessary to know the OS to
# execute the proper command syntax.  This will always
# return the Operating System in UPPERCASE characters

typeset -u OS  # Use the UPPERCASE values for the OS variable
OS='uname'     # Grab the Operating system, i.e. AIX, HP-UX
print $OS      # Send back the UPPERCASE value
}
```

To use the `get_OS_info` function, we can assign it to a variable using command substitution, use the function directly in a command statement, or redirect the output to a file. For this script modification, we are going to use the `get_OS_info` function directly in a `case` statement. Now we need five different `load_FS_data` functions, one for each of the five operating systems, and that is all the modification that is needed. Each of the `load_FS_data` functions will be unique in command syntax and the column fields to extract from the `df` command output, as well as the devices to exclude from testing. Because we wrote this script using functions, we will replace the original `load_FS_data` script, at the `Beginning of Main`, with a `case` statement that utilizes the `get_OS_info` function. The `case` statement will execute the appropriate `load_FS_data` function. Listing 17-14 shows how to test the OS flavor and execute the correct function.

```
case $(get_OS_info) in
   AIX)    # Load filesystem data for AIX
           load_AIX_FS_data
      ;;
   HP-UX) # Load filesystem data for HP-UX
           load_HP_UX_FS_data
      ;;
   LINUX) # Load filesystem data for Linux
           load_LINUX_FS_data
      ;;
   OPENBSD) # Load filesystem data for OpenBSD
           load_OPENBSD_FS_data
      ;;
   SUNOS) # Load filesystem data for Solaris
           load_Solaris_FS_data
      ;;
   *)      # Unsupported in script
           echo "\nUnsupported Operating System...EXITING\n"
           exit 1
esac
```

Listing 17-14 Operating system test

Listing 17-14 shows simple enough replacement code. In this `case` statement we either execute one of the functions or exit if the OS is not in the list with a return code of `1`, one. In these functions we will want to pay attention to the command syntax for each operating system, the columns to extract for the desired data, and the file systems that we want to ignore, if any. There is an `egrep`, or extended `grep`, in each statement that will allow for exclusions to the filesystems that are monitored. A typical example of this is a CD-ROM. Remember that a CD-ROM will always show that it is 100 percent utilized because it is mounted as read-only and you cannot write to it. Also, some operating systems list *mount points* that are really not meant to be monitored, such as `/proc` in AIX5L.

Command Syntax and Output Varies between Operating Systems

The command syntax and command output varies between UNIX operating systems. To get a similar output of the AIX `df -k` command on other operating systems, we sometimes have to change the command syntax. We also extract data from different columns in the output. The command syntax and resulting output for AIX, Linux, HP-UX, OpenBSD, and SUN/Solaris are listed in the text that follows as well as the columns of interest for each operating system output. Notice that HP-UX uses the `bdf` command instead of `df -k`. Please review Tables 17-2 through 17-11.

Table 17-2 AIX df -k Command Output

FILESYSTEM	1024-BLOCKS	FREE	%USED	IUSED	%IUSED	MOUNTED ON
/dev/hd4	32768	16376	51%	1663	11%	/
/dev/hd2	1212416	57592	96%	36386	13%	/usr
/dev/hd9var	53248	30824	43%	540	5%	/var
/dev/hd3	106496	99932	7%	135	1%	/tmp
/dev/hd1	4096	3916	5%	25	%	/home
/proc						/proc
/dev/hd10opt	638976	24456	97%	15457	10%	/opt
/dev/scripts_lv	102400	95264	7%	435	2%	/scripts
/dev/cd0	656756	0	100%	328378	100%	/cdrom

Table 17-3 AIX df -k Output Columns of Interest

DF OUTPUT COLUMNS	COLUMN CONTENTS
Column 1	The filesystem device name, `Filesystem`
Column 2	The size of the filesystem in 1024 blocks, `1024-blocks`
Column 3	The kilobytes of free filesystem space, `Free`
Column 4	The percentage of used capacity, `%Used`
Column 7	The mount point of the filesystem, `Mounted on`

Table 17-4 Linux df -k Command Output

FILESYSTEM	1K-BLOCKS	USED	AVAILABLE	USE%	MOUNTED ON
/dev/hda16	101089	32949	62921	34%	/
/dev/hda5	1011928	104	960420	0%	/backup
/dev/hda1	54416	2647	48960	5%	/boot
/dev/hda8	202220	13	191767	0%	/download
/dev/hda9	202220	1619	190161	1%	/home
/dev/hda12	124427	19	117984	0%	/tmp
/dev/hda6	1011928	907580	52944	94% /usr	—
/dev/hda10	155545	36	147479	0%	/usr/local
/dev/hda11	124427	29670	88333	25%/var	

Table 17-5 Linux df -k Output Columns of Interest

DF OUTPUT COLUMNS	COLUMN CONTENTS
Column 1	The filesystem device name, `Filesystem`
Column 2	The size of the filesystem in 1k-blocks, `1k-blocks`
Column 4	The kilobytes of free filesystem space, `Available`
Column 5	The percentage of used capacity, `Use%`
Column 6	The mount point of the filesystem, `Mounted on`

Table 17-6 OpenBSD df -k Command Output

FILESYSTEM	1K-BLOCKS	USED	AVAIL	CAPACITY	MOUNTED ON
/dev/wd0a	4918134	39672	4633506	1%	/
/dev/wd0i	4399006	10844	4168212	0%	/backup
/dev/wd0e	489550	2	465072	0%	/home
/dev/wd0h	2458254	12	2335330	0%	/scripts
/dev/wd0g	9840894	6	9348844	0%	/tmp
/dev/wd0d	9840984	516170	8832680	6%	/usr
/dev/wd0f	49166	7666	39042	16%	/var

Table 17-7 OpenBSD df -kOutput Columns of Interest

DF OUTPUT COLUMNS	COLUMN CONTENTS
Column 1	The filesystem device name, `Filesystem`
Column 2	The size of the filesystem in 1k-blocks, `1k-blocks`
Column 4	The kilobytes of free filesystem space, `Avail`
Column 5	The percentage of used capacity, `Capacity`
Column 6	The mount point of the filesystem, `Mounted on`

Table 17-8 SUN/Solaris df -k Command Output

FILESYSTEM	KBYTES	USED	AVAIL	CAPACITY	MOUNTED ON
/dev/dsk/c0d0s0	192423	18206	154975	11%	
/dev/dsk/c0d0s6	1015542	488678	465932	52%	/usr
/proc	0	0	0	0%	/proc

(*continued*)

Table 17-8 (*continued*)

FILESYSTEM	KBYTES	USED	AVAIL	CAPACITY	MOUNTED ON
Fd	0	0	0	0%	/dev/fd
Mnttab	0	0	0	0%	/etc/mnttab
/dev/dsk/c0d0s3	96455	5931	80879	7%	/var
Swap	554132	0	55413	0%	/var/run
/dev/dsk/c0d0s5	47975	1221	41957	3%	/opt
Swap	554428	296	554132	1%	/tmp
/dev/dsk/c0d0s7	1015542	1	954598	1%	/export/home
/dev/dsk/c0d0s1	375255	214843	122887	64%	/usr/openwin

Table 17-9 Sun/Solaris df -k Output Columns of Interest

DF OUTPUT COLUMNS	COLUMN CONTENTS
Column 1	The filesystem device name, `Filesystem`
Column 2	The size of the filesystem in 1k-blocks, `kbytes`
Column 4	The kilobytes of free filesystem space, `avail`
Column 5	The percentage of used capacity, `capacity`
Column 6	The mount point of the filesystem, `Mounted on`

Table 17-10 HP-UX bdf Command Output

FILESYSTEM	KBYTES	USED	AVAIL	%USED	MOUNTED ON
/dev/vg00/lvol3	151552	89500	58669	60%	/
/dev/vg00/lvol1	47829	24109	18937	56%	/stand
/dev/vg00/lvol9	1310720	860829	422636	67%	/var
/dev/vg00/lvol8	972800	554392	392358	59%	/usr
/dev/vg13/lvol1	4190208	1155095	2850597	29%	/u2
/dev/vg00/lvol7	102400	4284	92256	4%	/tmp
/dev/vg00/lvol13	2039808	1664073	352294	83%	/test2
/dev/vg00/lvol6	720896	531295	177953	75%	/opt
/dev/vg00/lvol5	409600	225464	176663	56%	/home

Table 17-11 HP-UX bdf Output Columns of Interest

DF OUTPUT COLUMNS	COLUMN CONTENTS
Column 1	The filesystem device name, `Filesystem`
Column 2	The size of the filesystem in 1k-blocks, `kbytes`
Column 4	The kilobytes of free filesystem space, `avail`
Column 5	The percentage of used capacity, `%used`
Column 6	The mount point of the filesystem, `Mounted on`

Now that we know how the commands and output vary between operating systems, we can take this into account when creating the shell functions to load the correct filesystem data for each system. Note in each of the following functions that one or more filesystems or devices are set to be ignored, which is specified by the `egrep` part of the statement:

```
####################################

function load_AIX_FS_data
{
   df -k | tail +2 | egrep -v '/dev/cd[0-9]|/proc' \
         | awk '{print $1, $2, $3, $4, $7}' > $WORKFILE
}

####################################

function load_HP_UX_FS_data
{
   bdf | tail +2 | egrep -v '/mnt/cdrom' \
       | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################

function load_LINUX_FS_data
{
   df -k | tail +2 | egrep -v '/mnt/cdrom'\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################

function load_OpenBSD_FS_data
{
   df -k | tail +2 | egrep -v '/mnt/cdrom'\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}
```

```
###################################

function load_Solaris_FS_data
{
   df -k | tail +2 | egrep -v '/dev/fd|/etc/mnttab|/proc'\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}
```

Each UNIX system is different, and these functions may need to be modified for your particular environment. The script modification to execute on all of the five operating systems includes entering the functions into the top part of the script, where functions are defined, and to replace the current `load_FS_data` function with a `case` statement that utilizes the `get_OS_info` function. This is an excellent example of how using functions can make life doing modifications much easier.

Programming a Shell-Neutral Script

What is the primary issue when executing a shell script in `sh`, `ksh`, and `Bash` environments? The `echo` command! Yep, I like to use the backslash operators for cursor control (`\n, \c, \t, \b`, and so on), and if the executing shell is not taken into consideration, the resulting output shows the cursor control operators as plain text. In Bourne and Bash shells, to use the backslash operators, the `echo -e` syntax must be used. The `case` statement to select the correct `echo` command is shown in Listing 17-15.

```
###### SHELL SPECIFIC VARIABLES ######

# Set the correct usage for the echo command for found $SHELL

case $SHELL in
*/bin/Bash) ECHO="echo -e"
            ;;
 */bin/ksh) ECHO="echo"
            ;;
  */bin/sh) ECHO="echo -e"
            ;;
         *) ECHO="echo"
            ;;
esac
```

Listing 17-15 Using a case statement to use the echo command correctly

In the shell script, whenever an `echo` is needed, the script syntax uses `$ECHO`, and the proper command usage is automatically used.

These scripts were written in Korn shell (`ksh`) to illustrate using different commands. Some systems' shells do not support the `print` command except `ksh`. The *final* script (it is never a final script!) will look like the following code, shown in Listing 17-16. Please scan through the boldface text in detail.

```
#!/usr/bin/ksh
#
# SCRIPT: fs_mon_ALL_OS.ksh
# AUTHOR: Randy Michael
# DATE: 09-25-2007
# REV: 6.0.P
#
# PURPOSE: This script is used to monitor for full filesystems,
#     which are defined as exceeding. the MAX_PERCENT value.
#     A message is displayed for all .full. filesystems.
#
# PLATFORM: AIX, Linux, HP-UX, OpenBSD, and Solaris
#
# REV LIST:
#       Randy Michael - 08-27-2007
#       Changed the code to use MB of free space instead of
#       the %Used method.
#
#       Randy Michael - 08-27-2007
#       Added code to allow you to override the set script default
#       for MIN_MB_FREE of FS Space
#
#       Randy Michael - 08-28-2007
#       Changed the code to handle both %Used and MB of Free Space.
#       It does an .auto-detection. but has override capability
#       of both the trigger level and the monitoring method using
#       the exceptions file pointed to by the $EXCEPTIONS variable
#
#       Randy Michael - 08-28-2007
#       Added code to allow this script to be executed on
#       AIX, Linux, HP-UX, and Solaris
#
#       Randy Michael . 09=25=2007
#       Added code for OpenBSD support
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this script
#
##### DEFINE FILES AND VARIABLES HERE ####

MIN_MB_FREE="100MB"    # Min. MB of Free FS Space
MAX_PERCENT="85%"      # Max. FS percentage value
FSTRIGGER="1000MB"     # Trigger to switch from % Used to MB Free

WORKFILE="/tmp/df.work" # Holds filesystem data
>$WORKFILE              # Initialize to empty
OUTFILE="/tmp/df.outfile" # Output display file
```

Listing 17-16 fs_mon_ALL_OS.ksh shell script

```
>$OUTFILE           # Initialize to empty
EXCEPTIONS="/usr/local/bin/exceptions" # Override data file
DATA_EXCEPTIONS="/tmp/dfdata.out" # Exceptions file w/o # rows
EXCEPT_FILE="N"        # Assume no $EXCEPTIONS FILE
THISHOST=`hostname`    # Hostname of this machine

###### FORMAT VARIABLES HERE ######

# Both of these variables need to be multiplied by 1024 blocks
(( MIN_MB_FREE = $(echo $MIN_MB_FREE | sed s/MB//g) * 1024 ))
(( FSTRIGGER = $(echo $FSTRIGGER | sed s/MB//g)  * 1024 ))

###### SHELL SPECIFIC VARIABLES ######

# Set the correct usage for the echo command for found $SHELL

case $SHELL in
*/bin/Bash) ECHO="echo -e"
            ;;
 */bin/ksh) ECHO="echo"
            ;;
  */bin/sh) ECHO="echo -e"
            ;;
         *) ECHO="echo"
            ;;
esac

#######################################
####### DEFINE FUNCTIONS HERE ########
#######################################

function get_OS_info
{
# For a few commands it is necessary to know the OS and its level
# to execute the proper command syntax.  This will always return
# the OS in UPPERCASE

typeset -u OS   # Use the UPPERCASE values for the OS variable
OS=`uname`   # Grab the Operating system, i.e. AIX, HP-UX
print $OS    # Send back the UPPERCASE value
}

###################################

function check_exceptions
{
# set -x # Uncomment to debug this function
```

Listing 17-16 (*continued*)

```
while read FSNAME FSLIMIT
do
    IN_FILE="N"

    # Do an NFS sanity check and get rid of any .:..
    # If this is found it is actually an error entry
    # but we will try to resolve it.  It will only
    # work if it is an NFS cross mount to the same
    # mount point on both machines.
    $ECHO $FSNAME | grep ':' >/dev/null \
         && FSNAME=$($ECHO $FSNAME | cut -d ':' -f2)

    # Check for empty and null variable
    if [[ ! -z $FSLIMIT && $FSLIMIT != '' ]]
    then
        if [[ $FSNAME = $FSMOUNT ]] # Found it!
        then
            # Check for "MB" Characters...Set IN_FILE=MB
            $ECHO $FSLIMIT | grep MB >/dev/null && IN_FILE="MB" \
                 && (( FSLIMIT = $($ECHO $FSLIMIT \
                       | sed s/MB//g) * 1024 ))
            # check for '%' Character...Set IN_FILE=PC, for %
            $ECHO $FSLIMIT | grep '%' >/dev/null && IN_FILE="PC" \
                 && FSLIMIT=$($ECHO $FSLIMIT | sed s/\%//g)

            case $IN_FILE in
            MB) # Use MB of Free Space Method
                # Up-case the characters, if they exist
                FSLIMIT=$($ECHO $FSLIMIT | tr '[a-z]' '[A-Z]')
                # Get rid of the 'MB' if it exists
                FSLIMIT=$($ECHO $FSLIMIT | sed s/MB//g)
                # Test for blank and null values
                if [[ ! -z $FSLIMIT && $FSLIMIT != '' ]]
                then
                   # Test for a valid filesystem 'MB' limit
                   if (( FSLIMIT >= 0 && FSLIMIT < FSSIZE ))
                   then
                      if (( FSMB_FREE < FSLIMIT ))
                      then
                         return 1 # Found out of limit
                                  # using MB Free method
                      else
                         return 3 # Found OK
                      fi
                   else
                       $ECHO "\nERROR: Invalid filesystem MAX for\
 $FSMOUNT - $FSLIMIT"
                       $ECHO "       Exceptions file value must be less\
```

Listing 17-16 (*continued*)

```
than or"
                    $ECHO "       equal to the size of the filesystem\
measured"
                     $ECHO "       in 1024 bytes\n"
                  fi
               else
                  $ECHO "\nERROR: Null value specified in exceptions\
file"
                  $ECHO "       for the $FSMOUNT mount point.\n"
               fi
               ;;
            PC) # Use Filesystem %Used Method
               # Strip out the % sign if it exists
               PC_USED=$($ECHO $PC_USED | sed s/\%//g)
               # Test for blank and null values
               if [[ ! -z "$FSLIMIT" && "$FSLIMIT" != '' ]]
               then
                  # Test for a valid percentage, i.e. 0-100
                  if (( FSLIMIT >= 0 && FSLIMIT <= 100 ))
                  then
                     if (( $PC_USED > $FSLIMIT ))
                     then
                        return 2 # Found exceeded by % Used method
                     else
                        return 3 # Found OK
                     fi
                  else
                     $ECHO "\nERROR: Invalid percentage for $FSMOUNT -\
$FSLIMIT"
                     $ECHO "       Exceptions file values must be"
                     $ECHO "       between 0 and 100%\n"
                  fi
               else
                  $ECHO "\nERROR: Null value specified in exceptions\
file"
                  $ECHO "       for the $FSMOUNT mount point.\n"
               fi
               ;;
            N) # Method Not Specified - Use Script Defaults
               if (( FSSIZE >= FSTRIGGER ))
               then # This is a "large" filesystem
                   if (( FSMB_FREE < MIN_MB_FREE ))
                   then
                        return 1 # Found out of limit
                                 # using MB Free method
                   else
                        return 3 # Found OK
                   fi
```

Listing 17-16 (*continued*)

```
                else # This is a standard filesystem
                    PC_USED=$($ECHO $PC_USED | sed s/\%//g) # Remove %
                    FSLIMIT=$($ECHO $FSLIMIT | sed s/\%//g) # Remove %
                    if (( PC_USED > FSLIMIT ))
                    then
                        return 2 # Found exceeded by % Used method
                    else
                        return 3 # Found OK
                    fi
                fi
                ;;
            esac
        fi
    fi
done < $DATA_EXCEPTIONS # Feed the loop from the bottom!!!

return 4 # Not found in $EXCEPTIONS file
}

####################################

function display_output
{
if [[ -s $OUTFILE ]]
then
      $ECHO "\nFull Filesystem(s) on $THISHOST\n"
      cat $OUTFILE
      print
fi
}

####################################

function load_EXCEPTIONS_data
{
# Ignore any line that begins with a pound sign, #
# and omit all blank lines

cat $EXCEPTIONS |  grep -v "^#" | sed /^$/d > $DATA_EXCEPTIONS
}

####################################

function load_AIX_FS_data
{

   df -k | tail +2 | egrep -v "/dev/cd[0-9]|/proc" \
         | awk '{print $1, $2, $3, $4, $7}' > $WORKFILE
```

Listing 17-16 (*continued*)

```
}

####################################

function load_HP_UX_FS_data
{

   bdf | tail +2 | egrep -v "/cdrom" \
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################

function load_LINUX_FS_data
{

   df -k | tail -n 2 | egrep -v "/cdrom"\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################

function load_OpenBSD_FS_data
{
   df -k | tail +2 | egrep -v "/mnt/cdrom"\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################

function load_Solaris_FS_data
{

   df -k | tail +2 | egrep -v "/dev/fd|/etc/mnttab|/proc"\
         | awk '{print $1, $2, $4, $5, $6}' > $WORKFILE
}

####################################
######### START OF MAIN #############
####################################

# Query the operating system to find the Unix flavor, then
# load the correct filesystem data for the resident OS

case $(get_OS_info) in
   AIX)   # Load filesystem data for AIX
          load_AIX_FS_data
      ;;
```

Listing 17-16 (*continued*)

```
   HP-UX) # Load filesystem data for HP-UX
          load_HP_UX_FS_data
      ;;
   LINUX) # Load filesystem data for Linux
          load_LINUX_FS_data
      ;;
   OPENBSD) # Load filesystem data for OpenBSD
          load_OpenBSD_FS_data
      ;;
   SUNOS) # Load filesystem data for Solaris
          load_Solaris_FS_data
      ;;
   *)     # Unsupported in script
          $ECHO "\nUnsupported Operating System for this\
 Script...EXITING\n"
          exit 1
esac

# Do we have a nonzero size $EXCEPTIONS file?

if [[ -s $EXCEPTIONS ]]
then # Found a nonempty $EXCEPTIONS file

    load_EXCEPTIONS_data
    EXCEP_FILE="Y"
fi

while read FSDEVICE FSSIZE FSMB_FREE PC_USED FSMOUNT
do
     if [[ $EXCEP_FILE = "Y" ]]
     then
         check_exceptions
         CE_RC="$?" # Check Exceptions Return Code (CE_RC)

         case $CE_RC in
         1) # Found exceeded in exceptions file by MB Method
            (( FS_FREE_OUT = FSMB_FREE / 1000 ))
            $ECHO "$FSDEVICE mounted on $FSMOUNT has ${FS_FREE_OUT}MB\
 Free" >> $OUTFILE
          ;;
         2) # Found exceeded in exceptions file by %Used method
            $ECHO "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                  >> $OUTFILE
          ;;
         3) # Found OK in exceptions file
            : # NO-OP Do Nothing.  A ':' is a no-op!
          ;;
```

Listing 17-16 (*continued*)

```
          4) # Not found in exceptions file - Use Default Triggers
             if (( FSSIZE >= FSTRIGGER ))
             then # This is a "large" filesystem
             FSMB_FREE=$($ECHO $FSMB_FREE | sed s/MB//g) # Remove the "MB"
               if (( FSMB_FREE < MIN_MB_FREE  ))
               then
                 (( FS_FREE_OUT = FSMB_FREE / 1000 ))
                $ECHO "$FSDEVICE mounted on $FSMOUNT has {FS_FREE_OUT}MB\
  Free" >> $OUTFILE
               fi
             else # This is a standard filesystem
                 PC_USED=$($ECHO $PC_USED | sed s/\%//g)
                 MAX_PERCENT=$($ECHO $MAX_PERCENT | sed s/\%//g)
                 if (( PC_USED > MAX_PERCENT ))
                 then
                     $ECHO "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                           >> $OUTFILE
                 fi
             fi
          ;;
         esac

     else # NO $EXCEPTIONS FILE USE DEFAULT TRIGGER VALUES

          if (( FSSIZE >= FSTRIGGER  ))
          then # This is a "large" filesystem - Use MB Free Method
           FSMB_FREE=$($ECHO $FSMB_FREE | sed s/MB//g) # Remove the 'MB'
            if (( FSMB_FREE < MIN_MB_FREE ))
            then
              (( FS_FREE_OUT = FSMB_FREE / 1000 ))
              $ECHO "$FSDEVICE mounted on $FSMOUNT has \
                    ${FS_FREE_OUT}MB Free" >> $OUTFILE
            fi
          else # This is a standard filesystem - Use % Used Method
              PC_USED=$($ECHO $PC_USED | sed s/\%//g)
              MAX_PERCENT=$($ECHO $MAX_PERCENT | sed s/\%//g)
              if (( PC_USED > MAX_PERCENT ))
              then
                  $ECHO "$FSDEVICE mount on $FSMOUNT is ${PC_USED}%" \
                        >> $OUTFILE
              fi
          fi
     fi
done < $WORKFILE # Feed the while loop from the bottom!!!!!

display_output

# End of Script
```

Listing 17-16 (*continued*)

A good study of the script in Listing 17-16 will reveal some nice ways to handle the different situations we encounter while writing shell scripts. As always, it is intuitively obvious!

The `/usr/local/bin/exceptions` file in Listing 17-17 is used on `yogi`.

```
# FILE: "exceptions"
#
# This file is used to override the default
# trigger value in the filesystem monitoring script
# fs_mon_ALL_OS_except.ksh, but also allows overriding the
# monitoring technique used, i.e. Max %Used and
# MINIMUM MB FREE of filesystem space.  The syntax to
# override is a /mount-point and a "trigger value" with
# either "%" or "MB" as a suffix.
#
# EXAMPLES:
#
# /usr 96%
# OR
# /usr 50MB
#
# All lines beginning with a # are ignored.
#
# NOTE: All Entries MUST have either "MB" or
#       "%" as a suffix!!!  Or else the script
#       defaults are used. NO SPACES PLEASE!
#
/opt 95%
/ 50%
/usr 70MB
/home 50MB
```

Listing 17-17 Sample exceptions file

Listing 17-17 should work, but it gives an error. If the monitoring script is executed using these exception file entries, it will result in the following output:

```
ERROR: Invalid filesystem MINIMUM_MB_FREE specified
       for /home - 50MB -- Current size is 4MB.
       Exceptions file value must be less than or equal
       to the size of the filesystem measured Megabytes


Full Filesystem(s) on yogi

/dev/hd4 mount on / is 51%
/dev/hd2 mounted on /usr has 57MB Free
/dev/hd10opt mount on /opt is 97%
```

The problem is with the `/home` filesystem entry in the `$EXCEPTIONS` file. The value specified is 50 Megabytes, and the `/home` filesystem is only 4 MB in size. In a case like this the `check_exceptions` function will display an error message and then use the shell script default values to measure the filesystem and return an appropriate return code to the calling script. So, if a modification is made to the exceptions file, the script needs to be run to check for any errors.

The important thing to note is that error checking and data validation should take place before the data is used for measurement. This sequence will also prevent any messages from standard error (`stderr`) that the system may produce.

Other Options to Consider

With one-terabyte disk drives coming out this year, the data explosion is heading to every home. The Lab Assignments give you a chance to modify the shell scripts to measure filesystem usage in the GB range and above.

We can always improve on a script, and the full filesystems script is no exception. Here are some thoughts.

Event Notification

Because monitoring for full filesystems should involve event notification, it is wise to modify the `display_output` function to send some kind of message, whether by page or email, or otherwise this information needs to be made known so that we can call ourselves proactive. Sending an email to your pager and desktop would be a good start. An entry like the statement that follows might work, but its success depends on the mail server and firewall configurations:

```
echo "Full Filesystem(s) on $THISHOST\n" > $MAILFILE
cat $OUTFILE >> $MAILFILE

mailx -s "Full Filesystem(s) on $THISHOST" $MAIL_LIST < $MAILFILE
```

For pager notification, the text message must be *very short*, but descriptive enough to get the point across. You can also set up a mail alias in sendmail, maybe something like `fs_support`. A mail alias is easier and more intuitive to maintain for the Systems Administrators.

Automated Execution

If we are to monitor the system, we want the system to tell us when *it* has a problem. We want event notification, but we also want the event notification to be automated. For filesystem monitoring, a cron table entry is the best way to do this. An interval of about 10–15 minutes 24×7 is most common. We have the exceptions capability built in so that if pages become a problem, the exceptions file can be modified to stop the

filesystem from being *in error*, and thus stop the paging. The cron entry that follows will execute the script every 10 minutes, on the 5s, 24 hours a day, 7 days a week:

```
5,15,25,35,45,55 * * * * /usr/local/bin/fs_mon_ALL_OS.ksh 2>&1
```

To make this cron entry you can either edit a cron table with `crontab -e` or use the following command sequence to append an entry to the end of the cron table:

```
crontab -l > /tmp/cron_hold.out

echo '5,15,25,35,45,55 * * * * /usr/local/bin/fs_mon_ALL_OS.ksh 2>&1' \
      >> /tmp/cron_hold.out

crontab /tmp/cron_hold.out

rm /tmp/cron_hold.out
```

For this to work, the `fs_mon_ALL_OS.ksh` script must be modified to send notification by some method. Paging, email, SNMP traps, and modem dialing are the preferred methods. You could send this output to the systems console, but who would ever see it?

Modify the egrep Statement

It may be wise to remove the `egrep` part of the `df` statement, used for filesystem exclusion, and use another method. As pointed out previously, grepping can be a mistake. Grepping was done here because most of the time we can get a unique character string for a filesystem device to make `grep` and `egrep` work without error, but not always. If this is a problem, creating a list either in a variable assignment in the script or in a file is the best bet. Then the new `$IGNORE_LIST` list can be searched and an exact match can be made.

Summary

Throughout this chapter we have changed our thinking about monitoring for full filesystems. The script that we use can be very simple for the average small shop, or more complex as we move to larger and larger storage solutions. All filesystems are not created equal in size, and when you get a mix of large and small filesystems on mixed operating systems, we have shown how to handle the mix with ease. Now we get to play with terabyte disk drives!

In the next chapter we will move into monitoring the paging and/or swap space. If we run out of paging or swap space, the system will start thrashing, and if the problem is chronic, the system may crash. We will look at the different monitoring methods for each operating system.

Lab Assignments

1. Modify the `fs_mon_ALL_OS.ksh` shell script so that the *exceptions* file will support not only MB (megabyte) limits, but will now support GB (gigabyte) exception limits. Name the new file `fs_mon_ALL_OS_GB.ksh`.
2. Modify the `fs_mon_ALL_OS_GB.ksh` shell script to use `df -m` (for megabyte) instead of `df -k` (kilobytes) to measure disk utilization. Name the new file `fs_mon_ALL_OS_GB_DF-M.ksh`.

CHAPTER 18

Monitoring Paging and Swap Space

Every Systems Administrator loves paging and swap space because they are the magic bullets to fix a system that does not have enough real physical memory — right? *Wrong!* This misconception is thought to be true by many people, at various levels, in a lot of organizations. The fact is that if your system does not have enough real memory to run your applications, adding more paging/swap space is not going to help. Depending on the system's hardware and the application(s) running on your system, swap space should start at least 1.5 times physical memory. Many high-performance applications such as SAP, Oracle, and DB2 require 4 to 10 GB of real memory, plus at least 2 times real memory in swap/paging space. *Did you notice I said GB of real memory?* At a minimum we need 8 GB of paging space, and it could be as high as 20 GB; so the actual amount of paging and swap space is variable, but 1.5 times is a good place to start. Use the application's recommended requirement, if one is suggested, as a starting point. Just be sure to take into account any other applications that are also running on the system.

Some of you may be asking, What is the difference between *paging* space and *swap* space? It depends on the UNIX flavor whether your system does swapping or paging, but both swap space and paging space are disk storage that makes up virtual memory along with real, or physical, memory. A *page fault* happens when a memory segment, or *page*, is needed in memory but is not currently resident in memory. When a page fault occurs, the system attempts to load the needed data into memory; this is called paging or swapping, depending on the UNIX system you are running. When the system is doing a lot of paging in and out of memory we need to be able to monitor this activity. If your system runs out of paging space or is in a state of continuous swapping, such that as soon as a segment is paged out of memory it is immediately needed again, the system is *thrashing*. If this thrashing condition continues for very long, you have a risk of the system crashing. In this chapter we are going to use the terms ''paging'' and ''swapping'' interchangeably.

Each of our five UNIX flavors (AIX, HP-UX, Linux, OpenBSD, and Solaris) uses different commands to list the swap-space usage. The output for each command and OS varies also. The goal of this chapter is to create six shell scripts: one script of each of the five operating systems and an all-in-one shell script that will run on any of our five UNIX flavors. Each of the shell scripts must produce the exact same output, which is shown in Listing 18-1.

```
Paging Space Report for yogi

Wed Jun  5 21:48:16 EDT 2007

Total MB of Paging Space:       336MB
Total MB of Paging Space Used:  33MB
Total MB of Paging Space Free:  303MB

Percent of Paging Space Used:   10%

Percent of Paging Space Free:   90%
```

Listing 18-1 Required paging- and swap-space report

Before we get started creating the shell scripts, we need the command syntax for each operating system. Each of the commands produces a different result, so this should be an interesting chapter in which we can try some varied techniques.

Syntax

As usual, we need the correct command syntax before we can write a shell script. As we go through each of the operating systems, the first thing I want you to notice is the command syntax used and the output received back. Because we want each UNIX flavor to produce the same output, as shown in Listing 18-1, we are going to have to do some math. This is not going to be hard math, but each of the paging- and swap-space command outputs is lacking some of the desired information, so we must calculate the missing pieces. Now we are going to see the syntax for each operating system.

AIX lsps Command

AIX does paging instead of swapping. This technique uses 4096-byte-block pages. When a page fault occurs, AIX has a complex algorithm that frees memory of the least used noncritical memory page to disk paging space. When the memory has space available, the page of data is paged in to memory. To monitor paging-space usage in AIX, you use the **lsps** command, which stands for *list paging space*. The `lsps` command has two command options: `-a`, to list each paging space separately, and `-s`, to show a summary of all paging spaces. Both `lsps` options are shown here:

```
# lsps -a

Page Space Physical Volume  Volume Group   Size  %Used Active Auto  Type
paging00   hdisk2           rootvg       1024MB     11    yes  yes    lv
hd6        hdisk0           rootvg       1024MB      9    yes  yes    lv


# lsps -s

Total Paging Space   Percent Used
       2048MB               10%
```

From the first command output, `lsps -a`, on this system notice that there are two paging spaces defined, `paging00` and `hd6`, both are the same size at 1 GB each, and each paging space is on a separate disk. This is an important point. In AIX, paging space is used in a round-robin fashion, starting with the paging space that has the largest area of free space. If one paging space is significantly larger, the round-robin technique is defeated, and the system will almost always use the larger paging space. This has a negative effect on performance because one disk will take all of the paging activity.

In the second output, `lsps -s`, we get a summary of all of the paging space usage. Notice that the only data that we get is the total size of the paging space and the percentage used. From these two pieces of data we must calculate the remaining parts of our required output, which is total paging space in MB, free space in MB, used space in MB, percent used, and percent free. We will cover these points in the scripting section for AIX later in this chapter.

HP-UX swapinfo Command

The HP-UX operating system uses swapping, which is evident by the command **swapinfo**. HP-UX does the best job of giving us the best detailed command output, so we need to calculate only one piece of data for our required output, percent of total swap space free. Everything else is provided with the `swapinfo -tm` command. The `-m` switch specifies to produce output in MB, and the `-t` switch specifies to produce a total line for a summary of all virtual memory. This command output is shown here:

```
[root@dino]/> swapinfo -tm
            Mb     Mb      Mb   PCT  START/      Mb
TYPE     AVAIL  USED    FREE  USED   LIMIT RESERVE  PRI  NAME
dev         96    21      73   22%  928768       -    1  /dev/dsk/c0t6d0
reserve      -    46     -46
memory      15     5      10   33%
total      111    72      37   65%       -       0    -
```

Notice in this output that HP-UX splits up virtual memory into three categories: `dev`, `reserve`, and `memory`. For our needs we could use the summary information that is shown in the `total` line at the bottom. As you can see on the `total` line,

the total virtual memory is 111 MB, and the system is consuming 72 MB of this total, which leaves 37 MB of free virtual memory. The fifth column shows that the system is consuming 65 percent of the available virtual memory. This `total` row is misleading, though, when we are interested only in the swap-space usage. The actual swap-space usage is located on the `dev` row of data at the top of the command output. As you can see, we need to calculate only the percent free, which is a simple calculation.

Linux free Command

Linux uses swapping and uses the **free** command to view memory and swap-space usage. The `free` command has several command switches, but the only one we are concerned with is the `-m` command switch to list output in MB. The swap information given by the `free -m` command is listed only in MB, and there are no percentages presented in the output. Therefore, from the total MB, used MB, and free MB, we must calculate the percentages for percentage used and percentage free. The following shows the `free -m` command output:

```
# free -m
             total       used       free     shared    buffers     cached
Mem:            52         51          1          0          1         20
-/+ buffers/cache:         30         22
Swap:          211          9        202
```

The last line in this output has the swap information listed in MB, specified by the `-m` switch. This command output shows that the system has 211 MB of total swap-space, of which 9 MB has been used and 202 MB of swap space is free.

OpenBSD swapctl Command

OpenBSD uses swapping and uses the **swapctl** command to view swap-space usage. The `swapctl` command has several command switches, but the only ones we are concerned with are the `-l` and `-k` command switches. The swap information given by the `swapctl -lk` command is listed in KB by using the `-k` switch. Percentages presented in the output show the percentage of current usage. Because we have our swap-space usage indicated in KB, we need to multiple by 1,000 for our standard MB output. The following shows the `swapctl -lk` command output:

```
# swapctl -lk
Device      1K-blocks     Used    Avail Capacity  Priority
swap_device    500000        0   500000     0%    0
```

As we can see in this OpenBDS output, the system has 500 MB of swap space defined, and 0 percent and 0 MB are currently utilized.

Solaris swap Command

The Solaris operating system does swapping, as indicated by the command **swap**. Of the `swap` command switches we are concerned with only the `-s` switch, which produces a summary of swap-space usage. All output from this command is produced in KB so we have to do a little division by 1,000 to get our standard MB output. Like Linux, the Solaris `swap` output does not show the swap status using percentages, so we must calculate these values. The `swap -s` output is shown here:

```
# swap -s
total: 26788k bytes allocated + 7256k reserved = 34044k used, 557044k
available
```

This is an unusual output to decipher because the data is all on the same line, but because Solaris attempts to create a mathematical statement we will have to use our own mathematical statements to fill in the blanks to get our required script output. The `swap -s` command output shows that the system has used a total of 34 MB and it has 557 MB of free swap space. We must calculate the total MB, the percentage used, and the percentage of free swap space. These calculations are not too hard to handle as we will see in the shell scripting section for Solaris later in this chapter.

Creating the Shell Scripts

Now that we have the basic syntax of the commands to get paging- and swap-space statistics, we can start our scripting of the solutions. In each case you should notice which pieces of data are missing from our required output, as shown in Listing 18-1. All of these shell scripts are different. Some pipe command outputs to a `while` loop to assign the values to variables, and some use other techniques to extract the desired data from the output. Please study each shell script in detail, and you will learn how to handle the different situations you are challenged with when working in a heterogeneous environment.

AIX Paging Monitor

As we previously discussed, the AIX `lsps -s` command output shows only the total amount of paging space measured in MB and the percentage of paging space that is currently in use. To get our standard set of data to display we need to do a little math. This is not too difficult when you take one step at a time. In this shell script let's use a file to store the command output data. To refresh your memory the `lsps -s` command output is shown again here (this output is using a different AIX system):

```
# lsps -s
Total Paging Space   Percent Used
      336MB               2%
```

The first thing we need to do is to remove the column headings. I like to use the `tail` command in a pipe for this purpose. The command syntax is shown in the next statement:

```
# lsps -s | tail +2
      336MB               2%
```

The `tail + 2` says to start listing the end of the file starting at line 2. This resulting output contains only the data, without the column headings. The next step is to store these values in variables so that we can work with them for some calculations. We are going to use a file for initial storage and then use a `while read` loop, which we feed from the bottom using input redirection with the filename. Of course, we could have piped the command output to the `while read` loop, but I want to vary the techniques in each shell script in this chapter. Let's look at the first part of the data gathering and the use of the `while read` loop, as shown in Listing 18-2.

```
PAGING_STAT=/tmp/paging_stat.out # Paging Stat hold file

# Load the $PAGING_STAT file with data

lsps -s | tail +2 > $PAGING_STAT

# Use a while loop to assign the values to variables

while read TOTAL PERCENT
do
     DO CALCULATIONS HERE

done < $PAGING_STAT
```

Listing 18-2 Logical view of AIX lsps -s data gathering

Notice in Listing 18-2 that we first define a file to hold the data, which is pointed to by the `$PAGING_STAT` variable. In the next step we redirect output of our paging space status command to the defined file. Next comes a `while` loop, where we `read` the file data and assign the first data field to the variable `TOTAL` and the second data field to the variable `PERCENT`.

Notice how the `$PAGING_STAT` file is used to feed the `while` loop from the bottom. As you saw in Chapter 2, ''24 Ways to Process a File Line-by-Line,'' this technique is one of the two fastest methods of reading data from a file. The middle of the `while` loop is where we do our calculations to fill in the blanks of our required output.

Speaking of calculations, we need to do three calculations for this script, but before we can perform the calculations on the data we currently have, we need to get rid of the suffixes attached to the variable data. The first step is to extract the `MB` from the `$TOTAL` variable and then extract the percent sign, `%`, from the `$PERCENT` variable. We do both of these operations using a **cut** command in a pipe, as shown here:

```
PAGING_MB=$(echo $TOTAL | cut -d 'MB' -f1)
PAGING_PC=$(echo $PERCENT | cut -d% -f1)
```

In both of these statements we use command substitution, specified by the `$(command_statement)` notation, to execute a command statement and assign the result to the variable specified. In the first statement we `echo` the `$TOTAL` variable and pipe the output to the `cut` command. For the `cut` command we specify the *delimiter* to be `MB`, and we enclose it with single tic marks, `'MB'`. Then we specify that we want the first field, specified by `-f1`. In the second statement we do the exact same thing, except that this time we specify that the percent sign, `%`, is the delimiter. The result of these two statements is that we have the `PAGING_MB` and `PAGING_PC` variables pointing to integer values without any other characters. Now we can do our calculations!

Let's do the most intuitive calculation first. We have the value of the percent of paging space used stored in the `$PAGING_PC` variable as an integer value. To get the percent of free paging space, we need to subtract the percent used value from 100, as shown in the next command statement:

```
(( PAGING_PC_FREE = 100 - PAGING_PC ))
```

Notice that we used the double parentheses mathematical method, specified by the `(( Math Statement ))`. I like this method because it is so intuitive to use. Also notice that you do *not* use the dollar sign, `$`, with variables when using this method. Because the double parentheses method expects a mathematical statement, any character string that is not numeric is assumed to be a variable, so the dollar sign can be omitted.

The next calculation is not so intuitive to some. We want to calculate the MB of paging space that is currently in use. Now let's think about this. We have the percentage of paging space used, the percentage of paging space free, and the total amount of paging space measured in MB. To calculate the MB of used paging space, we can use the value of the total MB of paging space and the percentage of paging space used divided by 100, which converts the value of paging space used into a decimal value internally. See how this is done in the next statement:

```
(( MB_USED = PAGING_MB * PAGING_PC / 100 ))
```

One thing to note in the preceding math statement: this will produce only an integer output. If you want to see the output in floating-point notation, you need to use the **bc** utility, which you will see in some of the following sections.

The last calculation is another intuitive calculation, to find the MB of free paging space. Because we already have the values for the total paging space in MB, and the MB of paging space in use, we need only to subtract the used value from the total. This is shown in the next statement:

```
(( MB_FREE = PAGING_MB - MB_USED ))
```

We have completed all of the calculations, so now we are ready to produce the required output for the AIX shell script. Take a look at the entire shell script shown in Listing 18-3, and pay particular attention to the boldface type.

```
#!/usr/bin/ksh
#
# SCRIPT: AIX_paging_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 5/31/2007
# REV: 1.1.P
#
# PLATFORM: AIX Only
#
# PURPOSE: This shell script is used to produce a report of
#          the system's paging space statistics including:
#
#          Total paging space in MB, MB of free paging space,
#          MB of used paging space, % of paging space used, and
#          % of paging space free
#
# REV LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
#############################################################
################ DEFINE VARIABLES HERE ######################

PC_LIMIT=65             # Percentage Upper limit of paging space
                        # before notification

THISHOST=$(hostname)    # Host name of this machine
PAGING_STAT=/tmp/paging_stat.out # Paging Stat hold file

#############################################################
################ INITIALIZE THE REPORT ######################

echo "\nPaging Space Report for $THISHOST\n"
date

#############################################################
############# CAPTURE AND PROCESS THE DATA ##################

# Load the data in a file without the column headings
lsps -s | tail +2 > $PAGING_STAT
```

Listing 18-3 AIX_paging_mon.ksh shell script listing

```
# Start a while loop and feed the loop from the bottom using
# the $PAGING_STAT file as redirected input, after "done"

while read TOTAL PERCENT
do
     # Clean up the data by removing the suffixes
     PAGING_MB=$(echo $TOTAL | cut -d 'MB' -f1)
     PAGING_PC=$(echo $PERCENT | cut -d% -f1)

     # Calculate the missing data: %Free, MB used and MB free
     (( PAGING_PC_FREE = 100 - PAGING_PC ))
     (( MB_USED = PAGING_MB * PAGING_PC / 100 ))
     (( MB_FREE = PAGING_MB - MB_USED ))

     # Produce the rest of the paging space report:
     echo "\nTotal MB of Paging Space:\t$TOTAL"
     echo "Total MB of Paging Space Used:\t${MB_USED}MB"
     echo "Total MB of Paging Space Free:\t${MB_FREE}MB"
     echo "\nPercent of Paging Space Used:\t${PERCENT}"
     echo "\nPercent of Paging Space Free:\t${PAGING_PC_FREE}%"

     # Check for paging space exceeded the predefined limit
     if ((PC_LIMIT <= PAGING_PC))
     then
          # Paging space is over the limit, send notification

         tput smso  # Turn on reverse video!

         echo "\n\nWARNING: Paging Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"

         tput rmso  # Turn off reverse video
     fi

done < $PAGING_STAT

rm -f $PAGING_STAT

# Add an extra new line to the output

echo "\n"
```

Listing 18-3 (*continued*)

There is one part of our shell script in Listing 18-3 that we have not covered yet. At the top of the script where we define variables, I added the `PC_LIMIT` variable. I normally set this threshold to 65 percent so that I will know when I have exceeded a safe system paging-space limit. When your system starts running at a

high paging-space level, you need to find the cause of this added activity. Sometimes developers do not write applications properly when it comes to deallocating memory. If a program runs for a long time and it is not written to clean up and release allocated memory, the program is said to have a *memory leak*. The result of running this memory leak program for a long time without a system reboot is that your system will run out of memory. When your system runs out of memory, it starts paging in and out to disk, and then your paging space starts edging up. The only way to correct this problem and regain your memory is to reboot the system, most of the time.

Notice at the end of the script that there is a test to see if the percentage of paging space used is greater than or equal to the limit that is set by the `PC_LIMIT` variable. If the value is exceeded, then reverse video is turned on so the WARNING message stands out on the screen. After the message is displayed, reverse video is turned back off. To turn on reverse video use the **tput smso** command. When reverse video is on, anything that you print to the screen appears in reverse video; however, do not forget to turn it off because this mode will continue *after* the shell script ends execution if you do not turn it off. To turn off the reverse video mode use the **tput rmso** command. Listings 18-4 and 18-5 show the shell script in action. Listing 18-4 shows a report of the system within the set 65 percent limit, and Listing 18-5 shows the report when the system has exceeded a 5 percent paging limit (I had to lower the threshold to 5 percent to test the shell script).

```
Paging Space Report for yogi

Fri Jun  7 15:47:08 EDT 2007

Total MB of Paging Space:       336MB
Total MB of Paging Space Used:  6MB
Total MB of Paging Space Free:  330MB

Percent of Paging Space Used:   2%

Percent of Paging Space Free:   98%
```

Listing 18-4 AIX_paging_mon.ksh in action

As you can see in Listing 18-4, `yogi` is not doing too much right now. Let's produce a little load on the system and set the trigger threshold in the `AIX_paging_mon.ksh` shell script to 5 percent so that we can see the threshold exceeded, as shown in Listing 18-5.

```
Paging Space Report for yogi

Fri Jun  7 15:54:30 EDT 2007
```

Listing 18-5 AIX_paging_mon.ksh exceeding a five percent paging limit

```
Total MB of Paging Space:       336MB
Total MB of Paging Space Used:  23MB
Total MB of Paging Space Free:  313MB

Percent of Paging Space Used:   7%

Percent of Paging Space Free:   93%


WARNING: Paging Space has Exceeded the 5% Upper Limit!
```

Listing 18-5 (*continued*)

This is still not much of a load, but it does make the point of the ability to set a trigger threshold for notification purposes. Of course, the reverse video of the warning message did not come to the page; believe me, it does show up in reverse video on the screen. Let's move on to the HP-UX system.

HP-UX Swap-Space Monitor

The HP-UX operating system does swapping, as shown by the `swapinfo` command. To check the statistics of swap space you use the `swapinfo -tm` command. The `-t` command switch adds a summary `total` line to the output, and the `-m` option specifies that the output space measurements are in MB, as opposed to the default of KB. As I said previously, HP-UX does the best job of producing the various virtual memory statistics, so we need to calculate only one piece of our required output, the percent of free swap space. Before we go any further, let's look at the command output we are dealing with, as shown in Listing 18-6.

```
swapinfo -tm
             Mb      Mb      Mb   PCT  START/      Mb
TYPE      AVAIL    USED    FREE  USED   LIMIT RESERVE  PRI  NAME
dev          96      23      71   24%  928768       -    1  /dev/dsk/c0t6d0
reserve       -      45     -45
memory       15       6       9   40%
total       111      74      35   67%       -       0    -
```

Listing 18-6 HP-UX swapinfo -tm command output

As you can see, HP-UX shows paging space for devices, reserved memory, and real memory usage. I like to use the `total` row of output to get a good summary of what all of the virtual memory is doing. It really does not matter if you use the `dev` row or the `total` row to do your monitoring, but for this exercise I am going to use the `dev` row to monitor only the swap space and not worry about what real memory is doing.

The easiest way to extract the data we want on the dev row in the output is to use grep to pattern match on the string dev, because dev appears on only one row of data. Piping the swapinfo command output to a grep statement produces the following output:

```
# swapinfo -tm | grep dev

dev          96      23      71   24%  928768       -    1  /dev/dsk/c0t6d0
```

The output that we want to extract, Total MB, Used MB, Free MB, and Percent Used, is located in fields $2, $3, $4, and $5, respectively. From looking at this we have at least two options to assign the field values to variables. We can use five awk statements, or we can pipe the preceding command output to a while read loop. Of course, the while read loop runs for only one loop iteration. The easiest technique is to pipe to the while loop. The following command will get us started:

```
swapinfo -tm | grep dev | while read junk SW_TOTAL SW_USED \
                                  SW_FREE PERCENT_USED junk2
```

Notice in the while read portion of this statement how we assign unneeded fields to variables named junk and junk2. The first field, specified by the junk variable, targets dev; we are not interested in saving this field, so it gets a junk assignment. The last variable, junk2, is a catch-all for anything remaining on the line of output; specifically, ''928768 - 1 /dev/dsk/c0t6d0'' gets assigned to the variable junk2 as one field. This is an extremely important part of the while read statement because you must account for everything when reading in a line of data. Had I left out the junk2 variable, the PERCENT_USED variable would point to the data ''24% 928768 - 1 /dev/dsk/c0t6d0'', when the only thing we want is 24%. The junk2 variable catches all of the remaining data on the line and assigns it to the junk2 variable. This brings up another point. If you want to capture the entire line of data and assign it to a single variable, you can do this too by using the following syntax:

```
while read DATA_LINE
do
     PARSE THE $DATA_LINE DATA HERE

done < $DATA_FILE
```

Using this syntax, all of the data is captured with a single variable, DATA_LINE, and the data is separated into fields just as it appears in the command output.

Back to our previous swapinfo statement, we have the data of interest stored in the following variables:

- SW_TOTAL — Total swap space available on the system measured in MB
- SW_USED — MB of swap space that is currently in use
- SW_FREE — MB of swap space that is currently free
- PERCENT_USED — Percentage of total swap space that is in use

The only part of our required output missing is the percentage of total swap space that is currently free. This is an easy calculation because we already have the `$PERCENT_USED`. For the calculation we need to remove the percent sign, `%`, in the `$PERCENT_USED` variable. The following statement does the removal of the percent sign and makes the calculation in one step:

```
((PERCENT_FREE = 100 - $(echo $PERCENT_USED | cut -d% -f1) ))
```

In the preceding mathematical statement, we assign 100 percent minus 24 percent to the variable `PERCENT_FREE` using command substitution to remove the percent sign from the `$PERCENT_USED` variable using the `cut` command. In the `cut` part of the statement we define `%` to be the delimiter, or field separator, specified by `-d%`, then we extract the first field, `24` in this case, using the `-f1` notation. Once the command substitution is complete, we are left with the following math statement:

```
((PERCENT_FREE = 100 - 24))
```

Now let's examine the entire shell script that is shown in Listing 18-7.

```
#!/usr/bin/ksh
#
# SCRIPT: HP-UX_swap_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 5/31/2007
# REV: 1.1.P
#
# PLATFORM: HP-UX Only
#
# PURPOSE: This shell script is used to produce a report of
#        the system's swap space statistics including:
#
#     Total paging space in MB, MB of free paging space,
#     MB of used paging space, % of paging space used, and
#     % of paging space free
#
# REV LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
################ DEFINE VARIABLES HERE ####################

PC_LIMIT=65             # Percentage Upper limit of paging space
                        # before notification
```

Listing 18-7 HP-UX_swap_mon.ksh shell script listing

```
THISHOST=$(hostname)   # Host name of this machine

############################################################
################ INITIALIZE THE REPORT ####################

echo "\nSwap Space Report for $THISHOST\n"
date

############################################################
############# CAPTURE AND PROCESS THE DATA #################

# Start a while read loop by using the piped-in input from
# the swapinfo -tm command output.


swapinfo -tm | grep dev | while read junk SW_TOTAL SW_USED \
                               SW_FREE PERCENT_USED junk2
do
    # Calculate the percentage of free swap space

    ((PERCENT_FREE = 100 - $(echo $PERCENT_USED | cut -d% -f1) ))

    echo "\nTotal Amount of Swap Space:\t${SW_TOTAL}MB"
    echo "Total MB of Swap Space Used:\t${SW_USED}MB"
    echo "Total MB of Swap Space Free:\t${SW_FREE}MB"
    echo "\nPercent of Swap Space Used:\t${PERCENT_USED}"
    echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

    # Check if paging space exceeded the predefined limit

    if (( PC_LIMIT <= $(echo $PERCENT_USED | cut -d% -f1) ))
    then
         # Swap space is over the predefined limit, send notification

         tput smso # Turn on reverse video!
         echo "\n\nWARNING: Swap Space has Exceeded the\
 ${PC_LIMIT}% Upper Limit!\n"
         tput rmso # Turn reverse video off!
    fi

done

echo "\n"
```

Listing 18-7 (*continued*)

There are a few things that I want to point out in Listing 18-7. The first point is that any time we use the `$PERCENT_USED` value we always use command substitution to remove the percent sign, `%`, as shown in the following command substitution statement:

```
$(echo $PERCENT_USED | cut -d% -f1)
```

The next part I want to go over is our required report output. At the top of the shell script we initialize the report by stating a report header including the hostname of the machine and the date stamp of the time the report was executed. Then we do any calculation that is needed to gather any missing data for our required output. Once all of our required data is gathered, we have a series of `echo` statements that add to the report. In these `echo` statements we spell out the data in an easily readable list. I want you to look at each `echo` statement and then look at the report output in Listing 18-8.

```
Swap Space Report for dino

Sun Oct 21 17:27:20 EDT 2007

Total Amount of Swap Space:     96MB
Total MB of Swap Space Used:    24MB
Total MB of Swap Space Free:    70MB

Percent of Swap Space Used:     25%

Percent of Swap Space Free:     75%
```

Listing 18-8 HP-UX swap-space report

There are three things I want you to notice in the `echo` statements. First is the use of the `\n` when we want to add another new line to the output, which is a blank line in this case. In Bash shell, you must add the `-e` switch to the `echo` command to enable the use of the backslash operators. In Korn shell, this is not a requirement. Second is the use of the `\t` to add a `TAB` to align the data output. And finally, note the use of the curly braces, `{VAR}`, around the variable names. The curly braces are needed because we are adding characters to the output, and these characters are adjacent to the variable's *name* and there is not a space, which include `MB` and `%` suffixes. To separate the extra characters from the variable name we need to use curly braces to ensure the separation.

At the end of the script in Listing 18-8 we compare the percent used variable to the trigger threshold that is defined in the `DEFINE VARIABLES` section at the top of the shell script. If the threshold is exceeded, we turn on reverse video, print a warning message, and then turn reverse video back off. The over threshold warning message is shown in Listing 18-9.

```
Swap Space Report for dino

Sun Oct 21 17:40:35 EDT 2007

Total Amount of Swap Space:     96MB
Total MB of Swap Space Used:    24MB
Total MB of Swap Space Free:    70MB

Percent of Swap Space Used:     25%

Percent of Swap Space Free:     75%


WARNING: Swap Space has Exceeded the 20% Upper Limit!
```

Listing 18-9 HP-UX swap-space report with over limit warning

I edited the shell script and changed the `PC_LIMIT` variable assignment to 20 percent for this example. The reverse video does not show up on paper, but on the screen it stands out so that the user will always notice the warning message. I usually set this threshold to 65 percent. When you exceed this level of swap-space usage, you really need to find the cause of the increased swapping.

Linux Swap-Space Monitor

The Linux operating system does swapping, and the command to gather swap-space statistics is the `free` command. The `free` command output by default lists swap-space usage in KB, but the `-m` switch is available for listing the statistics in MB. Additionally, the `free -m` output does not include any statistics measured in percentages, so we must calculate the percentage of free swap space and the percentage of used swap space.

These percentage calculations are relatively easy, but we really want to measure the percentage using floating-point notation this time. We need to use the `bc` utility for the mathematical calculations. Chapter 13, ''Floating-Point Math and the bc Utility,'' goes into great detail on floating-point math and the use of the `bc` utility. First, let's look at the following `free -m` output so that we know what we are dealing with:

```
# free -m
             total       used       free     shared    buffers     cached

Mem:            52         51          0          0          0         18
-/+ buffers/cache:         32         19
Swap:          211         14        197
```

The row of output that we are interested in is the last line of output, beginning with `Swap:`. This output shows that we have a total of 211 MB of swap space, where 14 MB is currently being used. This leaves 197 MB of free swap space. We have three out of five pieces of our required output, so we need to calculate only the percentage of free

swap space and the percentage of used space. For these calculations we need to look at the use of the `bc` utility.

The `bc` utility is a precision calculator language that is a UNIX level built-in program. For our purposes we have two techniques for using the `bc` utility. We can place our mathematical statement in an `echo` statement and pipe the output to `bc`. The second option is to use a *here* document with command substitution. For this exercise we are going to use the second option to look at the use of a here document.

To calculate the percentage of used swap space, we divide the total amount of swap space into MB of used swap space and multiply this total by 100, as shown in the following statement:

```
($SW_USED / $SW_TOTAL) * 100
```

This looks simple enough, but how do we get a floating-point output in a shell script? This is where the `bc` utility comes in. There is an option in `bc` called `scale`. The `scale` indicates how many decimal places to the right of the decimal point we want to use in the calculation. In our case we need to set `scale=4`. Now you are asking, Why four places? Because we are multiplying the result of the division by 100, we will have only two active decimal places with data, and the last two will have zeros in the end. Let's look at the following example to clear up any confusion:

```
PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)
```

From the previous values, the result of this calculation is 7.1000 percent of used space because `$SW_USED` is 15 MB and `$SW_TOTAL` is 211 MB. Now let's look more closely at the use of the `bc` utility. We are using command substitution with an enclosed here document. A here document has the following form:

```
command <<LABEL

...
Input to the command
...

LABEL
```

This is a neat way of providing input to a command that usually requires user input, and this is why it is referred to as a *here document*, because the input is *here*, as opposed to being entered by the user at the command line.

In our case we use the here document inside command substitution, which is specified by the `$(commands)` notation. The result is assigned to the `PERCENT_USED` variable. The calculation of the percent free is done in the same manner except that this time we divide the MB of free space into the MB of total swap space, as shown here:

```
PERCENT_FREE=$(bc <<EOF
scale=4
```

```
($SW_FREE / $SW_TOTAL) * 100
EOF
)
```

In our case, using the previously acquired data we get a result of 92.4100 percent. With these two calculations we have all of the data required for our standard output. We will cover the `bc` command, and we will use it again in the next section that deals with the Solaris swap-space monitor. Take a look at the entire shell script in Listing 18-10, and pay particular attention to the boldface type.

```
#!/usr/bin/ksh
#
# SCRIPT: linux_swap_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 5/31/2007
# REV: 1.1.P
#
# PLATFORM: Linux Only
#
#
# PURPOSE: This shell script is used to produce a report of
#          the system's swap space statistics including:
#
#       Total paging space in MB, MB of free paging space,
#       MB of used paging space, % of paging space used, and
#       % of paging space free
#
# REV LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
################################################################
################ DEFINE VARIABLES HERE #####################

THISHOST=$(hostname)   # Host name of this machine
PC_LIMIT=65            # Upper limit of Swap space percentage
                       # before notification

################################################################
################ INITIALIZE THE REPORT #####################

echo "\nSwap Space Report for $THISHOST\n"
date
```

Listing 18-10 Linux_swap_mon.ksh shell script listing

```
############################################################
############## CAPTURE AND PROCESS THE DATA #################

free -m | grep -i swap | while read junk SW_TOTAL SW_USED SW_FREE
do

# Use the bc utility in a here document to calculate
# the percentage of free and used swap space.

PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)

PERCENT_FREE=$(bc <<EOF
scale=4
($SW_FREE / $SW_TOTAL) * 100
EOF
)

     # Produce the rest of the paging space report:
     echo "\nTotal Amount of Swap Space:\t${SW_TOTAL}MB"
     echo "Total KB of Swap Space Used:\t${SW_USED}MB"
     echo "Total KB of Swap Space Free:\t${SW_FREE}MB"
     echo "\nPercent of Swap Space Used:\t${PERCENT_USED}%"
     echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

     # Grab the integer portion of the percent used to
     # test for the over limit threshold

     INT_PERCENT_USED=$(echo $PERCENT_USED | cut -d. -f1)

     if (( PC_LIMIT <= INT_PERCENT_USED ))
     then
         # Swap space limit has exceeded the threshold, send notification

          tput smso # Turn on reverse video!
          echo "\n\nWARNING: Paging Space has Exceeded the ${PC_LIMIT}%
Upper Limit!\n"
          tput rmso # Turn off reverse video!
     fi

done

echo "\n"
```

Listing 18-10 (*continued*)

Notice the `while read` portion of the `free -m` command. We use the variable `junk` as a place to store the first field, which contains `Swap:`. This is the same technique that we used in the HP-UX section of this chapter. If we had additional data fields after the MB of free swap space, we could use a `junk2` variable to hold this extra unneeded data, too.

Also notice that our `bc` calculations are done inside our `while read` loop. Even though I have indented everything else inside the loop for readability, you *cannot* use indention with these here documents! If you do indent anything, the calculation will fail, and this is extremely difficult to troubleshoot because it *looks* as if it should work.

Let's take a look at the shell script in Listing 18-10 in action in Listing 18-11.

```
#  ./linux_swap_mon.ksh

Swap Space Report for bambam

Sun Jun  9 13:01:06 EDT 2007

Total Amount of Swap Space:     211MB
Total KB of Swap Space Used:    16MB
Total KB of Swap Space Free:    195MB

Percent of Swap Space Used:     7.5800%

Percent of Swap Space Free:     92.4100%
```

Listing 18-11 Linux_swap_mon.ksh in action

Notice that the last two numbers in the percentage of used and free swap space are zeros. I am leaving the task of removing these two numbers as an exercise for you to complete. Now let's move on to the OpenBSD swap-space monitor.

OpenBSD Swap-Space Monitor

As we discussed previously, OpenBSD uses swapping and utilizes the `swapctl` command to view swap-space usage. The `swapctl` command has several command switches, but the only ones we are concerned with are `-l` and `-k`. The swap information given by the `swapctl -lk` command is listed in KB by using the `-k` switch. Percentages presented in the output show the percentage of current usage, so we need a calculation here. Additionally, because we have our swap-space usage indicated in KB, we need to multiply by 1,000 for our standard MB output. The following shows the `swapctl -lk` command output:

```
# swapctl -lk
Device      1K-blocks     Used    Avail Capacity  Priority
swap_device    500000        0   500000     0%    0
```

As we can see in this OpenBDS output, the system has 500 MB of swap space defined, and currently 0 percent and 0 MB are utilized.

We start our shell script by extracting the fields of interest using an `awk` statement for the `$2`, `$3`, `$4`, and `$5`, as shown here:

```
swapctl -lk | tail +2 | awk '{print $2, $3, $4, $5}' \
            | while read KB_TOT KB_USED KB_AVAIL PC_USED
```

Now that we have captured the data, let's do some calculations. We have the total, used, and free KB of paging-space statistics. We first need to multiply each of these values by 1,000 to get our standard MB values. The last step is to remove the `%` suffix and calculate the percent of free swap space. Pay attention to the boldface text in Listing 18-12.

```
#!/bin/Bash
#
# SCRIPT: OpenBSD_swap_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 10/31/2007
# REV: 1.2.p
#
# PLATFORM: OpenBSD Only
#
# PURPOSE: This shell script is used to produce a report of
#          the system's paging space statistics including:
#
#       Total paging space in MB, MB of Free paging space,
#       MB of Used paging space, % of paging space Used, and
#       % of paging space Free
#
# REV LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
############################################################
################ DEFINE VARIABLES HERE ####################

PC_LIMIT=65             # Percentage Upper limit of paging space
                        # before notification

THISHOST=$(hostname)   # Host name of this machine
PAGING_STAT=/tmp/paging_stat.out # Paging Stat hold file

############################################################
################ INITIALIZE THE REPORT ####################

echo "\nPaging Space Report for $THISHOST\n"
```

Listing 18-12 OpenBSD_swap_mon.ksh script

```
date

############################################################
############# CAPTURE AND PROCESS THE DATA #################

# Load the data in a file without the column headings

swapctl -lk | tail +2 | awk '{print $2, $3, $4, $5}' \
            | while read KB_TOT KB_USED KB_AVAIL PC_USED
do

     (( TOTAL = KB_TOT / 1000 ))
     (( MB_USED = KB_USED / 1000 ))
     (( MB_FREE = KB_AVAIL / 1000 ))
     PC_FREE_NO_PC=$(echo $PC_USED | awk -F '%' '{print $1}')
     (( PC_FREE = 100 - PC_FREE_NO_PC ))

     # Produce the rest of the paging space report:
     echo "\nTotal MB of Paging Space:\t${TOTAL}MB"
     echo "Total MB of Paging Space Used:\t${MB_USED}MB"
     echo "Total MB of Paging Space Free:\t${MB_FREE}MB"
     echo "\nPercent of Paging Space Used:\t${PC_USED}"
     echo "\nPercent of Paging Space Free:\t${PC_FREE}%\n"
done


# Check for paging space exceeded the predefined limit

if (( PC_LIMIT <= PC_FREE_NO_PC ))
then
     echo "\n\nWARNING: Paging Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"
fi
```

Listing 18-12 (*continued*)

Notice in Listing 18-12 that we used `awk` to extract the desired fields of data, as opposed to using the `junk` and `junk2` variable assignments as we previously did. This is a cleaner method for extracting data.

We also used `awk` to extract the `%` suffix from the percent used, as opposed to using the `cut` command. We define `%` as the delimiter, or field separator, using the `-F '%'` switch notation with `awk`. Listing 18-13 shows the `OpenBSD_swap_mon.ksh` shell script in action.

```
# ksh ./OpenBSD_swap_mon.ksh

Paging Space Report for fred
```

Listing 18-13 OpenBSD_swap_mon.ksh script in action

```
Mon Oct 29 18:01:28 EST 2007

Total MB of Paging Space:       500MB
Total MB of Paging Space Used:  0MB
Total MB of Paging Space Free:  500MB

Percent of Paging Space Used:   0%

Percent of Paging Space Free:   100%
```

Listing 18-13 (*continued*)

Notice with OpenBSD that to execute a shell script on the command line, you must specify the executing shell on the command line. Let's move on to the Solaris swap-space monitor.

Solaris Swap-Space Monitor

The Solaris operating system does swapping, and the command to gather swap space statistics is `swap -s`. The output of the `swap -s` command is all on a single line, which is different from any of the previously studied operating systems. Additionally, all of the swap-space statistics are measured in KB as opposed to MB, which is our required measurement. Before we go any further, let's look at the Solaris `swap -s` output:

```
# swap -s
total: 56236k bytes allocated + 9972k reserved = 66208k used, 523884k
available
```

As you can see, the output is a little difficult to understand. We are interested in two fields for our purposes: the ninth field, 66208k, and the eleventh field, 523884k. The ninth field represents the total amount of used swap space, and the eleventh field represents the free swap space, where both are measured in KB. We are not interested in the amount of reserved and allocated swap space individually, but in the total, which is located in the ninth field.

When I say the ninth and eleventh fields I am specifying that each field in the output is separated by at least one blank space, also called white space. From this definition it is intuitively obvious that `total:`, `+`, `=`, and `used` are all individual fields in the command output. This is important to know because we are going to use two `awk` statements to extract the `$9` and `$11` fields and assign them to different variables.

As in the Linux section, we do not have any percentages given in the output, so we must calculate the percentage of free swap space and the percentage of used swap space. If you looked at the Linux section, then you already know how to use the `bc` utility. If you jumped to the Solaris section, we will cover this again here.

The `bc` utility is a precision calculator language that is a UNIX level built-in program. For our purposes, we have two techniques for using the `bc` utility. We can place our

mathematical statement in an `echo` statement and pipe the output to `bc`. The second option is to use a *here* document with command substitution. For this exercise we are going to use the second option and look at the use of a here document.

To calculate the percentage of used swap space, we divide the total amount of swap space into MB of used swap space and multiply this total by 100, as shown in the following statement:

```
($SW_USED / $SW_TOTAL) * 100
```

This looks simple enough, but how do we get a floating-point output in a shell script? This is where the `bc` utility comes in. There is an option in `bc` called **scale**. The scale indicates how many decimal places to the right of the decimal point we want to use in the calculation. In our case we need to set `scale=4`. Now you are asking, Why four places? Because we are multiplying the result of the division by 100, we will have only two active decimal places with data after this multiplication, and the last two will have zeros. Let's look at this next example to clear up any confusion:

```
PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)
```

From the previous values the result of this calculation is 11.2200 percent of used space because `$SW_USED` is 66 MB and `$SW_TOTAL` is 590 MB. Now let's look more closely at the use of the `bc` utility. We are using command substitution with an enclosed here document. A here document has the following form:

```
command <<LABEL

...
Input to the command
...

LABEL
```

This is a neat way of providing input to a command that usually requires user input, and this is why it is referred to as a *here* document — the input is *here*, as opposed to being entered by the user at the command line.

In our case, we use the here document inside command substitution, which is specified by the `$(commands)` notation. The result is assigned to the `PERCENT_USED` variable. The calculation of the percent free is done in the same manner except that this time we divide the MB of free space into the MB of total swap space, as shown in the code that follows:

```
PERCENT_FREE=$(bc <<EOF
scale=4
($SW_FREE / $SW_TOTAL) * 100
```

```
EOF
)
```

In our case, the percentage of used swap space is 11.220 percent, and the percentage of free swap space is 88.7800 percent. Of course, to get the total swap space we added the `$9` and `$11` fields together. The entire shell script is shown in Listing 18-14.

```
#!/usr/bin/ksh
#
# SCRIPT: SUN_swap_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 5/31/2007
# REV: 1.1.P
#
# PLATFORM: Solaris Only
#
# PURPOSE: This shell script is used to produce a report of
#          the system's swap space statistics including:
#
#       Total paging space in MB, MB of free paging space,
#       MB of used paging space, % of paging space used, and
#       % of paging space free
#
# REV LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
#################################################################
################ DEFINE VARIABLES HERE ####################

PC_LIMIT=65             # Upper limit of Swap space percentage
                        # before notification
THISHOST=$(hostname)    # Host name of this machine

#################################################################
################ INITIALIZE THE REPORT ####################

echo "\nSwap Space Report for $THISHOST\n"
date

#################################################################
############# CAPTURE AND PROCESS THE DATA ################

# Use two awk statements to extract the $9 and $11 fields
# from the swap -s command output
```

Listing 18-14 SUN_swap_mon.ksh shell script

```
SW_USED=$(swap -s | awk '{print $9}' | cut -dk -f1)
SW_FREE=$(swap -s | awk '{print $11}' | cut -dk -f1)

# Add SW_USED to SW_FREE to get the total swap space

((SW_TOTAL = SW_USED + SW_FREE))

# Calculate the percent used and percent free using the
# bc utility in a here document with command substitution

PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)

PERCENT_FREE=$(bc <<EOF
scale=4
($SW_FREE / $SW_TOTAL) * 100
EOF
)

# Convert the KB measurements to MB measurements

((SW_TOTAL_MB = SW_TOTAL / 1000))
((SW_USED_MB  = SW_USED / 1000))
((SW_FREE_MB  = SW_FREE / 1000))

# Produce the remaining part of the report

echo "\nTotal Amount of Swap Space:\t${SW_TOTAL_MB}MB"
echo "Total KB of Swap Space Used:\t${SW_USED_MB}MB"
echo "Total KB of Swap Space Free:\t${SW_FREE_MB}MB"
echo "\nPercent of Swap Space Used:\t${PERCENT_USED}%"
echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

# Grab the integer portion of the percent used

INT_PERCENT_USED=$(echo $PERCENT_USED | cut -d. -f1)

# Check to see if the percentage used maximum threshold
# has been exceeded

if (( PC_LIMIT <= INT_PERCENT_USED ))
then
    # Percent used has exceeded the threshold, send notification

    tput smso # Turn on reverse video!
```

Listing 18-14 (*continued*)

```
    echo "\n\nWARNING: Swap Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"
    tput rmso # Turn off reverse video!
fi

echo "\n"
```

Listing 18-14 (*continued*)

Notice how we used two `awk` statements using two separate reads of the `swap -s` command output. These two measurements occur in such a short amount of time that it should not matter; however, you may want to change the method to a single read and store the output in a variable or file. I'm leaving this modification task for you to do as an exercise. In the next step we add the KB of free swap space to the KB of used swap space to find the total swap space on the system.

With these three KB measurements we calculate the percentage of used and free swap space using the `bc` utility inside a command substitution statement, while using a here document to provide input to the `bc` command. There is still one more step before we are ready to print the report — convert the KB measurements to MB. We only need to divide our KB measurements by 1,000, and we are ready to go. Next the remaining portions of the report are printed, and then the test is made to see if the percent used has exceeded the threshold limit, specified by the `PC_LIMIT` variable. If the percentage used limit is exceeded, then reverse video is turned on, the warning message is displayed, and reverse video is turned back off. The `SUN_swap_mon.ksh` shell script is shown in action in Listing 18-15.

```
#  ./SUN_swap_mon.ksh

Swap Space Report for wilma

Mon Jun 10 03:50:29 EDT 2007

Total Amount of Swap Space:     590MB
Total KB of Swap Space Used:    66MB
Total KB of Swap Space Free:    524MB

Percent of Swap Space Used:     11.2200%

Percent of Swap Space Free:     88.7800%
```

Listing 18-15 SUN_swap_mon.ksh script in action

Notice that the percentages are given as floating-pointing numbers, but there are two extra zeros. These two extra zeros are the result of specifying in the `bc` here document that the `scale=4` and then multiplying the result by 100. As an exercise, add a command to remove the two extra zeros. Are we finished? Not yet; we still need

a single shell script that will run on all five operating systems. Let's move on to the all-in-one section.

All-in-One Paging- and Swap-Space Monitor

Let's put everything together by making the five previous scripts into functions and use the **uname** command in a `case` statement to determine the UNIX flavor, and thus which function to run.

Let's look at this combined shell script, and we will go over the details at the end. The combined shell script is called `all-in-one_swapmon.ksh` and is shown in Listing 18-16.

```
#!/usr/bin/ksh
#
# SCRIPT: all-in-one_swapmon.ksh
#
# AUTHOR: Randy Michael
# DATE: 5/31/2007
# REV: 3.0.P
#
# PLATFORM: AIX, Solaris, HP-UX and Linux Only
#
# PURPOSE: This shell script is used to produce a report of
#          the system's paging or swap space statistics including:
#
#       Total paging space in MB, MB of Free paging space,
#       MB of Used paging space, % of paging space Used, and
#       % of paging space Free
#
# REV LIST:
#
# 11/5/2007 -- Randy Michael
#
# REVISION: Added a function for OpenBSD swap monitoring and
# changed the case statement controlling correct usage
# depending on the OS.
#
###############
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
#############################################################
################ DEFINE VARIABLES HERE ####################

PC_LIMIT=65             # Upper limit of Swap space percentage
                        # before notification
```

Listing 18-16 all-in-one_swapmon.ksh shell script

```
THISHOST=$(hostname)   # Host name of this machine

############################################################
################ INITIALIZE THE REPORT ####################

echo "\nSwap Space Report for $THISHOST\n"
date

############################################################
################ DEFINE FUNCTIONS HERE ####################

function SUN_swap_mon
{
############# CAPTURE AND PROCESS THE DATA ################

# Use two awk statements to extract the $9 and $11 fields
# from the swap -s command output

SW_USED=$(swap -s | awk '{print $9}' | cut -dk -f1)
SW_FREE=$(swap -s | awk '{print $11}' | cut -dk -f1)

# Add SW_USED to SW_FREE to get the total swap space

((SW_TOTAL = SW_USED + SW_FREE))

# Calculate the percent used and percent free using the
# bc utility in a here documentation with command substitution

PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)

PERCENT_FREE=$(bc <<EOF
scale=4
($SW_FREE / $SW_TOTAL) * 100
EOF
)

# Convert the KB measurements to MB measurements

((SW_TOTAL_MB = SW_TOTAL / 1000))
((SW_USED_MB  = SW_USED / 1000))
((SW_FREE_MB  = SW_FREE / 1000))

# Produce the remaining part of the report
```

Listing 18-16 (*continued*)

```
echo "\nTotal Amount of Swap Space:\t${SW_TOTAL_MB}MB"
echo "Total KB of Swap Space Used:\t${SW_USED_MB}MB"
echo "Total KB of Swap Space Free:\t${SW_FREE_MB}MB"
echo "\nPercent of Swap Space Used:\t${PERCENT_USED}%"
echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

# Grab the integer portion of the percent used

INT_PERCENT_USED=$(echo $PERCENT_USED | cut -d. -f1)

# Check to see if the percentage used maximum threshold
# has been exceeded

if (( PC_LIMIT <= INT_PERCENT_USED ))
then
    # Percent used has exceeded the threshold, send notification

    tput smso # Turn on reverse video!
    echo "\n\nWARNING: Swap Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"
    tput rmso # Turn off reverse video!
fi

echo "\n"
}

############################################################

function Linux_swap_mon
{
############## CAPTURE AND PROCESS THE DATA #################

free -m | grep -i swap | while read junk SW_TOTAL SW_USED SW_FREE
do

# Use the bc utility in a here document to calculate
# the percentage of free and used swap space.

PERCENT_USED=$(bc <<EOF
scale=4
($SW_USED / $SW_TOTAL) * 100
EOF
)

PERCENT_FREE=$(bc <<EOF
scale=4
($SW_FREE / $SW_TOTAL) * 100
EOF
```

Listing 18-16 (*continued*)

```
)

     # Produce the rest of the paging space report:
     echo "\nTotal Amount of Swap Space:\t${SW_TOTAL}MB"
     echo "Total KB of Swap Space Used:\t${SW_USED}MB"
     echo "Total KB of Swap Space Free:\t${SW_FREE}MB"
     echo "\nPercent of Swap Space Used:\t${PERCENT_USED}%"
     echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

     # Grap the integer portion of the percent used to
     # test for the over limit threshold

     INT_PERCENT_USED=$(echo $PERCENT_USED | cut -d. -f1)

     if (( PC_LIMIT <= INT_PERCENT_USED ))
     then
          tput smso
          echo "\n\nWARNING: Paging Space has Exceeded the \
${PC_LIMIT}% Upper Limit!\n"
          tput rmso
     fi

done

echo "\n"
}

#############################################################

function HP_UX_swap_mon
{
############## CAPTURE AND PROCESS THE DATA #################

# Start a while read loop by using the piped in input from
# the swapinfo -tm command output.


swapinfo -tm | grep dev | while read junk SW_TOTAL SW_USED \
                               SW_FREE PERCENT_USED junk2
do
    # Calculate the percentage of free swap space

    ((PERCENT_FREE = 100 - $(echo $PERCENT_USED | cut -d% -f1) ))

    echo "\nTotal Amount of Swap Space:\t${SW_TOTAL}MB"
    echo "Total MB of Swap Space Used:\t${SW_USED}MB"
    echo "Total MB of Swap Space Free:\t${SW_FREE}MB"
    echo "\nPercent of Swap Space Used:\t${PERCENT_USED}"
```

Listing 18-16 (*continued*)

```
    echo "\nPercent of Swap Space Free:\t${PERCENT_FREE}%"

    # Check for paging space exceeded the predefined limit

    if (( PC_LIMIT <= $(echo $PERCENT_USED | cut -d% -f1) ))
    then
        # Swap space is over the predefined limit, send notification

       tput smso # Turn on reverse video!
         echo "\n\nWARNING: Swap Space has Exceeded the\
 ${PC_LIMIT}% Upper Limit!\n"
         tput rmso # Turn reverse video off!
    fi

done

echo "\n"
}

############################################################

function AIX_paging_mon
{
################ DEFINE VARIABLES HERE ####################

PAGING_STAT=/tmp/paging_stat.out # Paging Stat hold file

############################################################
############# CAPTURE AND PROCESS THE DATA #################

# Load the data in a file without the column headings

lsps -s | tail +2 > $PAGING_STAT

# Start a while loop and feed the loop from the bottom using
# the $PAGING_STAT file as redirected input

while read TOTAL PERCENT
do
     # Clean up the data by removing the suffixes
     PAGING_MB=$(echo $TOTAL | cut -d 'MB' -f1)
     PAGING_PC=$(echo $PERCENT | cut -d% -f1)

     # Calculate the missing data: %Free, MB used and MB free
     (( PAGING_PC_FREE = 100 - PAGING_PC ))
     (( MB_USED = PAGING_MB * PAGING_PC / 100 ))
     (( MB_FREE = PAGING_MB - MB_USED ))
```

Listing 18-16 (*continued*)

```
      # Produce the rest of the paging space report:
      echo "\nTotal MB of Paging Space:\t$TOTAL"
      echo "Total MB of Paging Space Used:\t${MB_USED}MB"
      echo "Total MB of Paging Space Free:\t${MB_FREE}MB"
      echo "\nPercent of Paging Space Used:\t${PERCENT}"
      echo "\nPercent of Paging Space Free:\t${PAGING_PC_FREE}%"

      # Check for paging space exceeded the predefined limit
      if ((PC_LIMIT <= PAGING_PC))
      then
           # Paging space is over the limit, send notification

           tput smso  # Turn on reverse video!

          echo "\n\nWARNING: Paging Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"

           tput rmso  # Turn off reverse video
      fi

done < $PAGING_STAT

rm -f $PAGING_STAT

# Add an extra new line to the output

echo "\n"
}

############################################################

function OpenBSD_swap_mon
{
############################################################
############# CAPTURE AND PROCESS THE DATA #################

# Load the data in a file without the column headings

swapctl -lk | tail +2 | awk '{print $2, $3, $4, $5}' \
            | while read KB_TOT KB_USED KB_AVAIL PC_USED
do
      (( TOTAL = KB_TOT / 1000 ))
      (( MB_USED = KB_USED / 1000 ))
      (( MB_FREE = KB_AVAIL / 1000 ))
      PC_FREE_NO_PC=$(echo $PC_USED | awk -F '%' '{print $1}')
      (( PC_FREE = 100 - PC_FREE_NO_PC ))

      # Produce the rest of the paging space report:
```

Listing 18-16 (*continued*)

```
     echo "\nTotal MB of Paging Space:\t${TOTAL}MB"
     echo "Total MB of Paging Space Used:\t${MB_USED}MB"
     echo "Total MB of Paging Space Free:\t${MB_FREE}MB"
     echo "\nPercent of Paging Space Used:\t${PC_USED}"
     echo "\nPercent of Paging Space Free:\t${PC_FREE}%\n"
done


# Check for paging space exceeded the predefined limit

if (( PC_LIMIT <= PC_FREE_NO_PC ))
then
     echo "\n\nWARNING: Paging Space has Exceeded the ${PC_LIMIT}% \
Upper Limit!\n"
fi
}

############################################################
################## BEGINNING OF MAIN #######################
############################################################

# Find the Operating System and execute the correct function

case $(uname) in

     AIX) AIX_paging_mon
     ;;
     HP-UX) HP_UX_swap_mon
     ;;
     Linux) Linux_swap_mon
     ;;
     SunOS) SUN_swap_mon
     ;;
     OpenBSD) OpenBSD_swap_mon
     ;;
     *) echo "\nERROR: Unsupported Operating System...EXITING\n"
        exit 1
esac

# End of all-in-one_swapmon.ksh
```

Listing 18-16 (*continued*)

As you can see, there is not much to converting a shell script into a function. The only thing required is that you extract out of each shell script the core code that makes up the shell script. The common code should remain in the main body of the new shell script. In our example, the common parts are the `PC_LIMIT`, which defines the over limit percentage threshold, and the hostname of the machine. Everything else is unique to each of the five shell scripts and functions here.

To turn a shell script into a function, all you need to do is a cut and paste in your favorite editor and copy the main body of the shell script into a new shell script. This new function can be enclosed into a function in two ways, as follows:

```
function was_a_shell_script
{
shell_script_code_here
}
```

or

```
was_a_shell_script ()
{
shell_script_code_here
}
```

I tend to use the `function` definition instead of the POSIX C language type definition. This is a personal choice, but both types of function definitions produce the same result. If you are a C programmer you will most likely prefer the POSIX C type notation. I like to use the `function` definition so that a person coming behind me trying to edit the shell script will know intuitively that this is a function because it is spelled out in the definition.

Once we have each of the four functions defined inside a single shell script, we need to know only on which operating system we are running and to execute the appropriate function. To determine the UNIX flavor, we use the `uname` command. The following `case` statement runs the correct swap/paging function as defined by the UNIX flavor:

```
case $(uname) in

     AIX)   AIX_paging_mon
     ;;
     HP-UX) HP_UX_swap_mon
     ;;
     Linux) Linux_swap_mon
     ;;
     SunOS) SUN_swap_mon
     ;;
     OpenBSD) OpenBSD_swap_mon
     ;;
     *) echo "\nERROR: Unsupported Operating System...EXITING...\n"
        exit 1
     ;;
esac
```

Notice that if the UNIX flavor is not AIX, HP-UX, Linux, OpenBSD, or SunOS, the shell script gives an error message and exits with a return code of 1.

Other Options to Consider

As usual, we can always improve on a shell script, and this chapter is no exception. Each of these shell scripts could stand a little improvement one way or another because there is not just one way to do anything! I have noted a few suggestions here.

Event Notification

The only event notification I have included in these shell scripts and functions is a warning message presented to the user in reverse video. I usually add email notification to my alphanumeric pager also. Just use your preferred method of remote notification, and you will have the upper hand on keeping your systems running smoothly.

Log File

A log file is a great idea for this type of monitoring. I suggest that any time the threshold is crossed that a log file receives an appended message. This is simple to do by using the `tee -a` command in a pipe. See the `man` page on `tee` for more information.

Scheduled Monitoring

If you are going to do paging/swap monitoring, it is an extremely good idea to do this monitoring on a scheduled basis. Different shops have different requirements. I like to monitor every 15 minutes from 6:00 a.m. until 10:00 p.m. This way I have covered everyone from the East Coast to the West Coast. If you have locations in other time zones around the world, you may want to extend your coverage to include these times as well. The monitoring is up to you, but it is best to take a proactive approach and find the problem before someone tells *you* about it. You may also discover some trends of heavy system loads to help in troubleshooting.

Summary

In this chapter we started out with a predetermined output that we had to adhere to for any UNIX flavor, and we held to it. Each operating system presented us with a new challenge because in each instance we lacked part of the required data and we had to do a little math to get into the correct format. Each of these shell scripts is a unique piece of work, but in the end we combined everything into a single multi-OS functioning shell script that determines what the UNIX flavor is and executes the proper function to get the desired result. If the UNIX flavor is not AIX, HP-UX, Linux, OpenBSD, or Solaris, the shell script gives an error message and exits cleanly.

In this chapter we covered various techniques to extract and calculate data to produce an identical output no matter the UNIX flavor. I hope you gained some valuable experience with dealing with the challenge of handling different types of

data to produce a standard report. This type of experience is extremely important for heterogeneous environments. In the next chapter, we will look at some techniques to monitor the load on a system.

Lab Assignments

1. Schedule the `all-in-one_swapmon.ksh` shell script to execute, as the root user, every 10 minutes between the hours of 6:00 a.m. and 1:00 a.m., Monday through Friday, and 9:00 a.m. and 9:00 p.m. on Saturday and Sunday.
2. Add logging capability to the `all-in-one_swapmon.ksh` shell script.
3. Add email alerts when paging space is running low. This is a three-step alert system. Use a yellow alert for ranges between 65 percent and 75 percent. Use a red alert for ranges between 76 percent and 90 percent. Use a code blue alert for the most severe alerts, starting at 91 percent. The email alerts should specify the alert level and all swap/paging details. Code blue alerts must be repeated every 5 minutes until the problem is corrected, thus disabling the cron execution. (Tip: check for another instance of this same script executing. Remember that function calls show up in the process table also!)

CHAPTER 19

Monitoring System Load

Have you ever seen a system start slowing down as the wait state and uptime stats rise, and finally the system crashes? I have, and it is not a pretty sight when all of the heads start popping up over the cubes. In this chapter, we are going to look at some techniques to monitor the CPU load on a UNIX system. When the system is unhappy running under a heavy load, there are many possible causes. The system may have a runaway process that is producing a ton of zombie processes every second, or you have a tape drive failure and your database redo logs fill up a filesystem and cause the database and SAP to stop. In any case, we want to be proactive in catching a symptom in the early stages of loading down the system.

There are really only three basic things to look at when monitoring the CPU load on the system. First, look at the load statistics produced as part of the **uptime** command. This output indicates the average number of jobs in the run queue over the last 5, 10, and 15 minutes in AIX, and 1, 5, and 15 minutes for HP-UX, Linux, OpenBSD, and Solaris. The second measurement to look at is the percentages of CPU usage for system/kernel, user/application, I/O wait state, and idle time. These four measurements can be obtained from the **iostat**, **vmstat**, and **sar** outputs. We will look at each of these commands individually. The final step in monitoring the CPU load is to find the CPU hogs. Of course, to get a good feel for how the system is running we need to look at more system statistics, such as memory and swap-space utilizations, as well as disk and network I/O. Each of these can cause high I/O waits. Most systems have a `top`-like monitoring tool that shows the CPU process users in descending order of CPU usage. The output in Listing 19-1 is a sample output for the `top` command on a Linux machine.

```
top - 07:40:25 up 1 day, 21:32,  2 users,  load average: 0.22, 0.08, 0.02
Tasks: 110 total,   2 running, 108 sleeping,   0 stopped,   0 zombie
Cpu(s): 49.1%us,  1.0%sy,  0.0%ni, 49.9%id,  0.0%wa,  0.0%hi,  0.0%si,
0.0%st
```

Listing 19-1 Example top output on a Linux machine

```
Mem:   1027744k total,   732264k used,   295480k free,   173800k buffers
Swap:  2031608k total,        0k used,  2031608k free,   273460k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 9536 root      20   0 72480 1188  996 R  100  0.1   0:17.04
 random_file.bas
 9535 root      20   0 14580 1064  808 R    0  0.1   0:00.04 top
    1 root      20   0 10328  692  576 S    0  0.1   0:01.37 init
    2 root      15  -5     0    0    0 S    0  0.0   0:00.00 kthreadd
    3 root      RT  -5     0    0    0 S    0  0.0   0:00.00 migration/0
    4 root      15  -5     0    0    0 S    0  0.0   0:00.00 ksoftirqd/0
    5 root      RT  -5     0    0    0 S    0  0.0   0:00.03 watchdog/0
    6 root      RT  -5     0    0    0 S    0  0.0   0:00.00 migration/1
    7 root      15  -5     0    0    0 S    0  0.0   0:00.00 ksoftirqd/1
    8 root      RT  -5     0    0    0 S    0  0.0   0:00.04 watchdog/1
    9 root      15  -5     0    0    0 S    0  0.0   0:00.23 events/0
   61 root      15  -5     0    0    0 S    0  0.0   0:00.05 kblockd/1
   64 root      15  -5     0    0    0 S    0  0.0   0:00.00 kacpid
   65 root      15  -5     0    0    0 S    0  0.0   0:00.00 kacpi_notify
```

Listing 19-1 (*continued*)

We can also use the **ps auxw** command that displays CPU % usage for each process in descending order from the top. This chapter is limited to looking at the CPU load and the run queue statistics. We will look at each of these in this chapter. First, let's look at installing the **sysstat** package on Linux and the command syntax for the commands we're using.

Installing the System-Statistics Programs in Linux

If you are running a Linux system and cannot find the `iostat`, `sar`, and other commands to gather system statistics, you need to install the `sysstat` package. The easiest way to do the installation is to use `yum` (`apt` works, too). Listing 19-2 shows the `sysstat` package network installation using `yum`.

```
[root@yogi ~]# yum install sysstat
Loading "installonlyn" plugin
Setting up Install Process
Setting up repositories
core                                                                    [1/4]
updates                                                                 [2/4]
adobe-linux-i386                                                        [3/4]
extras                                                                  [4/4]
Reading repository metadata in from local files
Parsing package install arguments
```

Listing 19-2 Example of installing the sysstat package using yum

```
Resolving Dependencies
--> Populating transaction set with selected packages. Please wait.
---> Downloading header for sysstat to pack into transaction set.
sysstat-6.0.1-3.2.1.i386. 100% |=========================|  15 kB
    00:00
---> Package sysstat.i386 0:6.0.1-3.2.1 set to be updated
--> Running transaction check

Dependencies Resolved

================================================================================
=========
 Package                Arch       Version          Repository        Size
================================================================================
=========
Installing:
 sysstat                i386       6.0.1-3.2.1      core              154 k

Transaction Summary
================================================================================
========
Install      1 Package(s)
Update       0 Package(s)
Remove       0 Package(s)
Total download size: 154 k
Is this ok [y/N]: y
Downloading Packages:
(1/1): sysstat-6.0.1-3.2. 100% |=========================| 154 kB
    00:02
Running Transaction Test
Finished Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing: sysstat                      ########################## [1/1]

Installed: sysstat.i386 0:6.0.1-3.2.1
Complete!
```

Listing 19-2 (*continued*)

The nice thing about `yum` and `apt` is that any dependencies the installation has are resolved prior to installing the target package. For more information on `yum` and `apt`, see the manual pages (**man yum** and **man apt**, respectively). You can also download and install the RPM packages.

NOTE **You should pick either `yum` or `apt` and stick with that particular method. Do not use both, because some packages do not update cleanly if you do.**

Syntax

As usual with UNIX, there is not just one way to monitor a system for load. We can use any of the following commands to get system load statistics: `uptime`, `iostat`, `sar`, and `vmstat`. To illustrate the ability of each of these commands, we are going to take a look at each one of the commands individually.

NOTE In the next sections we are selecting specific fields of data from command output. It is up to *you* to individually verify that the command outputs I present are indeed the output fields that your particular UNIX flavor *and OS version* produce for each of the five operating systems presented here. Just be aware that different versions of the same operating system sometimes produce different output for the same command.

Syntax for uptime

Using the `uptime` command is the most direct method of getting a measurement of the system load. Part of the output of the `uptime` command is a direct measure of the average length of the run queue over the last 5 minutes, 10 minutes, and the last measurement is averaged over 15 minutes on AIX. For HP-UX, Linux, OpenBSD, and Solaris the `uptime` command is a direct measure of the average length of the run queue over the last 1 minute, 5 minutes, and the last measurement is averaged over 15 minutes. The length of the run queue is a direct measurement of how busy the CPU is by the number of runable processes waiting for CPU time, as an average, over a period of time.

We do need to put a bit of logic into the use of the `uptime` command in a shell script because the output field's position varies depending on how long it has been since the last system reboot, and, possibly, which UNIX flavor we are running. We are going to test each of these options to show why it is important to consider the output data you are using in a shell script.

We have five possible variations to look at in this `uptime` command output, as you will see. The first is 1–59 minutes, the second is 1–23 hours, and the third measurement is when the system has been up for more than 24 hours. After the system has been up for at least one day, we have to consider hours and minutes again! Believe it or not, the load fields continue to float during each day. When the system reaches an *exact* hour, to the minute, of the reboot day, an `hrs` field is added; this is true for the *anniversary* first hour, too. In this case, the `min` field is added along with the `day` field. Follow along through the next few examples to see how the fields vary during these five stages.

We are going to look at the last three fields, the load average. This load average is the number of runable processes in the run queue averaged over the last 1 minute, 5 minutes, and 15 minutes, since this is a Linux system, but all UNIX flavors have the same type behavior.

Linux

This `uptime` output is shown when the Linux system has been up 20 minutes. The fields we want are in the `$9`, `$10`, and `$11` positions:

```
# uptime
  12:17pm  up 20 min,  4 users,  load average: 2.29, 2.17, 1.51
```

This `uptime` output is shown when the Linux system has been up for 1 hour and 7 minutes. The fields we want are in the `$8`, `$9`, and `$10` positions:

```
# uptime
  1:04pm  up  1:07,  4 users,  load average: 1.74, 2.10, 2.09
```

This `uptime` output is shown when the Linux system has been up for 12 days, 19 hours, and 3 minutes. The fields we want are in the `$10`, `$11`, and `$12` positions:

```
# uptime
  4:40pm  up 12 days, 19:03,  4 users,  load average: 1.52, 0.47, 0.16
```

This `uptime` output is shown when the Linux system has been up for 14 days and exactly 17 minutes. The fields we want are in the `$11`, `$12`, and `$13` positions:

```
# uptime
  9:16pm  up 14 days, 17 mins,  9 users,  load average: 1.31, 1.82, 1.61
```

This `uptime` output is shown when the Linux system has been up for 14 days and exactly 5 hours. The fields we want are in the `$11`, `$12`, and `$13` positions:

```
# uptime
  9:16pm   up 14 days, 5 hr,  2 users,  load average: 1.01, 1.69, 1.84
```

What's the Common Denominator?

The most obvious common denominator is that the load statistics are the last three fields of the output. The load average on a Linux machine shows the average number of runable processes over the preceding 1-, 5-, and 15-minute intervals. Because the field positions vary, we need to look at the total number of fields in the output of the uptime command and subtract 2 for the first field, subtract 1 for the second field, and the third field is the last field in the output. By knowing the exact fields where the data resides we can directly access the last three fields of output. In the ''Scripting the Solutions'' section we will look closely at the details.

Syntax for iostat

To get the CPU load statistics from the `iostat` command, we have to be a little flexible between UNIX flavors. For AIX and HP-UX machines, we need to use the `-t` command

switch. For Linux and Solaris, we use the `-c` switch. And for OpenBSD, we use the `-C` switch. Due to the UNIX flavor dependency, we need to first check the operating system using the `uname` command. Then, based on the operating system, we can assign the proper switch to the `iostat` command.

Let's look at the output of the `iostat` command for each of our UNIX flavors, AIX, HP-UX, Linux, OpenBSD, and Solaris.

AIX

```
# iostat -t 10 2

tty:     tin       tout    avg-cpu:  % user     % sys      % idle     % iowait
         0.2       33.6                2.4       8.2        84.0        5.4
         0.1     1188.4               16.8      83.2         0.0        0.0
```

In this AIX output, notice the last four fields, `%user`, `%sys`, `%idle`, and `%iowait`. These four fields are the ones that we want to extract. The field positions are `$3`, `$4`, `$5`, and `$6`, and we want just the last line of the output because the first line of data is an average since the last system reboot. Also, notice that the rows of actual data consist entirely of numeric characters. This will become important as we look at each operating system.

HP-UX

```
# iostat -t 10 2

                      tty           cpu
                    tin tout   us  ni  sy  id
                      0    2    1   0   1  97

  device    bps     sps    msps

  c0t6d0      0     0.0     1.0


                tty              cpu
              tin tout        us  ni  sy  id
                0    0        41   0  59   0

  device    bps     sps    msps

  c0t6d0      1     0.1     1.0
```

Notice that the HP-UX output differs greatly from the AIX `iostat` output. The only thing that distinguishes the CPU data from the rest of the data is the fact that the entire row of data is numeric. This is an important characteristic of the HP-UX data, and it will help us extract the data that we are looking for. Notice again that the first set of statistics is an average since the last system reboot.

Linux

```
[root@booboo scripts]# iostat -c 10 2
Linux 2.6.23.1-21.fc7 (booboo)  12/17/2007

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.03    0.04    0.04    0.06    0.00   99.83

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          23.48    0.00   26.67    0.10    0.00   49.75
```

Notice that the Linux `iostat` command switch for CPU statistics is `-c`, instead of the `-t` that we used for AIX and HP-UX. In this output we have the average of the CPU load since the last reboot, and then the current data is shown in the second command output. Also notice that the actual data presented is entirely numeric. It looks as if we have a trend.

OpenBSD

```
# iostat -C 10 2
             cpu
 us ni sy in id
  0  0  0  0 99
 73  0 26  1  0
```

The OpenBSD `iostat -C 10 2` output shows the load average statistics since the last system reboot on the first line of data and the most current data on the last line. Notice again that the actual data is a row of numeric characters. Knowing that the data is always on a row that is numeric characters allows us to greatly simplify writing this shell script.

Solaris

```
iostat -c 10 2

     cpu
 us sy wt id
  3 14  0 83
 17 81  0  2
```

The Solaris `iostat -c` output shows the load average statistics since the last system reboot on the first line of data and the most current data on the last line. Notice again that the actual data is a row of numeric characters. Knowing that the data is always on a row that is numeric characters allows us to greatly simplify writing this shell script.

What Is the Common Denominator?

The real common denominator for the `iostat` command data between each UNIX flavor is that we have a row of numeric data only. The only thing remaining is the fields for each OS, which vary by field and content. We want just the last line of data, which is the most current data. From this set of criteria, let's write a little code to see how we can specify the correct switch and set the proper fields to extract. We can do both of these tasks with a single `case` statement, as shown in Listing 19-3.

```
OS=$(uname)

case $OS in
AIX|HP-UX)    SWITCH='-t'
              F1=3
              F2=4
              F3=5
              F4=6
              echo "\nThe Operating System is $OS\n"
              ;;
Linux)        SWITCH='-c'
              F1=1
              F2=3
              F3=4
              F4=5
              echo "\nThe Operating System is $OS\n"
              ;;
SunOS)        SWITCH='-c'
              F1=1
              F2=2
              F3=3
              F4=4
              echo "\nThe Operating System is $OS\n"
              ;;
OpenBSD)      SWITCH="-C"
              F1=1
              F2=2
              F3=3
              F4=5
              ;;
*)            echo "\nERROR: $OS is not a supported operating system\n"
              echo "\n\t...EXITING...\n"
              exit 1
              ;;
esac
```

Listing 19-3 case statement for the iostat fields of data

Notice in Listing 19-3 that we use a single `case` statement to set up the environment for the shell script to run the correct `iostat` command for each of the four

UNIX flavors. If the UNIX flavor is not in the list, the user receives an error message before the script exits with a return code of 1, one. Later we will cover the entire shell script.

Syntax for sar

The `sar` command stands for *system activity report*. Using the `sar` command we can take direct sample intervals for a specific time period. For example, we can take 4 samples that are 10 seconds each, and the `sar` command automatically averages the results for us.

Let's look at the output of the `sar` command for each of our UNIX flavors, AIX, HP-UX, Linux, and Solaris. OpenBSD does not support the `sar` command.

AIX

```
# sar 10 4

AIX yogi 3 5 00CF8DEF4C00    12/20/07

System configuration: lcpu=32

12:51:26    %usr    %sys    %wio   %idle   physc
12:51:36       6       2       0      92   16.00
12:51:46       8       2       0      90   16.01
12:51:56       8       2       1      89   15.97
12:52:06       9       5       2      84   16.00

Average        7       3       1      89   16.00
```

Now let's look at the average of the samples directly:

```
# sar 10 4 | grep Average

Average        7       3       1      89   16.00
```

HP-UX

```
# sar 10 4

HP-UX dino B.10.20 A 9000/715    11/26/07

22:48:10    %usr    %sys    %wio   %idle
22:48:20      40      60       0       0
22:48:30      40      60       0       0
22:48:40      12      19       0      68
22:48:50       0       0       0     100

Average       23      35       0      42
```

Now let's look at the average of the samples directly:

```
# sar 10 4 | grep Average

Average       25      37       0      38
```

Linux

```
[root@booboo scripts]# sar 10 4
Linux 2.6.20-1.2316.fc5 (booboo)  12/20/2007

12:51:43 PM       CPU     %user     %nice   %system   %iowait     %idle
12:51:53 PM       all     95.10      0.00      4.90      0.00      0.00
12:52:03 PM       all     76.32      0.00      5.29      0.00     18.38
12:52:13 PM       all     22.68      0.00      2.70      0.00     74.63
12:52:23 PM       all     93.00      0.00      4.50      0.00      2.50
Average:          all     71.76      0.00      4.35      0.00     23.89
```

Now let's look at the average of the samples directly:

```
# sar 10 4 | grep Average

Average:          all     71.76      0.00      4.35      0.00     23.89
```

Solaris

```
# sar 10 4

SunOS wilma 5.8 Generic i86pc    11/26/07

23:01:55    %usr    %sys    %wio   %idle
23:02:05       1       1       0      98
23:02:15      12      53       0      35
23:02:25      15      67       0      18
23:02:35      21      59       0      21

Average       12      45       0      43
```

Now let's look at the average of the samples directly:

```
# sar 10 4 | grep Average
Average       12      45       0      43
```

What Is the Common Denominator?

With the `sar` command the only common denominator is that we can always `grep` on the word "Average." Like the `iostat` command, the fields vary between some UNIX

flavors. We can use a similar `case` statement to extract the correct fields for each UNIX flavor, as shown in Listing 19-4.

```
OS=$(uname)

case $OS in
AIX|HP-UX|SunOS)
       F1=2
       F2=3
       F3=4
       F4=5
       echo "\nThe Operating System is $OS\n"
       ;;
Linux)
       F1=3
       F2=5
       F3=6
       F4=7
       echo "\nThe Operating System is $OS\n"
       ;;
*)     echo "\nERROR: $OS is not a supported operating system\n"
       echo "\n\t...EXITING...\n"
       exit 1
       ;;
esac
```

Listing 19-4 case statement for the sar fields of data

Notice in Listing 19-4 that a single `case` statement sets up the environment for the shell script to select the correct fields from the `sar` command for each of the five UNIX flavors. If the UNIX flavor is not in the list, the user receives an error message before the script exits with a return code of 1, one. Later we will cover the entire shell script.

Syntax for vmstat

The `vmstat` command stands for *virtual memory statistics*. Using the `vmstat` command, we can get a lot of data about the system, including memory, paging space, page faults, and CPU statistics. We are concentrating on the CPU statistics in this chapter, so let's stay on track. The `vmstat` commands also allow us to take direct samples over intervals for a specific time period. The `vmstat` command does not do any averaging for us; however, we are going to stick with two intervals. The first interval is the average of the system load since the last system reboot, like the `iostat` command. The last line contains the most current sample.

Let's look at the output of the `vmstat` command for each of our UNIX flavors, AIX, HP-UX, Linux, OpenBSD, and Solaris.

AIX

```
[root:yogi]@/scripts# vmstat 30 2
kthr     memory             page              faults        cpu
----- ----------- ------------------------ ------------ -----------
 r  b   avm   fre  re  pi  po  fr   sr  cy  in   sy  cs us sy id wa
 0  0 23936   580   0   0   0   0    2   0 103 2715 713  8 25 67  0
 1  0 23938   578   0   0   0   0    0   0 115 9942 270 24 76  0  0
```

The last line of output is what we are looking for. This is the average of the CPU load over the length of the interval. We want just the last four columns in the output. The fields that we want to extract for AIX are in positions `$14`, `$15`, `$16`, and `$17`.

HP-UX

```
# vmstat 30 2
       procs          memory            page            faults      cpu
r   b  w  avm   free  re  at   pi  po   fr  de  sr   in    sy  cs  us sy id
0  39  0  8382  290  122  26   2    0    0    0  3   128   2014 146 14 21 65
1  40  0  7532  148  345  71   0    0    0    0  0   108   5550 379 29 43 27
```

The HP-UX `vmstat` output is a long string of data. Notice for the CPU data that HP-UX supplies only three values: user part, system part, and the CPU idle time. The fields that we want to extract are in positions `$16`, `$17`, and `$18`.

Linux

```
[root@yogi scripts]# vmstat 30 2
procs -----------memory---------- ---swap-- -----io---- --system-- -----
cpu------
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id
 wa st
 0  0 197248  69768   4480 177328    0    0     2    14   17    7  5  1 93  0  0

 3  0 197248  68892   4540 177344    0    0     0    41 1123 2376 74  5 21
 0  0
```

Like AIX, the Linux `vmstat` output for CPU activity has four fields: user part, system part, the CPU idle time, and I/O wait. The fields that we want to extract are in positions `$13`, `$14`, `$15`, and `$16`.

OpenBSD

```
# vmstat 30 2
procs   memory        page                    disks     traps          cpu
r b w    avm    fre   flt  re  pi  po  fr  sr wd0 cd0  int   sys   cs us sy id
2 0 0   7556 446888     5   0   0   0   0   0   0   0  235    60   14  9  4 87
2 0 0   7560 446888     3   0   0   0   0   0   0   0  229 20157   16 73 27  0
```

Like HP-UX, the OpenBSD `vmstat` output for CPU activity has three fields: user part, system part, and the CPU idle time. The fields that we want to extract are in positions `$17`, `$18`, and `$19`.

Solaris

```
# vmstat 30 2
 procs     memory            page            disk        faults      cpu
 r b w   swap  free  re  mf pi po fr de sr cd f0 s0 --  in   sy  cs us sy id
 0 0 0 558316 33036  57 433  2  0  0  0  0  0  0  0 111  500  77  2  8 90
 0 0 0 556192 29992 387 2928 0  0  0  0  0  1  0  0  0 155 2711 273 14 60 26
```

As with HP-UX and Linux, the Solaris `vmstat` output for CPU activity consists of the last three fields: user part, system part, and the CPU idle time. The fields that we want to extract are in positions `$20`, `$21`, and `$22`.

What Is the Common Denominator?

There are at least two common denominators for the `vmstat` command output between the UNIX flavors. The first is that the CPU data is in the last fields. On AIX the data is in the last four fields with the added I/O wait state. HP-UX, Linux, OpenBSD, and Solaris do not list the wait state. The second common factor is that the data is always on a row that is entirely numeric. Again, we need a `case` statement to parse the correct fields for the command output. Take a look at Listing 19-5 for the exact fields we want to capture.

```
OS=$(uname)

case $OS in
AIX)
       F1=14
       F2=15
       F3=16
       F4=17
       echo "\nThe Operating System is $OS\n"
       ;;
HP-UX)
       F1=16
       F2=17
       F3=18
       F4=1 # This "F4=1" is bogus and not used for HP-UX
       echo "\nThe Operating System is $OS\n"
       ;;
Linux)
```

Listing 19-5 case statement for the vmstat fields of data

```
        F1=13
        F2=14
        F3=15
        F4=16
        echo "\nThe Operating System is $OS\n"
        ;;
OpenBSD)
        F1=17
        F2=18
        F3=19
        F4=1 # This "F4=1" is bogus and not used for Linux
        echo "\nThe Operating System is $OS\n"
        ;;
SunOS)
        F1=20
        F2=21
        F3=22
        F4=1 # This "F4=1" is bogus and not used for SunOS
        echo "\nThe Operating System is $OS\n"
        ;;
*)      echo "\nERROR: $OS is not a supported operating system\n"
        echo "\n\t...EXITING...\n"
        exit 1
        ;;
esac
```

Listing 19-5 (*continued*)

Notice in Listing 19-5 that the `F4` variable gets a valid assignment only on the AIX match. For HP-UX, Linux, OpenBSD, and Solaris, the `F4` variable is assigned the value of the `$1` field, specified by the `F4=1` variable assignment. This bogus assignment is made so that we do not need a special `vmstat` command statement for each operating system. You will see how this works in detail in the ''Scripting the Solutions'' section.

Scripting the Solutions

Each of the techniques presented is slightly different in execution and output. Some options need to be timed over an interval for a user-defined amount of time, measured in seconds. We can get an immediate load measurement using the `uptime` command, but the `sar`, `iostat`, and `vmstat` commands require the user to specify a period of time to measure over and the number of intervals to sample the load. If you enter the `sar`, `iostat`, or `vmstat` commands without any arguments, the statistics presented are an average since the last system reboot. Because we want current statistics, the scripts must supply a period of time to sample. We are always going to initialize the `INTERVAL` variable to equal 2. The first line of output is measured since the last system reboot, and the second line is the current data that we are looking for.

Let's look at each of these commands in separate shell scripts in the following sections.

Using uptime to Measure the System Load

Using `uptime` is one of the best indicators of the system load. The last columns of the output represent the average of the *run queue* over the last 5, 10, and 15 minutes for an AIX machine, and over the last 1, 5, and 10 minutes for HP-UX, Linux, OpenBSD, and Solaris. A run queue is where jobs wanting CPU time line up for their turn for some processing time in the CPU. The priority of the process, or on some systems a *thread*, has a direct influence on how long a job has to wait in line before getting more CPU time. The lower the priority, the more CPU time. The higher the priority, the less CPU time.

The `uptime` command always has an average of the length of the run queue. The threshold trigger value that you set will depend on the normal load of your system. My little desktop AIX box starts getting very slow when the run queue hits 2, but the p570 at work typically runs with a run queue value over 10 because it is a multiprocessor machine running a multi-terabyte database, as shown here:

```
# uptime
  04:08PM   up 96 days,   8:46,  2 users,  load average: 14.13, 11.08, 6.37
```

With these differences in acceptable run queue levels, you will need to tailor the threshold level for notification on a machine-by-machine basis.

Scripting with the uptime Command

Scripting the `uptime` solution is a short shell script, and the response is immediate. As you remember in the ''Syntax'' section, we had to follow the floating load statistics as the time since the last reboot moved from minutes, to hours, and even days after the machine was rebooted. But knowing that the data always resides in the last three fields helps us create a simple method of directly accessing the data. The good thing is that the floating fields are consistent across the UNIX flavors studied in this book. Check out the `uptime_loadmon.Bash` script in Listing 19-6 and we will cover the details at the end.

```
#!/bin/Bash
#
# SCRIPT: uptime_loadmon.Bash
# AUTHOR: Randy Michael
# DATE: 12/16/2007
# REV: 1.0.P
# PLATFORM: AIX, HP-UX, Linux, OpenBSD, and Solaris
#
# PURPOSE: This shell script uses the "uptime" command to
```

Listing 19-6 uptime_loadmon.Bash shell script

```
#          extract the most current load average data, which
#          in this case is the average number of jobs in the
#          run queue.
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check script syntax without any execution
#
#####################################################
############# DEFINE VARIABLES HERE #################
#####################################################

MAXLOAD=2.00   # Trigger value to warn

# Extract the integer and decimal parts of $MAXLOAD value
MAXLOAD_INT=$(echo $MAXLOAD | awk -F '.' '{print $1}')
MAXLOAD_DEC=$(echo $MAXLOAD | awk -F '.' '{print $2}')

# Check the UNIX flavor for the correct uptime values
# AIX specifies load as the last 5, 10, and 15 minutes.
# The other UNIX flavors specify the load in the last
# 1, 5, and 15 minutes.

case $(uname) in
AIX)     L1=5
         L2=10
         L3=15
         ;;
  *)
         L1=1
         L2=5
         L3=15
         ;;
esac


#####################################################
# DEFINE FUNCTIONS HERE
#####################################################


function get_max
{
# This function returns the number of arguments
# presented to the function

(($# == 0)) && return -1
echo $#
}
```

Listing 19-6 (*continued*)

```
#####################################################
#  BEGINNING OF MAIN
#####################################################

echo -e "\nGathering System Load Average using the \"uptime\" command\n"

# This next command statement extracts the latest
# load statistics no matter what the UNIX flavor is.

NUM_ARGS=$(get_max $(uptime)) # Get the total number of fields in
uptime output

((NUM_ARGS == -1)) && echo "ERROR: get_max Function Error...EXITING..."\
                   && exit 2

# Find the exact fields that represent the run queue load stats

ARGM2=$(((NUM_ARGS - 2)))  # Subtract 2 from the total
ARGM1=$(((NUM_ARGS - 1)))  # Subtract 1 from the total
ARGM=$NUM_ARGS             # Last value in string

# Extract the run queue data in the last 3 fields of uptime output

uptime | sed s/,//g | awk '{print $'$ARGM2', $'$ARGM1', $'$ARGM'}' \
       | while read LAST5 LAST10 LAST15
do
    # Separate the values into integer and decimal parts

    echo $LAST5 | awk -F '.' '{print $1, $2}' \
    | while read INT DEC
      do
          # Test if the load is above the trigger threshold
        if (( INT > MAXLOAD_INT ))
       then
           echo -e "\nWARNING: System load has \
reached ${LAST5}\n"
       elif (( INT == MAXLOAD_INT ))
       then
           # Since the integer values are at threshold we need
           # to check the decimal values

             if (( DEC >= MAXLOAD_DEC ))
             then
               echo -e "\nWARNING: System load has \
reached ${LAST5}\n"
           fi
       fi
```

Listing 19-6 (*continued*)

```
        echo "System load average for the last $L1 minutes is $LAST5"
        echo "System load average for the last $L2 minutes is $LAST10"
        echo "System load average for the last $L3 minutes is $LAST15"
        echo  -e "\nThe load threshold is set to ${MAXLOAD}\n"
    done
done
```

Listing 19-6 (*continued*)

The `uptime_loadmon.Bash` shell script in Listing 19-6 shows how we can extract output fields that vary in number. We know that the run queue statistics always reside in the last three fields of the `uptime` command output. So, to know how many fields are present in the output, we call the function `get_max`, which takes as its `$1` argument the `uptime` command's output. This function returns `-1` if the function is called but does not have any arguments, or a positive integer value of the number of fields present in the `uptime` command output. On my Fedora Linux machine that has been up for more than 15 days, the `uptime` command produces output with 12 fields of data. So, we are interested the data in fields `$10`, `$11`, and `$12` for our run queue measurements as shown here:

```
[root@booboo ~]# uptime
 15:17:50 up 15 days,  6:36, 10 users,  load average: 0.94, 0.63, 0.49
```

The fields vary in number depending on how long the system has been up since the last reboot. The ''uptime'' changes from minutes, hours, and days the longer the system is up and running. With this type of varying output, we cannot just hard code specific fields; we have to do a little math first. The code to find our fields of interest is shown here in Listing 19-7.

```
# Find the exact fields that represent the run queue load stats

ARGM2=$(((NUM_ARGS - 2)))  # Subtract 2 from the total
ARGM1=$(((NUM_ARGS - 1)))  # Subtract 1 from the total
ARGM=$NUM_ARGS             # Last value in string
```

Listing 19-7 Code to extract the last three fields of command output

Knowing the total number of fields allows us to capture the first load value directly by subtracting 2 from the value returned by the `get_max` function. To get the second field, we subtract 1, and the last field is the final value we want to capture. We directly extract the correct fields using the following regular expression in the highlighted `awk` statement in bold text:

```
uptime | sed s/,//g | awk '{print $'$ARGM2', $'$ARGM1', $'$ARGM'}' \
       | while read LAST5 LAST10 LAST15
```

If our `uptime` output produces 12 fields of output, we are interested in fields `$10`, `$11`, and `$12`. We use the three field values we calculated in Listing 19-7 here in a regular expression to pick out exactly the fields we are interested in. So, the regular expression `$'$ARGM1'` specifies the `$10` field. Following along with this, the regular expression `$'$ARGM2'` points to the `$11` field, and so on.

The three data fields are assigned to the `LAST5`, `LAST10`, and `LAST15` variables. You can see the `uptime_loadmon.ksh` shell script in action in Listings 19-8 and 19-9.

```
#  ./uptime_loadmon.ksh

Gathering System Load Average using the "uptime" command


System load value is currently at 1.86
The load threshold is set to 2.00
```

Listing 19-8 Script in action under "normal" load

Listing 19-8 shows the `uptime_loadmon.ksh` shell script in action on a machine that is under a normal load. Listing 19-9 shows the same machine under an excessive load — at least, it is excessive for this little machine.

```
#  ./uptime_loadmon.ksh

Gathering System Load Average using the "uptime" command


WARNING: System load has reached 2.97


System load value is currently at 2.97
The load threshold is set to 2.00
```

Listing 19-9 Script in action under "excessive" load

This is about all there is to using the `uptime` command. Let's move on to the `sar` command.

Using sar to Measure the System Load

Some UNIX flavors have the `sar` data collection set up by default. This `sar` data is presented when the `sar` command is executed without any switches. The data that is displayed is automatically collected at scheduled intervals throughout the day and compiled into a report at day's end. By default, the system keeps a month's worth of data available for online viewing. This is great for seeing the basic trends of the

machine as it is loaded through the day. If we want to collect data at a specific time of day for a specific period of time, we need to add the number of seconds for each interval and the total number of intervals to the `sar` command. The final line in the output is an average of all of the previous sample intervals.

This is where our shell script comes into play. By using a shell script with the times and intervals defined, we can take samples of the system load over small or large increments of time without interfering with the system's collection of `sar` data. This can be a valuable tool for things like taking hundreds of small incremental samples as a development application is being tested. Of course, this technique can also help in troubleshooting just about any application. Let's look at how we script the solution.

Scripting with the sar Command

For each of our UNIX flavors, the `sar` command produces four CPU load statistics. The outputs vary somewhat, but the basic idea remains the same. In each case, we define an `INTERVAL` variable specifying the total number of samples to take and a `SECS` variable to define the total number of seconds for each sample interval. Notice that we used the variable `SECS` as opposed to `SECONDS`. We do not want to use the variable `SECONDS`, because it is a shell built-in variable used for timing in a shell and it increments automatically. As I stated in the introduction, this book uses variable names in uppercase so the reader will quickly know that the code is referencing a variable; however, in the real world you may want to use the lowercase version of the variable name. It really would not matter here because we are defining the variable value and then using it within the same second, hopefully.

The next step in this shell script is to define which positional fields we need to extract to get the `sar` data for each of the UNIX operating systems. For this step we use a `case` statement using the `uname` command output to define the fields of data. It turns out that AIX, HP-UX, and SunOS operating systems all have the `sar` data located in the `$2`, `$3`, `$4`, and `$5` positions. Linux differs in this respect with the `sar` data residing in the `$3`, `$5`, `$6`, and `$7` positions. In each case, these field numbers are assigned to the `F1`, `F2`, `F3`, and `F4` variables inside the `case` statement. Let's look at the `sar_loadmon.Bash` shell script in Listing 19-10 and cover the remaining details at the end. OpenBSD does not support `sar`.

```
#!/bin/Bash
#
# SCRIPT: sar_loadmon.ksh
# AUTHOR: Randy Michael
# DATE: 12/20/2007
# REV: 1.0.P
# PLATFORM: AIX, HP-UX, Linux, and Solaris
#
# PURPOSE: This shell script takes multiple samples of the CPU
```

Listing 19-10 sar_loadmon.Bash shell script

```
#          usage using the command. The average of
#          sample periods is shown to the user based on the
#          UNIX operating system that this shell script is
#          executing on. Different UNIX flavors have differing
#          outputs and the fields vary too.
#
# REV LIST:
#
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
######################################################
############# DEFINE VARIABLES HERE ################
######################################################

SECS=30  # Defines the number of seconds for each sample
INTERVAL=10 # Defines the total number of sampling intervals
OS=$(uname) # Defines the UNIX flavor

######################################################
##### SET UP THE ENVIRONMENT FOR EACH OS HERE ######
######################################################

# These point to the correct field in the
# command output for each UNIX flavor.

case $OS in
AIX|HP-UX|SunOS)
      F1=2
      F2=3
      F3=4
      F4=5
      echo -e "\nThe Operating System is $OS\n"
      ;;
Linux)
      F1=3
      F2=5
      F3=6
      F4=7
      echo -e "\nThe Operating System is $OS\n"
      ;;
*)    echo -e "\nERROR: $OS is not a supported operating system\n"
      echo -e "\n\t...EXITING...\n"
      exit 1
      ;;
esac
```

Listing 19-10 (*continued*)

```
#####################################################
######## BEGIN GATHERING STATISTICS HERE ##########
#####################################################

echo -e "Gathering CPU Statistics using sar...\n"
echo "There are $INTERVAL sampling periods with"
echo "each interval lasting $SECS seconds"
echo -e "\n...Please wait while gathering statistics...\n"

# This "sar" command takes $INTERVAL samples, each lasting
# $SECS seconds. The average of this output is captured.

sar $SECS $INTERVAL | grep Average \
          | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
          | while read FIRST SECOND THIRD FOURTH
do
     # Based on the UNIX Flavor, tell the user the
     # result of the statistics gathered.

     case $OS in
     AIX|HP-UX|SunOS)
           echo -e "\nUser part is ${FIRST}%"
           echo "System part is ${SECOND}%"
           echo "I/O Wait is ${THIRD}%"
           echo -e "Idle time is ${FOURTH}%\n"
           ;;

     Linux)
           echo -e "\nUser part is ${FIRST}%"
           echo "Nice part is ${SECOND}%"
           echo "System part is ${THIRD}%"
           echo -e "Idle time is ${FOURTH}%\n"
           ;;
     esac
done
```

Listing 19-10 (*continued*)

In the shell script in Listing 19-10 we start by defining the data time intervals. In these definitions we are taking 10 interval samples of 30 seconds each, for a total of 300 seconds, or 5 minutes. Then we grab the UNIX flavor using the `uname` command and assigning the operating system value to the `OS` variable. Following these definitions we define the data fields that contain the `sar` data for each operating system.

Now we get to the interesting part where we actually take the data sample. Look at the following `sar` command statement, and we will decipher how it works:

```
sar $SECS $INTERVAL | grep Average \
          | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
          | while read FIRST SECOND THIRD FOURTH
```

We really need to look at the statement one pipe at a time. In the very first part of the statement we take the sample(s) over the defined number of intervals. Consider the following statement and output:

```
SECS=30
INTERVAL=10

# sar $SECS $INTERVAL

AIX yogi 3 5 00CF7EFE1D00    12/19/07

System configuration: lcpu=32

14:38:38    %usr    %sys    %wio   %idle   physc
14:38:41       6       2       0      92   16.01
14:38:44       5       3       0      92   15.99
14:38:47       6       2       0      92   15.99
14:38:50       8       3       0      89   16.00
14:38:53       6       3       0      91   16.01
14:38:56       6       2       0      91   15.99
14:38:59       6       2       0      92   16.01
14:39:02      10       6       0      84   15.99
14:39:05      10       6       0      85   15.97
14:39:08       5       4       0      92   16.01

Average        7       3       0      90   16.00
```

The preceding output is produced by the first part of the `sar` command statement. Then, all of this output is piped to the next part of the statement, as shown here:

```
sar $SECS $INTERVAL | grep Average

Average        7       3       0      90   16.00
```

Now we have the row of data that we want to work with, which we grepped out using the word `Average` as a pattern match. The next step is to extract the positional fields that contain the data for user, system, I/O wait, and idle time for AIX. Remember in the previous script section that we defined the field numbers and assigned them to the `F1`, `F2`, `F3`, and `F4` variables, which in our case results in `F1=2`, `F2=3`, `F3=4`, and `F4=5`. Using the following extension to our previous command we get the following statement:

```
sar $SECS $INTERVAL | grep Average \
    | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}'
```

Notice that we continued the command statement on the next line by placing a backslash (\) at the end of the first line of the statement. In the `awk` part of the statement you can see a confusing list of dollar signs and ''`F`'' variables. The purpose of this set of

characters is to *directly* access what the "F" variables are pointing to. Let's run through this in detail by example.

The F1 variable has the value 2 assigned to it. This value is the positional location of the first data field that we want to extract. So we want to access the value at the $2 position. Make sense? When we extract the $2 data we get the value 7, as defined in the previous step. Instead of going in this roundabout method, we want to *directly* access the *field* that the F1 variable points to. Just remember that a variable is only a pointer to a value, nothing more! We want to point directly to what another variable is pointing to. The solution is to use the following regular expression:

```
$'$F1'
```

or

```
$\$F1
```

In any case, the innermost pointer ($) must be *escaped*, which removes the special meaning. For this shell script we use the $'$F1' notation. The result of this notation, in this example, is 7, which is the value that we want. This is not smoke and mirrors when you understand how it works.

The final part of the sar command statement is to pipe the four data fields to a while loop so that we can do something with the data, which is where we end the sar statement and enter the while loop.

The only thing that we do in the while loop is to display the results based on the UNIX flavor. The sar_loadmon.ksh shell script is in action in Listing 19-11.

```
# ./sar_loadmon.ksh

The Operating System is AIX

Gathering CPU Statistics using sar...

There are 10 sampling periods with
each interval lasting 30 seconds

...Please wait while gathering statistics...


User part is 7%
System part is 3%
I/O wait state is 0%
Idle time is 90%
```

Listing 19-11 sar_loadmon.ksh shell script in action

From the output presented in Listing 19-11 you can see that the shell script queries the system for its operating system, which is AIX here. Then the user is notified of the sampling periods and the length of each sample period. The output is displayed to the user by field. That is it for using the `sar` command. Now let's move on to the `iostat` command.

Using iostat to Measure the System Load

The `iostat` command is mostly used to collect disk storage statistics, but by using the `-t`, `-c`, or, `-C` command switch, depending on the operating system, we can see the CPU statistics as we saw them in the syntax section for the `iostat` command. We are going to create a shell script using the `iostat` command and use almost the same technique as we did in the last section.

Scripting with the iostat Command

In this shell script we are going to use a very similar technique to the `sar` shell script in the previous section. The difference is that we are going to take only two intervals with a long sampling period. As an example, the `INTERVAL` variable is set to `2`, and the `SECS` variable is set to `300` seconds, which is 5 minutes. Also, because we have two possible switch values, `-t` and `-c`, we need to add a new variable called `SWITCH`. Let's look at the `iostat_loadmon.Bash` shell script in Listing 19-12, and we will cover the differences at the end in more detail.

```
#!/bin/Bash
#
# SCRIPT: iostat_loadmon.ksh
# AUTHOR: Randy Michael
# DATE: 12/20/2007
# REV: 1.0.P
# PLATFORM: AIX, HP-UX, Linux, OpenBSD, and Solaris
#
# PURPOSE: This shell script take two samples of the CPU
#          usage using the command. The first set of
#          data is an average since the last system reboot. The
#          second set of data is an average over the sampling
#          period, or $INTERVAL. The result of the data acquired
#          during the sampling period is shown to the user based
#          on the UNIX operating system that this shell script is
#          executing on. Different UNIX flavors have differing
#          outputs and the fields vary too.
#
# REV LIST:
#
```

Listing 19-12 iostat_loadmon.Bash shell script

```
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
##################################################
############# DEFINE VARIABLES HERE ###############
##################################################

SECS=300   # Defines the number of seconds for each sample
INTERVAL=2    # Defines the total number of sampling intervals
STATCOUNT=0   # Initializes a loop counter to 0, zero
OS=$(uname)   # Defines the UNIX flavor

##################################################
##### SET UP THE ENVIRONMENT FOR EACH OS HERE ######
##################################################

# These "F-numbers" point to the correct field in the
# command output for each UNIX flavor.

case $OS in
AIX|HP-UX)  SWITCH='-t'
            F1=3
            F2=4
            F3=5
            F4=6
            echo -e "\nThe Operating System is $OS\n"
            ;;
Linux)      SWITCH='-c'
            F1=1
            F2=3
            F3=4
            F4=6
            echo -e "\nThe Operating System is $OS\n"
            ;;
SunOS)      SWITCH='-c'
            F1=1
            F2=2
            F3=3
            F4=4
            echo -e "\nThe Operating System is $OS\n"
            ;;
OpenBSD)    SWITCH='-C'
            F1=1
            F2=2
            F3=3
            F4=5
            echo -e "\nThe Operating System is $OS\n"
```

Listing 19-12 (*continued*)

```
            ;;
*)          echo -e "\nERROR: $OS is not a supported operating system\n"
            echo -e "\n\t...EXITING...\n"
            exit 1
            ;;
esac

#####################################################
######## BEGIN GATHERING STATISTICS HERE ##########
#####################################################

echo -e "Gathering CPU Statistics using vmstat...\n"
echo "There are $INTERVAL sampling periods with"
echo "each interval lasting $SECS seconds"
echo -e "\n...Please wait while gathering statistics...\n"

# Use "iostat" to monitor the CPU utilization and
# remove all lines that contain alphabetic characters
# and blank spaces. Then use the previously defined
# field numbers, for example, F1=4,to point directly
# to the 4th position, for this example. The syntax
# for this techniques is ==>  $'$F1'.

iostat $SWITCH $SECS $INTERVAL | egrep -v '[a-zA-Z]|^$' \
         | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
         | while read FIRST SECOND THIRD FOURTH
do
 if ((STATCOUNT == 1)) # Loop counter to get the second set
 then                  # of data produced by "iostat"

     case $OS in # Show the results based on the UNIX flavor
     AIX)
           echo -e "\nUser part is ${FIRST}%"
           echo "System part is ${SECOND}%"
           echo "Idle part is ${THIRD}%"
           echo -e "I/O wait state is ${FOURTH}%\n"
           ;;
     HP-UX|OpenBSD)
           echo -e "\nUser part is ${FIRST}%"
           echo "Nice part is ${SECOND}%"
           echo "System part is ${THIRD}%"
           echo -e "Idle time is ${FOURTH}%\n"
           ;;
     SunOS|Linux)
           echo -e "\nUser part is ${FIRST}%"
           echo "System part is ${SECOND}%"
           echo "I/O Wait is ${THIRD}%"
           echo -e "Idle time is ${FOURTH}%\n"
```

Listing 19-12 (*continued*)

```
            ;;
        esac

    fi
    ((STATCOUNT = STATCOUNT + 1)) # Increment the loop counter
done
```

Listing 19-12 (*continued*)

The similarities are striking between the `sar` implementation and the `iostat` script shown in Listing 19-12. At the top of the shell script we define an extra variable, `STATCOUNT`. This variable is used as a loop counter, and it is initialized to 0, zero. We need this counter because we have only two intervals, and the first line of the output is the load average since the last system reboot. The second, and final, set of data is the CPU load statistics collected during our sampling period, so it is the most current data. Using a counter variable, `STATCOUNT`, we collect the data and assign it to variables on the second loop iteration, or when the `STATCOUNT` is equal to `1`, one.

In the next section we use the UNIX flavor given by the `uname` command in a `case` statement to assign the correct switch to use in the `iostat` command. This is also where the `F1`, `F2`, `F3`, and `F4` variables are defined with the positional placement of the data we want to extract from the command output.

Now comes the fun part. Let's look at the `iostat` command statement we use to extract the CPU statistics here:

```
iostat $SWITCH $SECS $INTERVAL | egrep -v '[a-zA-Z]|^$' \
          | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
          | while read FIRST SECOND THIRD FOURTH
```

The beginning of the `iostat` command statement uses the correct command switch, as defined by the operating system, and the sampling time and the number of intervals, which is two this time. From this first part of the `iostat` statement we get the following output on a Linux system:

```
SWITCH='-c'
SECS=300
INTERVAL=2

iostat $SWITCH $SECS $INTERVAL

Linux 2.6.23.8-34.fc7 (booboo)  12/19/2007

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.01    0.03    0.01    0.03    0.00   99.92

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          23.30    0.00   26.60    0.40    0.00   49.70
```

Remember that the first row of data is an average of the CPU load since the last system reboot, so we are interested in the last row of output. If you remember from the syntax section for the `iostat` command, the common denominator for this output is that the data rows are entirely numeric characters. Using this as the criteria to extract data, we add to our `iostat` command statement as shown here:

```
iostat $SWITCH $SECS $INTERVAL | egrep -v '[a-zA-Z]|^$'
```

The `egrep` addition to the preceding command statement does two things for us. First, it excludes all lines of the output that have alphabetic characters, leaving only the rows with numbers. The second thing we get is the removal of all blank lines from the output. Let's look at each of these.

To omit the alpha characters we use the `egrep` command with the `-v` option, which says to display everything in the output *except* the rows that the pattern matched. To specify all alpha characters we use the following regular expression:

```
[a-zA-Z]
```

Then to remove all blank lines we use the following expression:

```
^$
```

The caret character means *begins with*, and to specify blank lines we use the dollar sign (`$`). If you want to remove all of the lines in a file that are commented out with a hash mark (`#`), use `^#`.

When we join these two expressions in a single extended `grep` (`egrep`), we get the following extended regular expression:

```
egrep -v '[a-zA-Z]|^$'
```

At this point we are left with the following output:

```
  0.01    0.03    0.01    0.03    0.00   99.92
 23.30    0.00   26.60    0.40    0.00   49.70
```

This brings us to the next addition to the `iostat` command statement in the shell script. This is where we add the `awk` part of the statement using the `F1`, `F2`, `F3`, and `F4` variables, as shown here:

```
iostat $SWITCH $SECS $INTERVAL | egrep -v '[a-zA-Z]|^$' \
          | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
          | while read FIRST SECOND THIRD FOURTH
```

This is the same code that we covered in the preceding section, where we point *directly* to what another pointer is pointing to. For Linux, `F1=1`, `F2=2`, `F3=3`, and `F4=4`. With this information we know that `$'$F1'` on the first line of output is

equal to 0.01, and on the second row this same expression is equal to 23.30. Now that we have the values we have a final pipe to a while loop. Remember that in the while loop we have added a loop counter, STATCOUNT. On the first loop iteration, the while loop does nothing. On the second loop iteration, the values 23.30, 0.26.60, 0.40, and 49.70 are assigned to the variables FIRST, SECOND, THIRD, and FOURTH, respectively.

Using another case statement with the $OS value the output is presented to the user based on the operating system fields, as shown in Listing 19-13.

```
The Operating System is Linux

Gathering CPU Statistics using vmstat...

There are 2 sampling periods with
each interval lasting 300 seconds

...Please wait while gathering statistics...


User part is 39.35%
Nice part is 0.00%
System part is 31.59%
Idle time is 29.06%
```

Listing 19-13 iostat_loadmon.ksh shell script in action

Notice that the output is in the same format as the sar script output. This is all there is to the iostat shell script. Let's now move on to the vmstat solution.

Using vmstat to Measure the System Load

The vmstat shell script uses the exact same technique as the iostat shell script in the previous section. Only AIX produces four fields of output; the remaining UNIX flavors have only three data points to measure for the CPU load statistics. The rest of the vmstat output is for virtual memory statistics, which is the main purpose of this command anyway. Let's look at the vmstat script.

Scripting with the vmstat Command

When you look at this shell script for vmstat you will think that you just saw this shell script in the previous section. Most of these two shell scripts are the same, with only minor exceptions. Let's look at the vmstat_loadmon.Bash shell script in Listing 19-14 and cover the differences in detail at the end.

```
#!/bin/Bash
#
# SCRIPT: vmstat_loadmon.ksh
# AUTHOR: Randy Michael
# DATE: 12/20/2007
# REV: 1.0.P
# PLATFORM: AIX, HP-UX, Linux, OpenBSD, and Solaris
#
# PURPOSE: This shell script takes two samples of the CPU
#          usage using the command. The first set of
#          data is an average since the last system reboot. The
#          second set of data is an average over the sampling
#          period, or $INTERVAL. The result of the data acquired
#          during the sampling period is shown to the user based
#          on the UNIX operating system that this shell script is
#          executing on. Different UNIX flavors have differing
#          outputs and the fields vary too.
#
# REV LIST:
#
#
# set -n # Uncomment to check the script syntax without any execution
# set -x # Uncomment to debug this shell script
#
#####################################################
############# DEFINE VARIABLES HERE ################
#####################################################

SECS=300  # Defines the number of seconds for each sample
INTERVAL=2   # Defines the total number of sampling intervals
STATCOUNT=0  # Initializes a loop counter to 0, zero
OS=$(uname)  # Defines the UNIX flavor

#####################################################
##### SET UP THE ENVIRONMENT FOR EACH OS HERE ######
#####################################################

# These "F-numbers" point to the correct field in the
# command output for each UNIX flavor.

OS=$(uname)

case $OS in
AIX)
```

Listing 19-14 vmstat_loadmon.Bash shell script

```
        F1=14
        F2=15
        F3=16
        F4=17
        echo -e "\nThe Operating System is $OS\n"
        ;;
HP-UX)
        F1=16
        F2=17
        F3=18
        F4=1 # This "F4=1" is bogus and not used for HP-UX
        echo -e "\nThe Operating System is $OS\n"
        ;;
Linux)
        F1=13
        F2=14
        F3=15
        F4=16
        echo -e "\nThe Operating System is $OS\n"
        ;;
OpenBSD)
        F1=17
        F2=18
        F3=19
        F4=1 # This "F4=1" is bogus and not used for Linux
        echo -e "\nThe Operating System is $OS\n"
        ;;
SunOS)
        F1=20
        F2=21
        F3=22
        F4=1 # This "F4=1" is bogus and not used for SunOS
        echo -e "\nThe Operating System is $OS\n"
        ;;
*)      echo -e "\nERROR: $OS is not a supported operating system\n"
        echo -e "\n\t...EXITING...\n"
        exit 1
        ;;
esac

#################################################
######## BEGIN GATHERING STATISTICS HERE ##########
#################################################

echo -e "Gathering CPU Statistics using vmstat...\n"
echo "There are $INTERVAL sampling periods with"
echo "each interval lasting $SECS seconds"
echo -e "\n...Please wait while gathering statistics...\n"
```

Listing 19-14 (*continued*)

```
# Use "vmstat" to monitor the CPU utilization and
# remove all lines that contain alphabetic characters
# and blank spaces. Then use the previously defined
# field numbers, for example F1=20,to point directly
# to the 20th position, for this example. The syntax
# for this technique is ==>  $'$F1' and points directly
# to the $20 positional parameter.

vmstat $SECS $INTERVAL | egrep -v '[a-zA-Z]|^$' \
         | awk '{print $'$F1', $'$F2', $'$F3', $'$F4'}' \
         | while read FIRST SECOND THIRD FOURTH
do
 if ((STATCOUNT == 1)) # Loop counter to get the second set
 then                  # of data produced by

     case $OS in  # Show the results based on the UNIX flavor
     AIX|Linux)
           echo -e "\nUser part is ${FIRST}%"
           echo "System part is ${SECOND}%"
           echo "Idle part is ${THIRD}%"
           echo -e "I/O wait state is ${FOURTH}%\n"
           ;;
     HP-UX|OpenBSD|SunOS)
           echo -e "\nUser part is ${FIRST}%"
           echo "System part is ${SECOND}%"
           echo -e "Idle time is ${THIRD}%\n"
           ;;
     esac

 fi
 ((STATCOUNT = STATCOUNT + 1)) # Increment the loop counter
done
```

Listing 19-14 (*continued*)

We use the same variables in Listing 19-14 as we did in Listing 19-12 with the `iostat` script. The differences come when we define the ''`F`'' variables to indicate the fields to extract from the output and the presentation of the data to the user. As I stated before, only AIX produces a fourth field output.

In the first `case` statement, where we assign the `F1`, `F2`, `F3`, and `F4` variables to the field positions that we want to extract for each operating system, notice that only AIX and Linux assign the `F4` variable to a valid field. HP-UX, OpenBSD, and SunOS all have the `F4` variable assigned the field `$1`, `F4=1`. I did it this way so that I would not have to rewrite the `vmstat` command statement for a second time to extract just three fields. This method helps to make the code shorter and less confusing — at least I hope it is less confusing! There is a comment next to each `F4` variable assignment that states that this field assignment is bogus and not used in the shell script.

Other than these minor changes the shell script for the `vmstat` solution is the same as the solution for the `iostat` command. The `vmstat_loadmon.ksh` shell script is in action in Listing 19-15 on a Solaris machine.

```
# ./vmstat_loadmon.ksh

The Operating System is SunOS

Gathering CPU Statistics using vmstat...

There are 2 sampling periods with
each interval lasting 300 seconds

...Please wait while gathering statistics...


User part is 14%
System part is 54%
Idle time is 31%
```

Listing 19-15 vmstat_loadmon.ksh shell script in action

Notice that the Solaris output shown in Listing 19-15 does not show the I/O wait state. This information is available only on AIX for the `vmstat` shell script. The output format is the same as the last few shell scripts. It is up to you how you want to use this information. Let's look at some other options that you may be interested in next.

Other Options to Consider

As with any shell script there is always room for improvement, and this set of shell scripts is no exception. I have a few suggestions, but I'm sure that you can think of a few more.

Try to Detect Any Possible Problems for the User

One thing that would be valuable when looking at the CPU load statistics is to try to detect any problems. For example, if the system percentage plus the user percentage is consistently greater than 90 percent, the system may be CPU bound. This is easy to code into any of these shell scripts using the following statement:

```
((SYSTEM + USER > 90)) && echo "\nWarning: This system is CPU-bound\n"
```

Another possible problem happens when the I/O wait percentage is consistently over 80 percent; then the system may be I/O bound. This, too, is easy to code into the shell scripts. System problem thresholds vary widely depending on whom you are talking to, so I will leave the details up to you. I'm sure you can come up with some other problem detection techniques.

Show the User the Top CPU Hogs

Whenever the system is stressed under load, the cause of the problem may be a runaway process or a developer trying out the `fork()` system call during the middle of the day (same problem, different cause!). To show the user the top CPU hogs, you can use the `ps auxw` command. Notice that there is *not* a hyphen before `auxw`! Something like the following command syntax will work:

```
ps auxw | head -n 15
```

The output is sorted by CPU usage in descending order from the top. Also, most UNIX operating systems have a `top`-like command. In AIX, it is `topas`; in HP-UX and Linux, it is `top`; and in Solaris, it is `prstat`. Any of these commands will show you real-time process statistics.

Gathering a Large Amount of Data for Plotting

Another method is to get a lot of short intervals over a longer period of time. The `sar` command is perfect for this type of data gathering. Using this method of short intervals over a long period, maybe eight hours, gives you a detailed picture of how the load fluctuates through the day. This is the perfect kind of detailed data for graphing on a line chart. It is very easy to take the `sar` data and use a standard spreadsheet program to create graphs of the system load versus time.

Summary

This chapter presented some different concepts that are not in any other chapter, and it is always intended that way throughout this book. Play around with these shell scripts, and see how you can improve the usefulness of each script. It is always fun to find a new use for a shell script by playing with the code.

In the next chapter, we are going to study some techniques to monitor for stale disk partitions on an AIX system. I hope you gained some knowledge in this chapter, and every chapter. See you in the next chapter.

Lab Assignments

1. Modify the `uptime_loadmon.Bash` shell script to add an email alert if the trigger threshold is exceeded.
2. Modify the `sar_loadmon.Bash`, `iostst_loadmon.Bash`, and `vmstat_loadmon.Bash` shell scripts to add a threshold trigger when the average user time exceeds 95% during the sampling period.
3. Modify the `sar_loadmon.Bash` shell script so that it will collect data over a long period of time and save this data for plotting. The idea is to set up 60-second sample intervals sampling 30 times per hour. This data should be stored in a flat text file with the following data on each separate line: date/time stamp, user time, system time, I/O wait (for systems that support this), and idle time.

CHAPTER 20

Monitoring for Stale Disk Partitions (AIX-Specific)

Monitoring for stale disk partitions is an AIX thing. To understand this chapter you need to be familiar with the Logical Volume Manager (LVM) that is at the heart of the AIX disk subsystem. We will get to the LVM in the next section. At the high level a stale disk partition means that the mirrored disks are not in sync. Sometimes when you find stale disk partitions you can resync the mirrors, and all is well. If the mirrors will not sync up, you may be seeing the first signs of a failing disk.

We are going to look at three methods of monitoring for stale partitions:

- Monitoring at the logical volume (LV) level
- Monitoring at the physical volume (PV), or disk, level
- Monitoring at the volume group (VG), PV, and LV levels to get the full picture

All three methods will report the number of stale disk partitions, but it is nice to know the VG, PV, and the LV that are involved in the unsynced mirrors. We are going to step through the entire process of building these shell scripts, starting with the command syntax required to query the system. Before we start our scripting effort, I want to give you a high-level overview of the AIX LVM and the commands we are going to use.

AIX Logical Volume Manager (LVM)

Unlike most UNIX operating systems, IBM manages disk resources with what IBM calls the *Logical Volume Manager* (LVM). The LVM consists of the following components, starting with the smallest.

Starting at the physical volume (PV) level, or a Logical Unit Number (LUN) presented in a SAN environment, AIX's LVM recognizes this device (disk drive or LUN) as a new *physical volume*, or PV. Each PV, or disk, in the LVM is broken down into small partitions called *physical partitions* (PP). The default PP size depends on the disk drives

the system found when `cfgmgr` (Configuration Manager) was executed either by a reboot or by executing the `cfgmgr -V` command on the command line as `root`.

The LVM uses groups of these PPs to create a *logical map* to point to the actual PPs on the disk. These mapped partitions are called *logical partitions* (LP). The sizes of an LP and PP are exactly the same because an LP is just a pointer to a PP. Therefore, the operating system always sees contiguous disk space.

At the next level up, we have the logical volume (LV). An LV consists of one or more LPs. The LV can span multiple PVs. This is the level at which the Systems Administrator creates mirrors or various RAID configurations. When an LV is first created, the LV is considered *raw*, at least in AIX, meaning that it does not have a filesystem mount point. Raw LVs are commonly used for databases.

On top of an LV we can create a filesystem, which has a mount point — for example, `/scripts`. The LV does not require a filesystem if you want the LV to remain raw, but you can create one.

A volume group (VG) is a collection of one or more physical volumes (PVs), or disks. A PV is listed on the system as an `hdisk#`, where `#` is an integer value. A VG is the largest component of the LMV. A VG contains one or more LVs, so this is the mechanism that allows an LV to span multiple PVs.

That is the high-level overview of the LVM and its components. For this chapter we are going to focus our attention at the VG, PV, LV, and PP levels, and we are concerned only with disks in a mirrored configuration. If you want more information on the AIX LVM, there are plenty of IBM Red Book books that go into great detail about AIX system management at `www.redbooks.ibm.com`.

The Commands and Methods

As usual, we need the command syntax before we can write a shell script. We will work with three LVM commands in this chapter. Each of these commands queries the system for specific information on the components and status of the disk subsystem. Before we proceed, it is important to know what each of these commands is used for and what type of information can be gathered from the system.

Disk Subsystem Commands

The **lsvg** command queries the system for VG information. To see which VGs are *varied-on*, or active, we add the `-o` switch to the `lsvg` command. We also have the `-l` flag that allows the `lsvg` command to query the system for the contents of a specific VG. We are interested in one of the fields in the `lsvg <VG_name>` command output, called `STALE_PPs:`, which has a value representing the number of stale PVs in the target VG. Ideally, we want this number to be zero.

Then we move to the LV command, **lslv**. The `lslv` command will query the system for the status information of a specific LV, which is entered as a command parameter. One of the fields in the output of the `lslv <LV_name>` command is `STALE PP:`. This output shows the number of stale PPs for the LV specified on the command line.

Ideally, we want this number to be zero. If we add the `-l` flag to the `lslv` command, we can see which PVs are associated with the LV in the first column of the command output.

Next we can move down to the PV, or disk, level. The **lspv** command queries the system for information on a specific PV, which is passed as a command parameter to the `lspv` command. Like `lslv`, the `lspv` command also reports the number of `STALE PARTITIONS:` as a field in the output.

You will see the output of each of these commands as we write the scripts for this chapter. We have the commands defined, so we are now ready to start creating our first shell script to monitor for stale disk partitions.

Method 1: Monitoring for Stale PPs at the LV Level

The easiest, but not always the quickest, method of checking for stale disk partitions is to work at the LV level of the LVM structure. Querying the system for LV stale-partition information gives the high-level overview for each LV. If, however, the LV spans more than one PV, or disk, another step must be taken to find the actual mirrored disks that are not in sync. We will get to this finer granularity of monitoring in the next section of this chapter.

We start our monitoring by issuing an LVM query to find each of the active VGs on the system, or the VGs that are *varied online*. For this step we use the `lsvg -o` command. The `-o` flag tells the `lsvg` command to list only the VGs that are *currently* varied online. Many more VGs may exist on the system, but if they are not varied online we cannot check the status of any of the LVs that reside within the VG, because the entire VG is inactive. Let's assign the VG list to a variable called `ACTIVE_VG_LIST`:

```
ACTIVE_VG_LIST=$(lsvg -o)
```

My test machine has two VGs, and both are active:

```
rootvg
appvg2
```

The previous command saves the active VGs in a variable. Using the `ACTIVE_VG_LIST` variable contents, we next create a list of active LVs on the system. Each VG will have one or more LVs that may or may not be active, or *open*. Using the `$ACTIVE_VG_LIST` data we can query the system to list each active LV within each active VG. The `lsvg -l $VG` command queries the system at the VG level to display the contents. Listing 20-1 shows the output of the `lsvg -l appvg2 rootvg` command on my test machine.

```
appvg2:
LV NAME             TYPE    LPs   PPs   PVs  LV STATE      MOUNT POINT
tel_lv              jfs     2     2     1    open/syncd    /usr/telalert
oracle_lv           jfs     128   128   1    open/syncd    /oracle
```

Listing 20-1 Output of the lsvg -l appvg2 rootvg command

```
oradata_lv      jfs     128   128   1    open/syncd    /oradata
ar_lv           jfs     16    16    1    open/syncd    /usr/ar
remp_tmp01      jfs     128   128   1    open/syncd    /remd_tmp01
export_lv       jfs     100   100   1    open/syncd    /export
loglv00         jfslog  1     1     1    open/syncd    N/A
remp2_ctl01     jfs     1     1     1    open/syncd    /remd_ctl01
remp2_ctl02     jfs     1     1     1    open/syncd    /remd_ctl02
remp2_ctl03     jfs     1     1     1    open/syncd    /remd_ctl03
rempR2_dat01    jfs     192   192   1    open/syncd    /remd_dat01
R2remedy_lv     jfs     10    10    1    open/syncd    /usr/remedy
remp2_log1a     jfs     1     1     1    open/syncd    /remd_log1a
remp2_log1b     jfs     1     1     1    open/syncd    /remd_log1b
remp2_log2a     jfs     1     1     1    open/syncd    /remd_log2a
remp2_log2b     jfs     1     1     1    open/syncd    /remd_log2b
remp2_log3a     jfs     1     1     1    open/syncd    /remd_log3a
remp2_log3b     jfs     1     1     1    open/syncd    /remd_log3b
remp2_log4a     jfs     1     1     1    open/syncd    /remd_log4a
remp2_log4b     jfs     1     1     1    open/syncd    /remd_log4b
remp2_log5a     jfs     1     1     1    open/syncd    /remd_log5a
remp2_log5b     jfs     1     1     1    open/syncd    /remd_log5b
remp2_rbs01     jfs     47    47    1    open/syncd    /remd_rbs01
remp2_sys01     jfs     4     4     1    open/syncd    /remd_sys01
arlogs_lv       jfs     35    35    1    open/syncd    /usr/ar/logs
remp2_usr01     jfs     6     6     1    open/syncd    /remd_usr01
rootvg:
LV NAME         TYPE    LPs   PPs   PVs  LV STATE      MOUNT POINT
hd5             boot    1     2     2    closed/syncd  N/A
hd6             paging  80    160   2    open/syncd    N/A
hd8             jfslog  1     2     2    open/syncd    N/A
hd4             jfs     4     8     2    open/syncd    /
hd2             jfs     40    80    2    open/syncd    /usr
hd9var          jfs     10    20    2    open/syncd    /var
hd3             jfs     10    20    2    open/syncd    /tmp
hd1             jfs     3     6     2    open/syncd    /home
local_lv        jfs     9     18    2    open/syncd    /usr/local
```

Listing 20-1 (*continued*)

The list of LVs is shown in column one. Notice the sixth column in the output in Listing 20-1, `LV STATE`. Most of the LVs are `open/synced`, but one LV, `hd5`, is `closed/synced`. The `hd5` LV that is closed is the *boot logical volume* and is active only when the system is booting up. Because we want only active LVs, all we need to do is to `grep` on the string `open` and then `awk` out the first column. The next command saves the list of currently active LVs in a variable called `ACTIVE_LV_LIST`:

```
ACTIVE_LV_LIST=$(lsvg -l $ACTIVE_VG_LIST | grep open | awk '{print $1}')
```

In the preceding command, we use our `$ACTIVE_VG_LIST` as a command parameter for the `lsvg -l` command. Then we pipe (|) to `grep` the `lsvg` output for only the

rows that contain the string `open`. Next, another pipe is used to `awk` out the first column, specified by `awk '{print $1}'`. The result is a list of currently active LV names. If you think about a two-dimensional array, the `grep` command works on the *rows* and the `awk` command works on the *columns*.

The only thing left to do is to query each LV for the number of stale PPs, specified by the `STALE PP:` field. To check every LV we need to set up a `for` loop to run the same command on each LV in the active list. The command we use to query the LV is `lslv -L $LV_NAME`. The output for a single LV is shown in Listing 20-2.

```
LOGICAL VOLUME:     remp_tmp01            VOLUME GROUP:   appvg2
LV IDENTIFIER:      00011151b819f83a.5    PERMISSION:     read/write
VG STATE:           active/complete       LV STATE:       opened/syncd
TYPE:               jfs                   WRITE VERIFY:   off
MAX LPs:            512                   PP SIZE:        32 megabyte(s)
COPIES:             1                     SCHED POLICY:   parallel
LPs:                128                   PPs:            128
STALE PPs:          0                     BB POLICY:      relocatable
INTER-POLICY:       minimum               RELOCATABLE:    yes
INTRA-POLICY:       middle                UPPER BOUND:    32
MOUNT POINT:        /remd_tmp01           LABEL:          /remd_tmp01
MIRROR WRITE CONSISTENCY: on
EACH LP COPY ON A SEPARATE PV ?: yes
```

Listing 20-2 LV statistics for the remp_tmp01 logical volume

Notice in the command output in Listing 20-2 the eighth row, where the field `STALE PPs:` is listed. The second column of this row contains the number of stale partitions in the LV. Ideally, we want this value to be zero, 0. If the value is greater than zero we have a problem. Specifically, the mirrored disks associated with this LV are not in sync, which translates to a worthless mirror. Looking at this output, how are we supposed to get the number of stale disk partitions? It turns out that this is a very simple combination of `grep` and `awk`. Take a look at the following command statement:

```
NUM_STALE_PP=$(lslv -L $LV | grep "STALE PP" | awk '{print $3}'
```

This statement saves the number of stale PPs into the `NUM_STALE_PP` variable. We accomplish this feat by command substitution, specified by the `VARIABLE= $( commands )` notation. The way to make this task easy is to do the parsing one step at a time. First, the row containing the `STALE PP` string is extracted and is provided as input to the next command in the pipe. The next command in the pipe is an `awk` statement that extracts only the third field, specified by `'{print $3}'`. At this point you may be asking why we used the third field instead of the second. By default, `awk` uses white space as a field separator, and because `STALE PPs: 0` contains two areas of white space, we need the third field instead of the second.

Now that we have all of the commands, all we need to do is set up a loop to run the previous command against each LV stored in the `$ACTIVE_LV_LIST` variable. A little `for` loop will work just fine for this script. The loop is shown in Listing 20-3.

```
THIS_HOST=$(hostname)

for LV in $ACTIVE_LV_LIST
do
      NUM_STALE_PP=$(lslv -L $LV | grep "STALE PP" | awk '{print $3}'
      if ((NUM_STALE_PP > 0))
      then
            echo "\n${THIS_HOST}: $LV has $NUM_STALE_PP stale PPs"
      fi
done
```

Listing 20-3 Loop to show the number of stale PPs from each LV

I want to point out several things in Listing 20-3. First, notice that we save the hostname of the machine in a variable called `THIS_HOST`. When creating any type of report we need to know which machine we are reporting on. When you have more than 100 machines, things can get a little confusing if you do not have a `hostname` to go with the report.

A `for` loop needs a list of items to loop through. To get the list of active LVs, we use the `$ACTIVE_LV_LIST` to provide our `for` loop with a list. The next step is to run the `lslv -L` command for each LV listed and extract the field that shows the number of stale PPs. For this command we again use command substitution to assign the value to a variable called `NUM_STALE_PP`. Using this saved value we do a numeric test in the `if` statement. Notice that we did not add a dollar sign (`$`) in front of the `NUM_STALE_PP` variable. Because we used the double parentheses numeric test method, the command assumes that every nonnumeric string is a variable, so the dollar sign (`$`) is not needed.

If we find that the number of stale PPs is greater than zero, we use an `echo` statement to show the `hostname` of the machine followed by the LV name that has stale partitions and, last, the number of stale partitions that were found. These steps are followed for every active LV in every active VG on the entire system. The full shell script is shown in Listing 20-4.

```
#!/bin/ksh
#
# SCRIPT: stale_LV_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 01/22/2007
# REV: 1.1.P
#
# PLATFORM: AIX only
#
# PURPOSE: This shell script is used to query the system
#       for stale PPs in every active LV within every active
```

Listing 20-4 stale_LV_mon.ksh shell script

```
#       VG.
#
# REVISION LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check command syntax without any execution

THIS_HOST=`hostname`  # Hostname of this machine
STALE_PP_COUNT=0      # Initialize to zero

# Find all active VGs
echo "\nGathering a list of active Volume Groups"
ACTIVE_VG_LIST=$(lsvg -o)

# Find all active LVs in every active VG.
echo "\nCreating a list of all active Logical Volume"
ACTIVE_LV_LIST=$(lsvg -l $ACTIVE_VG_LIST | grep open | awk '{print $1}')

# Loop through each active LV and query for stale disk partitions
echo "\nLooping through each Logical Volume searching for stale PPs"
echo "...Please be patient; this may take several minutes to complete..."

for LV in $ACTIVE_LV_LIST
do
     # Extract the number of STALE PPs for each active LV
     NUM_STALE_PP=`lslv -L $LV | grep "STALE PP" | awk '{print $3}'`
     # Check for a value greater than zero
      if ((NUM_STALE_PP > 0))
      then
           # Increment the stale PP counter
           (( STALE_PP_COUNT = $STALE_PP_COUNT + 1))
           # Report on all LVs containing stale disk partitions
           echo "\n${THIS_HOST}: $LV has $NUM_STALE_PP PPs"
      fi
done

# Give some feedback if no stale disk partitions were found

if ((STALE_PP_COUNT == 0))
then
      echo "\nNo stale PPs were found in any active LV...EXITING...\n"
fi
```

Listing 20-4 (*continued*)

Notice in the script in Listing 20-4 that we added notification at each step in the process. As always, we need to let the user know what is going on. Before each command I added an `echo` statement to show the user how we progress through the

shell script. I also added a `STALE_PP_COUNT` variable to give feedback if no stale PPs were found. Now let's move on to searching for stale PPs at the PV level instead of the LV level.

Method 2: Monitoring for Stale PPs at the PV Level

Checking for stale disk partitions at the LV level will let you know that one or more LVs have stale PPs. To get a better picture of where the unsynced mirrors reside, we need to look at the `hdisk` level. In this section we are going to change the query point for searching for stale PPs from the LV to the PV, or disk level. The savings in execution time between these two methods is threefold in favor of working directly with the disks by my measurements. On my test machine the LV query took 40.77 seconds in real time, 0.36 seconds of system time, and 0.02 seconds of user time. Using the PV query method I reduced the execution time to 12.77 seconds in real time and 0.17 seconds of system time, and I had the same 0.02 seconds for user time. To understand the LV and PV configuration I have 18 mirrored disks, which are 9 mirror pairs of 9.1 GB disk drives, and a total of 32 LVs. Because an LV query takes longer to execute than a PV query, it is understandable that the PV query won. Depending on the system configuration, this timing advantage may not always hold.

In the PV monitoring method we still are concerned only with the hdisks that are in currently varied-on volume groups (VGs), as we did in the LV method using the `lsvg -o` command. Using this active VG list we can query each active VG and extract all of the hdisks that belong to each VG. Once we have a complete list of all of the hdisks we can start a loop and query each of the PVs independently. The output of a PV query is similar to the LV query statistics in Listing 20-2. Take a look at the PV query of `hdisk5` using the `lspv -l hdisk5` command in Listing 20-5.

```
PHYSICAL VOLUME:    hdisk5                    VOLUME GROUP:     appvg2
PV IDENTIFIER:      00011150e33c3f14 VG IDENTIFIER     00011150e33ce9bb
PV STATE:           active
STALE PARTITIONS:   0                         ALLOCATABLE:      yes
PP SIZE:            16 megabyte(s)            LOGICAL VOLUMES:  2
TOTAL PPs:          542 (8672 megabytes)      VG DESCRIPTORS:   1
FREE PPs:           397 (6352 megabytes)
USED PPs:           145 (2320 megabytes)
FREE DISTRIBUTION:  89..00..91..108..109
USED DISTRIBUTION:  20..108..17..00..00
```

Listing 20-5 PV statistics for the hdisk5 physical volume

In the output in Listing 20-5 the `STALE PARTITIONS:` field in row four and its value are the third field in the row. If the stale partition value ever exceeds zero, we use the same type of reporting technique that we used in the LV query in Method 1. If no stale partitions are found, we can give the ''all is well'' message and exit the script.

Because we have the basic idea of the process, let's take a look at the shell script in Listing 20-6. We will explain the technique in further detail at the end of the code listing.

```
#!/usr/bin/ksh
#
# SCRIPT: stale_PP_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 01/29/2007
# REV: 1.2.P
#
# PLATFORM: AIX only
#
# PURPOSE: This shell script is used to query the system for stale PPs.
#         The method queries the system for all of the currently
#         varied-on volume groups and then builds a list
#         of the PVs to query. If a PV query detects any stale
#         partitions notification is sent to the screen. Each step in
#         the process has user notification
#
# REVISION LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution

THIS_HOST=$(hostname)   # Hostname of this machine
HDISK_LIST=             # Initialize to NULL
STALE_PP_COUNT=0        # Initialize to zero

# Inform the user at each step
echo "\nGathering a list of hdisks to query\n"

# Loop through each currently varied-on VG

for VG in $(lsvg -o)
do
    # Build a list of hdisks that belong to currently varied-on VGs
    echo "Querying $VG for a list of disks"
    HDISK_LIST="$HDISK_LIST $(lsvg -p $VG |grep disk \
                                          | awk '{print $1}')"
done

echo "\nStarting the hdisk query on individual disks\n"

# Loop through each of the hdisks found in the previous loop

for HDISK in $(echo $HDISK_LIST)
do
    # Query a new hdisk on each loop iteration
```

Listing 20-6 stale_PP_mon.ksh shell script

```
    echo "Querying $HDISK for stale partitions"
    NUM_STALE_PP=$(lspv -L $HDISK | grep "STALE PARTITIONS:" \
                  | awk '{print $3}')
    # Check to see if the stale partition count is greater than zero
    if ((NUM_STALE_PP > 0))
    then
         # This hdisk has at least one stale partition - Report it!
         echo "\n${THIS_HOST}: $HDISK has $NUM_STALE_PP Stale
Partitions"

         # Build a list of hdisks that have stale disk partitions
         STALE_HDISK_LIST=$(echo $STALE_HDISK_LIST; echo $HDISK)
   fi
done

# If no stale partitions were found send an "all is good" message

((NUM_STALE_PP > 0)) \
  || echo "\n${THIS_HOST}: No Stale PPs have been found...EXITING...\n"
```

Listing 20-6 (*continued*)

We totally changed our viewpoint in our search for stale disk partitions. Instead of working at each LV we are scanning each disk, or PV, independently. The search time on my test machine was three times faster, but my machine configuration does not mean that your system query will be as fast. I want to start at the top of our `stale_PP_mon.ksh` shell script in Listing 20-6 and work to the bottom.

We start off the script by initializing three variables, `THIS_HOST` (the hostname of the reporting machine), `HDISK_LIST` (the list of PVs to query, which we initialize to NULL), and `STALE_PP_COUNT` (the total number of stale disk partitions on all disks, which is initialized to zero). We will show how each of these variables is used as we progress through the script.

The next step is to use the list of currently varied-on VGs (using the `lsvg -o` command) to create a list of currently available hdisks — at least they should be available. We do this in a `for` loop by appending to the `HDISK_LIST` variable during each loop iteration. Once we have a list of available system disks, we start a `for` loop to query each hdisk individually. During the query statement

```
NUM_STALE_PP=$(lspv -L $HDISK | grep "STALE PARTITIONS:"  \
              | awk '{print $3}')
```

we capture the number of stale disk partitions by using `grep` and `awk` together in the same statement. Just remember that the `grep` command acts on the *rows* and the `awk` statement acts on the *columns*. On each loop iteration we check the value of the `$NUM_STALE_PP` variable. If the count is greater than zero we do two things: report

the disk to the screen, and append to the STALE_HDISK_LIST variable. Notice how we append to a variable that currently has data in it. By initializing the variable to NULL (specified by VARIABLE=), by creating an assignment to nothing, we can always append to the variable using the following syntax:

```
VARIABLE="$VARIABLE $NEW_VALUE"
```

Because the $VARIABLE has an initial value of nothing, NULL, the first value assigned is a new value, and all subsequent values are appended to the VARIABLE variable on each loop iteration.

At the end of the script we test the $NUM_STALE_PP variable, which has a running count of all stale disk partitions. If the value is zero, we let the end user know that everything is OK. Notice how we do the test. We do a numerical test on the $NUM_STALE_PP variable to see if it is greater than zero. If the value is one or more, the statement is true. On a true statement the logical OR (||) passes control to the second part of the statement, which states ''No stale PPs have been found.'' The logical OR saves an if statement and is faster to execute than an if statement.

Now, that was a fun little script. We can improve on both scripts that have been presented thus far. There is a procedure to attempt to resync the disks containing stale partitions. In the next section we are going to combine the LV and PP query methods and add in a VG query as the top-level query to search for stale disk partitions. We will also attempt to resync all of the stale LVs that we find, if the ATTEMPT_RESYNC variable is set to TRUE.

Method 3: VG, LV, and PV Monitoring with a resync

We have looked at stale disk mirrors from two angles, but we can look for stale disk partitions at a higher level, the VG level. By using the lsvg command we can find which VG has disks that have stale PPs. Using the lsvg <VG_name> command we can shorten our queries to a limited number of disks, although with Murphy's Law working, it just might be the largest VG on the planet!

The strategy that we want to follow is first to query each active VG for stale PVs, which we find using the lsvg <VG_name> command. Then, for each VG that has the STALE PV: field greater than zero, we query the current VG in the loop to get a list of associated PVs, or disks. Using a list of all of the PVs that we found, we conduct a query of each disk to find both the list of LVs the PV is associated with and the value of the STALE PARTITIONS: field. For each PV found, to have at least one stale partition, we query the PV for a list of LVs that reside on the current PV. Please don't get confused now! The steps involved are a natural progression through the food chain to the source. The final result of all of these queries is that we know which VG, PV, and LV have unsynced mirrors, which is the complete picture that we want.

The process that we follow in this section is faster to execute and easier to follow, so let's start. The commands we are going to use are shown in Listing 20-7.

```
lsvg -o                Produces a list of active VGs
lsvg $VG_NAME          Queries the target VG for status information
lsvg -p $VG_NAME       Produces a list of hdisks that belong to the VG
lspv $PV_NAME          Queries the hdisk specified by $PV_NAME
lspv -l $PV_NAME       Produces a list of LVs on the target hdisk
lslv $LV_NAME          Queries the target LV for status information
syncvg $HDISK_LIST     Synchronizes the mirrors at the hdisk level
syncvg -l $LV_LIST     Synchronizes the mirrors at the LV level
varyonvg               Synchronizes only the stale partitions
```

Listing 20-7 Command summary for the Method 3 shell script

Using the nine commands in Listing 20-7 we can produce a fast-executing shell script that produces the full picture of exactly where all of the unsynced mirrors reside, and we can even attempt to fix the problem!

For this shell script I want to present you with the entire script; then we will step through and explain the philosophy behind the techniques used. In studying Listing 20-8, pay close attention to the bold text.

```
#!/usr/bin/ksh
#
# SCRIPT: stale_VG_PV_LV_PP_mon.ksh
#
# AUTHOR: Randy Michael
# DATE: 01/29/2007
# REV: 1.2.P
#
# PLATFORM: AIX only
#
# PURPOSE: This shell script is used to query the system for stale PPs.
#          The method queries the system for all of the currently
#          varied-on volume groups and then builds a list of the PVs to
#          query. If a PV query detects any stale partitions notification
#          is sent to the screen. Each step in the process has user
#          notification.
#
# REVISION LIST:
#
#
# set -x # Uncomment to debug this shell script
# set -n # Uncomment to check command syntax without any execution
#
# EXIT CODES: 0 ==> Normal execution or no stale PP were found
#             1 ==> Trap EXIT
#             2 ==> Auto resyncing failed
#
```

Listing 20-8 stale_VG_PV_LV_PP_mon.ksh shell script

```
#############################################################################
########## DEFINE VARIABLES HERE ####################

ATTEMPT_RESYNC=FALSE    # Flag to enable auto resync, "TRUE" will resync

LOGFILE="/tmp/stale_PP_log" # Stale PP logfile
THIS_HOST=$(hostname)       # Hostname of this machine
STALE_PP_COUNT=0            # Initialize to zero
STALE_PV_COUNT=0            # Initialize to zero
HDISK_LIST=                 # Initialize to NULL
INACTIVE_PP_LIST=           # Initialize to NULL
STALE_PV_LIST=              # Initialize to NULL
STALE_LV_LIST=              # Initialize to NULL
STALE_VG_LIST=              # Initialize to NULL
RESYNC_LV_LIST=             # Initialize to NULL
PV_LIST=                    # Initialize to NULL

#######################################
#### INITIALIZE THE LOG FILE ####

>$LOGFILE          # Initialize the log file to empty
date >> $LOGFILE   # Date the log file was created
echo "\n$THIS_HOST \n" >> $LOGFILE # Hostname for this report

#### DEFINE FUNCTIONS HERE ############

# Trap Exit function

function trap_exit
{
echo "\n\t...EXITING on a TRAPPED signal...\n"
}

#######################################

# Set a trap...

trap 'trap_exit; exit 1' 1 2 3 5 15

#######################################
######### BEGINNING OF MAIN ###########
#######################################

# Inform the user at each step

# Loop through each currently varied-on VG and query VG for stale PVs.
# For any VG that has at least one stale PV we then query the VG
# for the list of associated PVs and build the $PV_LIST
```

Listing 20-8 (*continued*)

```
echo "\nSearching each Volume Group for stale Physical Volumes...\c" \
        | tee -a $LOGFILE

# Search each VG for stale PVs, then build a list of VGs and PVs
# that have stale disk partitions

for VG in $(lsvg -o)
do
     NUM_STALE_PV=$(lsvg $VG | grep 'STALE PVs:' | awk '{print $3}')

     if ((NUM_STALE_PV > 0))
     then
          STALE_VG_LIST="$STALE_VG_LIST $VG"
          PV_LIST="$PV_LIST $(lsvg -p $VG | tail +3 | awk '{print $1}')"
          ((STALE_PV_COUNT = STALE_PV_COUNT + 1))
     fi
done

# Test to see if any stale PVs were found; if not then
# exit with return code 0

if ((STALE_PV_COUNT == 0))
then
     echo "\nNo Stale Disk Mirrors Found...EXITING...\n" \
| tee -a $LOGFILE
     exit 0
else
     echo "\nStale Disk Mirrors Found!...Searching each hdisk for \
stale PPs...\c" | tee -a $LOGFILE
fi

# Now we have a list of PVs from every VG that reported stale PVs
# The next step is to query each PV to make sure each PV is in
# an "active" state and then query each PV for stale PPs.
# If a PV is found to be inactive then we will not query
# the PV for stale partitions, but move on to the next PV in
# the $PV_LIST.

for HDISK in $PV_LIST
do
     PV_STATE=$(lspv $HDISK | grep 'PV STATE:' | awk '{print $3}')
     if [[ $PV_STATE != 'active' ]]
     then
         INACTIVE_PV_LIST="$INACTIVE_PV_LIST $HDISK"
     fi
     if ! $(echo $INACTIVE_PV_LIST | grep $HDISK) >/dev/null 2>&1
     then
```

Listing 20-8 (*continued*)

```
          NUM_STALE_PP=$(lspv $HDISK | grep 'STALE PARTITIONS:' \
                         | awk '{print $3}')
          if ((NUM_STALE_PP > 0))
          then
               STALE_PV_LIST="$STALE_PV_LIST $HDISK"
               ((STALE_PP_COUNT = $STALE_PP_COUNT + 1))
          fi
     fi
done

# Now we have the list of PVs that contain the stale PPs.
# Next we want to get a list of all of the LVs affected.

echo "\nSearching each disk with stale PPs for associated LVs\c" \
        | tee -a $LOGFILE

for PV in $STALE_PV_LIST
do
     STALE_LV_LIST="$STALE_LV_LIST $(lspv -l $PV | tail +3 \
                    | awk '{print $1}')"
done

# Using the STALE_LV_LIST variable list we want to query
# each LV to find which ones need to be resynced

echo "\nSearch each LV for stale partitions to build a resync LV \
list\c" | tee -a $LOGFILE

for LV in $STALE_LV_LIST
do
     LV_NUM_STALE_PP=$(lslv $LV | grep "STALE PPs:" | awk '{print $3}')
     (($LV_NUM_STALE_PP != 0)) && RESYNC_LV_LIST="$RESYNC_LV_LIST $LV"
done

# If any inactive PVs were found we need to inform the user
# of each inactive PV

# Check for a NULL variable

if [[ -n "$INACTIVE_PV_LIST" && "$INACTIVE_PV_LIST" != '' ]]
then
     for PV in $INACTIVE_PV_LIST
     do
          echo "\nWARNING: Inactive Physical Volume Found:" \
| tee -a $LOGFILE
          echo "\n$PV is currently inactive:\n" | tee -a $LOGFILE
          echo "\nThis script is not suitable to to correct this \
```

Listing 20-8 (*continued*)

```
problem..." | tee -a $LOGFILE
          echo "       ...CALL IBM SUPPORT ABOUT ${PV}..." \
| tee -a $LOGFILE
     done
fi

echo "\nStale Partitions have been found on at least one disk!" \
        | tee -a $LOGFILE
echo "\nThe following Volume Group(s) have stale PVs:\n" \
        | tee -a $LOGFILE
echo $STALE_VG_LIST | tee -a $LOGFILE
echo "\nThe stale disk(s) involved include the following:\n" \
        | tee -a $LOGFILE
echo $STALE_PV_LIST | tee -a $LOGFILE
echo "\nThe following Logical Volumes need to be resynced:\n" \
        | tee -a $LOGFILE
echo $RESYNC_LV_LIST | tee -a $LOGFILE

if [[ $ATTEMPT_RESYNC = "TRUE" ]]
then
     echo "\nAttempting to resync the LVs on $RESYNC_PV_LIST ...\n" \
             | tee -a $LOGFILE
     syncvg -l $RESYNC_LV_LIST | tee -a $LOGFILE 2>&1
     if (( $? == 0))
     then
          echo "\nResyncing all of the LVs SUCCESSFUL...EXITING..." \
                  | tee -a $LOGFILE
     else
          echo "\nResyncing FAILED...EXITING...\n" | tee -a $LOGFILE
          exit 2
     fi
else
     echo "\nAuto resync is not enabled...set to TRUE to automatically \
resync\n" | tee -a $LOGFILE
     echo "\n\t...EXITING...\n" | tee -a $LOGFILE
fi

echo "\nThe log file is: $LOGFILE\n"
```

Listing 20-8 (*continued*)

The shell script in Listing 20-8 is interesting because of the techniques used. As we start at the top of the shell script, notice the first variable definition, `ATTEMPT_RESYNC`. I initialize this variable to `FALSE` because resyncing at the LV level can cause a significant system load. A better method is to run the **varyonvg** command without any arguments. This method will only resync the stale partitions. Because of the possibility of loading down the system and slowing production response time, I initialize this

variable to FALSE. If I am working on a test/development or sandbox machine, I usually set the ATTEMPT_RESYNC variable to TRUE, in uppercase. The TRUE setting will attempt to resync, at the LV level, every stale LV.

The remaining variables initialize the LOGFILE and THIS_HOST variables to the log filename and hostname, respectively. A couple of counters are initialized to zero, and seven other variables are initialized to NULL. In the next section we initialize the $LOGFILE with header information.

The only function in this script is the trap_exit function. The trap_exit function displays to standard output (stdout) ...EXITING on a TRAPPED signal... when a trap is captured. The trap is set for exit codes 1, 2, 3, 5, and 15 and then the script exits with return code 1. This functionality is just a notification measure for the user. Now we are at BEGINNING OF MAIN in our script.

At each step through this shell script we want to give the user feedback so that he or she will know what is going on. When writing shell scripts you need to do two things: comment *everything* and give your users feedback so that they know what is going on. In our first query we inform the users that we are searching each VG for stale PVs. For this step we use the lsvg -o command to get a list of currently varied-on VGs. Using this active VG list, we use a for loop to loop through each active VG and query for the STALE PVs: field using the lsvg $VG command to extract the number of stale PVs in each VG using both grep and awk. When any stale PVs are detected, the VG is added to the STALE_VG_LIST variable, and all of the PVs in the VG are then added to the PV_LIST variable, specified by the lsvg -p $VG command. Next the STALE_PV_COUNT variable is incremented by one for each PV using the math notation ((STALE_PV_COUNT = STALE_PV_COUNT + 1)). At this point we have a list of all of the VGs that have stale PVs and a list of all of the PVs in all of the VGs that have stale PVs identified.

If the STALE_PV_COUNT variable is zero, there are no stale disk partitions to report in the system for the currently varied-on VGs. If the count is zero, we inform the user that no stale disk mirrors were found, and we exit the script with a return code of 0, zero. If no stale disk partitions exist, this shell script executes in seconds. If the count is greater than zero, we inform the user that stale disk mirrors were found, and we continue to the next step, which is to query each PV in the $PV_LIST, searching for stale disk partitions.

To query each PV that is part of a VG that has stale PVs identified, we use a for loop to loop through each hdisk assigned to the $PV_LIST variable. Before we can query the disk, we need to ensure that the PV is in an *active* state. If the disk is inactive, we cannot query that disk. In this section of the shell script we use the lspv $HDISK command within the for loop twice. The first time we are ensuring that the disk is active, and in the second step we query the disk for the value of the STALE PARTITIONS: field. If the disk is found to be inactive, we just add the disk to the INACTIVE_PV_LIST variable. If the disk is in an active state and the query detects any stale partitions, we add the hdisk to the STALE_PV_LIST variable. Notice in this section the if statement syntax that is used to check for inactive PVs before the disk query is initiated:

```
if ! $(echo $INACTIVE_PV_LIST | grep $HDISK) >/dev/null 2>&1
```

This test ensures that the disk is not listed in the $INACTIVE_PV_LIST variable. The nice thing about using this syntax is that we use the if statement to check the return code of the enclosed command. We also negate the response so that we are testing for the disk not being listed in the variable by using the ! operator. To stop any screen output, the command is redirected to the bit bucket, and standard error is redirected to standard output, specified by the 2>&1 notation. Through the process of this for loop we populate the STALE_PV_LIST variable, which is a list of each of the active disks on the system that have stale disk partitions. We also keep a running count of the stale PPs found.

In the next section we use the populated $STALE_PV_LIST variable to get a list of all of the LVs that are part of each disk in the stale disk list. In this step we use another for loop to loop through each stale PV and populate the STALE_LV_LIST variable using the lspv -l $PV command. Then we use this newly populated $STALE_LV_LIST to query each LV to find which ones have stale PPs. For this section we query each LV using the lslv $LV command and extract the value of the STALE PP: field using a combination of grep and awk commands in a pipe. Each LV found to have at least one stale PP is added to the RESYNC_LV_LIST variable, which is used later to resync each of the LVs, if enabled, and in the log report.

Now we use the list of inactive PVs, using the $INACTIVE_PV_LIST variable, to produce notification to the user of each inactive PV found on the system. We start with an if statement and test for the $INACTIVE_PV_LIST variable being NULL, or empty. If the variable is not NULL, we loop through each PV in the list and issue a warning message to the user for each inactive PV. This information is also logged in the $LOGFILE using a pipe to the tee -a command to append to the $LOGFILE and display the information to the screen at the same time.

In the next step, we give the user a list of each VG, PV, and LV that is affected by the stale disk partitions. After this notification is both logged and displayed we attempt to resync the mirrors at the LV level. Sometimes there are just one or two LVs on a PV that have stale disk partitions, so the LV is where we want to attempt to resync. We will attempt a resync only if the $ATTEMPT_RESYNC variable is initialized to TRUE. Any other value will cause this step to be skipped, but the user is notified that the resync option is disabled. If a resync is enabled, the syncvg -l $RESYNC_LV_LIST command is executed. The return code is checked for a zero value, indicating a successful resync operation. If the return code is not zero, you need to call IBM support and replace the disk before it goes dead on you. The steps involved in replacing a disk are beyond the scope of this book. We can also use the varyonvg command to resync only the stale partitions.

Other Options to Consider

As usual, any shell script can be improved, and this set of shell scripts is no exception.

SSA Disks

The **ssaxlate** command is used with a type of disk developed by IBM known as Serial Storage Architecture (SSA). The SSA disks not only use the hdisk# but also have an

associated pdisk#. Normally the hdisk# and the pdisk# differ on the system. The ssaxlate command gives a cross-reference between the two disk representations. It is always a good idea to have this extra information if we are dealing with SSA disks, especially if you are replacing an SSA disk. To use the ssaxlate command, you need to know the specific hdisk# to translate to the corresponding pdisk#, or vice versa. As an example, we want to know what pdisk# translates to hdisk36. The command syntax to do the translation is shown here:

```
# ssaxlate -l hdisk36
pdisk32
```

In this example, hdisk36 translates to pdisk32. From this you can infer that hdisk0 through hdisk3 are not SSA disks. Usually the first few disks on an AIX system are SCSI, SATA, or FATA disk drives. You can also translate a pdisk# into the corresponding hdisk# by running the ssaxlate command against the pdisk#.

Log Files

In the first two shell scripts in this chapter we did not use a log file as we did in Method 3. It is always nice to have a log file to look at after the fact when you are running any type of system query. Creating a log file is a simple process of defining a variable to point to a filename that you want to use for a log file and appending output to the log file variable. If your system tends to fill up the /tmp filesystem, I recommend creating a log directory, maybe in /usr/local/logs, or creating a separate filesystem just for log files. You can still have the mount point /usr/local/logs, or anything you want. If /tmp fills up, you will not be able to write anything to the log file. You may also want to keep a month's worth of log files to review in case of system problems. To do this you can add a date stamp as a filename extension and remove all files older than 30 days with the find command.

Automated Execution

You can make a cron entry in the root cron table to execute this shell script to automate running the script daily. A sample cron table entry is shown here:

```
05 23 * * * /usr/local/bin/stale_PP_mon.ksh >/dev/null 2>&1
```

The preceding cron table entry will execute the stale_PP_mon.ksh shell script every day at 11:05 p.m., 365 days a year. The output is redirected to the bit bucket, but the log file will be created for review the next day.

Event Notification

If you use the previous cron table entry to execute the shell script every day, you may want to get some kind of notification by way of an email or a page. The easiest way is to email the log file to yourself every day. You can also modify the shell script to

produce a very short message as a page. As an example, you could send one of the following text messages to an alphanumeric pager:

```
$THIS_HOST: stale PP check OK

$THIS_HOST: stale PP check FAILED
```

These are short messages to get the point across, and you will know which machine the page came from.

Summary

In this chapter we looked at a logical progression of creating a shell script by starting at the basics. I hope you have gained at least some knowledge of the AIX Logical Volume Manager (LVM) through this experience. As you can see in this chapter, the first attempt to solve a challenge may not always be the best, or fastest, method; but this is how we learn. If we take these small steps and work up a full-blown shell script with all of the bells and whistles, we have learned a great deal. I know a lot of you do not work on AIX systems, but this is still a valuable exercise.

In the next chapter we are continuing with another AIX topic, turning on/off SSA disk identification lights. See you in the next chapter!

Lab Assignment

1. Rewrite the shell script in Listing 20-8 to utilize functions for each test type: VG, PV, and LV.

CHAPTER 21

Turning On/Off SSA Identification Lights

If your system utilizes the Serial Storage Architecture (SSA) disk subsystem from IBM, you understand how difficult it is to find a specific failed disk in the hundreds of disks that populate the racks. Other needs for SSA disk identification include finding all of the drives attached to a particular system. Then you may also want to see only the drives that are in currently varied-on volume groups or a specific group of disks. In revising this book, I thought about deleting this chapter; however, many shops still use SSA, and this chapter has some very good shell scripting techniques, so I decided to keep this topic. Even if you do not utilize SSA disks, please stick around and follow through the scripting techniques to pick up a few scripting tips.

In identifying hardware components in a system, you usually have a set of tools for this function. This chapter is going to concentrate on AIX systems. The script presented in this chapter is valid only for AIX, but with a few modifications it can run on other UNIX flavors that utilize the SSA subsystem. I am sticking to AIX because this script has an option to query *volume groups*, which not all UNIX flavors support. If your systems are running the Veritas filesystem, then only a few commands need to be modified for my identification script to work because Veritas supports the concept of a volume group.

In identifying an SSA disk you have two ways of referencing the disk. In AIX all disks are represented as an `hdisk#`. As an example, `hdisk0` almost always contains the operating system, and it is part of the `rootvg` volume group. It is not often an SSA disk; it is usually an internal SCSI disk. If an hdisk is an SSA disk, it has a second disk name that is used within the SSA subsystem, which is called the `pdisk#`. Not often are the `hdisk#` and the `pdisk#` the same number because the first couple of disks are usually SCSI drives. We need to be able to translate an hdisk to its associated pdisk, and vice versa.

Syntax

As always, we need to start out with the commands to accomplish the task. With the SSA subsystem we are concerned about two commands that relate to hdisks and pdisks. The first command, **ssaxlate**, translates an `hdisk#` into a `pdisk#`, or vice versa. The second command we use is the ***ssaidentify*** command, which requires a pdisk representation of the SSA disk drive. This command is used to turn the SSA disk-identification lights on and off. We want the script to identify the SSA disks to recognize either disk format, hdisk or pdisk. With the `ssaxlate` command this is not a problem.

To use these commands you need to know only the SSA disk to act on and add the appropriate command switch. Let's look at both commands here.

Translating an hdisk to a pdisk

```
# ssaxlate -l hdisk43

pdisk41
```

In this example `hdisk43` translates to `pdisk41`. This tells me that the hdisk-to-pdisk offset is 2, which I have to assume means that `hdisk0` and `hdisk1` are both SCSI disks, and `hdisk3` through at least `hdisk43` are all SSA disks. This is not always the case. It depends on how the AIX configuration manager discovered the disks in the first place, but my statement is a fair assumption. We could just as easily translate `pdisk41` to `hdisk43` by specifying `pdisk41` in the `ssaxlate` command.

The next step is to actually turn on the identification light for hdisk43, which we discovered to be pdisk41. The `ssaidentify` command wants the disks represented as pdisks, so we need to use pdisk41 for this command.

Identifying an SSA Disk

```
# ssaidentify -l pdisk41 -y
```

The `ssaidentify` command will just return a return code of success or failure, but no text is returned. If the return code is 0, zero, the command was successful. If the return code is nonzero, the command failed for some reason and a message is sent to standard error, which is file descriptor 2. All we are interested in is whether or not the return code is zero.

The Scripting Process

In the SSA identification script we are going to use a lot of functions. These functions perform the work, so we just need the logic to decide which function to execute. An important thing you need to understand about functions is that the function *must* be declared, or written, in the code previous to when you want to execute the function.

This makes sense if you think about it: you have to write the code before you can use it! The functions involved in this shell script are listed in Table 21-1 for your convenience.

Table 21-1 SSA Identification Functions

FUNCTION NAME	PURPOSE
`usage`	Shows the user how to use the shell script
`man_page`	Shows detailed information on how to use the shell script
`cleanup`	Executes when a trapped exit signal is detected
`twirl`	Used to give the user feedback that processing continues
`all_defined_ pdisks`	Controls SSA identification lights for all system SSA disks
`all_varied_on_pdisks`	Controls SSA disks only in currently varied-on volume groups
`list_of_disks`	Controls SSA identification of a list of one or more disks

Usage and User Feedback Functions

As you can see, we have our work cut out for us, so let's get started. The first function is the `usage` function. When a user input error is detected you want to give the user some feedback on how to properly use the shell script. Always create a `usage` function. I want to show you this function because I did something you may not know that you can do. I used a single `echo` command and have 15 separate lines of output. Take a look at the function in Listing 21-1 to see the method.

```
function usage
{
echo "\nUSAGE ERROR...
\nMAN PAGE ==> $SCRIPTNAME  -?
\nTo Turn ALL Lights Either ON or OFF:
\nUSAGE: SSAidentify.ksh [-v] [on] [off]
EXAMPLE: SSAidentify.ksh -v  on
\nWill turn ON ALL of the system's currently VARIED ON
SSA identify lights. NOTE: The default is all DEFINED SSA disks
\nTo Turn SPECIFIC LIGHTS Either ON or OFF Using EITHER
the pdisk#(s) AND/OR the hdisk#(s):
\nUSAGE: SSAidentify.ksh [on] [off] pdisk{#1} [hdisk{#2}]...
EXAMPLE: SSAidentify.ksh on hdisk36 pdisk44 pdisk47
\nWill turn ON the lights to all of the associated pdisk#(s)
that hdisk36 translates to and PDISKS pdisk44 and pdisk47.
\nNOTE: Can use all pdisks, all hdisks or BOTH hdisk
```

Listing 21-1 Usage function with a single echo command

```
and pdisk together if you want..."

exit 1
}
```

Listing 21-1 (*continued*)

As you can see in Listing 21-1, I enclose the entire text that I want to `echo` to the screen within double quotes, `"usage text"`. To place text on the next line, just press the `ENTER` key. If you want an extra blank line or a `TAB`, use one or more of the many cursor functions available with the `echo` command, as shown in Table 21-2.

Table 21-2 Cursor Control Commands for the echo Command

ECHO FUNCTION	PURPOSE
`\n`	Inserts a new line with a carriage return
`\t`	Tabs over on TAB length characters for each `\t` entered
`\b`	Backs the cursor up one space for each `\b` entered
`\c`	Leaves the cursor at the current position, without a carriage return or line feed

There are many more in the `man` pages on your system. When incorrect usage of the shell script is detected, which you have to build into the script, the proper usage message in Listing 21-2 is displayed on the screen.

```
USAGE ERROR...

MAN PAGE ==> SSAidentify.ksh  -?

To Turn ALL Lights Either ON or OFF:

USAGE: SSAidentify.ksh [-v] [on] [off]
EXAMPLE: SSAidentify.ksh -v  on

Will turn ON ALL of the system's currently VARIED ON
SSA identify lights. NOTE: The default is all DEFINED SSA disks

To Turn SPECIFIC LIGHTS Either ON or OFF Using EITHER
the pdisk#(s) AND/OR the hdisk#(s):

USAGE: SSAidentify.ksh [on] [off] pdisk{#1} [hdisk{#2}]...
EXAMPLE: SSAidentify.ksh on hdisk36 pdisk44 pdisk47

Will turn ON the lights to all of the associated pdisk#(s)
```

Listing 21-2 Example of cursor control using the echo command

```
that hdisk36 translates to and PDISKS pdisk44 and pdisk47.

NOTE: Can use all pdisks, all hdisks or BOTH hdisk
and pdisk together if you want...
```

Listing 21-2 (*continued*)

By using cursor control with the `echo` command, we can eliminate using a separate `echo` command on every separate line of text we want to display. I do the same thing in the `man_page` function. You can see this function in its entirety in the full shell script shown in Listing 21-9.

Before I show you the `cleanup` function, I want to show you the `twirl` function. The `twirl` function is used to give feedback to the user, which you saw back in Chapter 4, ''Progress Indicators Using a Series of Dots, a Rotating Line, or Elapsed Time.'' As a brief review, the `twirl` function displays the appearance of a line rotating. And this is accomplished through? You guessed it, cursor control using the `echo` command. I like the `twirl` function because it is not too hard to understand and it is very short. This function works by starting an infinite `while` loop, which is done using the `:` (colon) no-op operator. A no-op does nothing and always has a zero return code, so it is perfect to create an infinite loop. The next step is to have a counter that counts only from 0 to 4. When the counter reaches 4 it is reset back to 0, zero. At each count a `case` statement is used to decide which of the four lines, -, \, |, and /, is to be displayed. At the same time, the cursor is backed up so it is ready to overwrite the previous line character with a new one. There is a sleep for one second on each loop iteration. You must leave the `sleep` statement in the code or you will see a big load on the system by all of the continuous updates to the screen. I use this function for giving user feedback when a time-consuming job is executing. When the job is finished I `kill` the `twirl` function and move on. The easiest way to `kill` a background function is to capture the PID just after kicking off the background job, which is assigned to the `$!` shell variable. This is similar to the way `$?` is used to see the return code of the last command. The `twirl` function is shown in Listing 21-3.

```
function twirl
{
TCOUNT="0"      # For each TCOUNT the line twirls one increment

while :         # Loop forever...until you break out of the loop
do
       TCOUNT=$(expr ${TCOUNT} + 1) # Increment the TCOUNT

       case ${TCOUNT} in
           "1")    echo '-'"\b\c"
                   sleep 1
                   ;;
           "2")    echo '\\'"\b\c"
                   sleep 1
```

Listing 21-3 Twirl function listing

```
                ;;
        "3")    echo "|\b\c"
                sleep 1
                ;;
        "4")    echo "/\b\c"
                sleep 1
                ;;
        *)      TCOUNT="0" ;;  # Reset the TCOUNT to "0", zero.
    esac
done
# End of twirl function
}
```

Listing 21-3 (*continued*)

When I have a time-consuming job starting, I start the `twirl` function with the following commands:

```
twirl &

TWIRL_PID=$!
```

This leads into the next function, `cleanup`. In normal operation the `twirl` function is killed in the main body of the script, or in the function that it is called in, by using the `kill` command and the previously saved PID, which is pointed to by the `TWIRL_PID` variable. Life, though, is not always normal. In the top of the main body of the shell script we set a **trap**. The `trap` is used to execute one or more commands, programs, or shell scripts when a specified exit code is captured. Of course, *you cannot* `trap` *a* `kill -9`! In this shell script we execute the `cleanup` function on exit codes 1, 2, 3, 5, and 15. You can add more exit codes if you want. This `cleanup` function displays a message on the screen that a `trap` has occurred and runs the `kill -9 $TWIRL_PID` command before exiting the shell script. If you omit the `trap` and the `twirl` function is running in the background, it will continue to run in the background! You cannot miss it — you always have a twirling line on your screen. Of course, you can `kill` the PID if you can find it in the process table with the `ps` command. The cleanup function is shown in Listing 21-4.

```
function cleanup
{
echo "\n...Exiting on a trapped signal...EXITING STAGE LEFT...\n"

kill -9 $TWIRL_PID

# End of cleanup function
}
```

Listing 21-4 Cleanup function listing

When an exit code is captured the user is informed that the shell script is exiting, and then the `kill` command is executed on the PID saved in the `$TWIRL_PID` variable.

Control Functions

Now we get into the real work of turning on and off the SSA identification lights starting with the `all_defined_pdisks` function. This function is the simplest of the SSA identification functions in this chapter. The goal is to get a list of every SSA disk on the system and use the `pdisk#` to control the identification lights by turning all lights on or off in sequence.

To understand this function you need to understand an AIX command called **lsdev** and the switches we use to extract only the pdisk information. The `lsdev` command is used to display devices in the system and the characteristics of devices. The `-C` switch tells the `lsdev` command to look at only the currently defined devices. Then the `-c` command switch is added to specify the particular *class* of device; in our case the device class is `pdisk`. So far our `lsdev` command looks like the following statement:

```
# lsdev -Cc pdisk
```

But we want to drill down a little deeper in the system. We can also specify a *subclass* to the previously defined class by adding the `-s` switch with our subclass `ssar`. We also want to have a formatted output with column headers, so we add the `-H` switch. These headers just help ensure that we have good separation between fields. Now we have the following command:

```
# lsdev -Cc pdisk -s ssar -H
```

When you use this command on a system with SSA disks you see an output similar to the one in Listing 21-5.

```
name    status    location        description

pdisk0  Available 34-08-5B91-01-P SSA160 Physical Disk Drive
pdisk1  Available 34-08-5B91-02-P SSA160 Physical Disk Drive
pdisk2  Available 34-08-5B91-03-P SSA160 Physical Disk Drive
pdisk3  Available 34-08-5B91-04-P SSA160 Physical Disk Drive
pdisk4  Available 24-08-5B91-05-P SSA160 Physical Disk Drive
pdisk5  Available 24-08-5B91-07-P SSA160 Physical Disk Drive
pdisk6  Available 24-08-5B91-06-P SSA160 Physical Disk Drive
pdisk7  Available 24-08-5B91-08-P SSA160 Physical Disk Drive
pdisk8  Available 24-08-5B91-09-P SSA160 Physical Disk Drive
pdisk9  Available 24-08-5B91-10-P SSA160 Physical Disk Drive
pdisk10 Available 24-08-5B91-11-P SSA160 Physical Disk Drive
pdisk11 Available 24-08-5B91-12-P SSA160 Physical Disk Drive
pdisk12 Available 34-08-5B91-13-P SSA160 Physical Disk Drive
```

Listing 21-5 lsdev listing of pdisks

```
pdisk13 Available 34-08-5B91-14-P SSA160 Physical Disk Drive
pdisk14 Available 34-08-5B91-16-P SSA160 Physical Disk Drive
pdisk15 Available 34-08-5B91-15-P SSA160 Physical Disk Drive
```

Listing 21-5 (*continued*)

In Listing 21-5 we have more information than we need. The only part of this `lsdev` command output that we are interested in is in the first column, and only the lines that have ''`pdisk`'' in the first column. To filter this output we need to expand our `lsdev` command by adding `awk` and `grep` to filter the output. Our expanded command is shown here:

```
# lsdev -Cc pdisk -s ssar -H | awk '{print $1}' | grep pdisk
```

In this command statement we extract the first column using the `awk` statement in a pipe, while specifying the first column with the `'{print $1}'` notation. Then we use `grep` to extract only the lines that contain the pattern `pdisk`. The result is a list of all currently defined pdisks on the system.

To control the identification lights for the pdisks in this list we use a `for` loop and use our `lsdev` command to create the list of pdisks with command substitution. These steps are shown in Listing 21-6.

```
function all_defined_pdisks
{
   # TURN ON/OFF ALL LIGHTS:
   # Loop through each of the system's pdisks by using the "lsdev"
   # command with the "-Cc pdisk" switch while using "awk" to extract
   # out the actual pdisk number.  We will either
   # turn the identifier lights on or off, specified by the $SWITCH
   # variable:
   #
   #    Turn lights on:  -y
   #    Turn lights off: -n
   #
   # as the $SWITCH value to the "ssaidentify" command, as used below...

echo "\nTurning $STATE ALL of the system's pdisks...Please Wait...\n"

for PDISK in $(lsdev -Cc pdisk -s ssar -H | awk '{print $1}' \
              | grep pdisk)
do
    echo "Turning $STATE ==> $PDISK"
    ssaidentify -l $PDISK -${SWITCH} \
   || echo "Turning $STATE $PDISK Failed"
```

Listing 21-6 all_defined_pdisks function listing

```
done
echo "\n...TASK COMPLETE...\n"
}
```

Listing 21-6 (*continued*)

In Listing 21-6 notice the command substitution used in the `for` loop, which is in bold text. The command substitution produces the list arguments that are assigned to the `$PDISK` variable on each loop iteration. As each pdisk is assigned, the `ssaidentify` command is executed using the `$PDISK` definition as the target and uses the `-$SWITCH` as the action to take, which can be either `-y` for light on or `-n` for light off. These values are defined in the main body of the shell script. As each light is being turned on or off the user is notified. If the action fails the user is notified of the failure also. This failure notification is done using a logical OR, specified by the double pipes, `||`.

The next function is `all_varied_on_pdisks`. This function is different in that we must approach the task of getting a list of SSA disks to act on using completely different strategy. The result we want is the ability to control the SSA disks that are in volume groups that are currently varied-on. To get this list we must first get a list of the varied-on volume groups using the `lsvg -o` command. This command gives a list of varied-on volume groups directly without any added text, so we are okay with this command's output. Using this list of volume groups we can now use the `lspv` command to get a full listing of defined hdisks. From this list we use `grep` to extract the hdisks that are in currently varied-on volume groups. Notice that all of this activity so far is at the hdisk level. We need to have pdisks to control the identification lights. To build a list of hdisks to convert, we use a `for` loop, tagging on the volume groups with the `VG` variable. For each `$VG` we run the following command to build a list:

```
# lspv | grep $VG >> $HDISKFILE
```

Notice that we use a file to store this list. A file is needed because if a variable were used we might exceed the character limit for a variable, which is 2,048 on most systems. As you know, most large shops have systems with hundreds, if not thousands, of SSA disks. To be safe we use a file for storage here.

Using this list of hdisks we are going to use another `for` loop to translate each of the hdisks into the associated pdisk. Because we may still have a huge list containing pdisks we again use a file to hold the list. The translation takes place using the `ssaxlate` command, but what if some of these hdisks are not SSA disks? Well, the translation will fail! To get around this little problem we first test each translation and send all of the output to the bit bucket and check the return code of the `ssaxlate` command. If the return code is 0, zero, then the hdisk is an SSA disk. If the return code is nonzero, the hdisk is not an SSA disk. The result is that only pdisks are added to the new pdisk list file, which is pointed to by the `PDISKFILE` variable. Because this translation may take quite a while we start the `twirl` function, which is our progress indicator, in the background before the translation begins. As soon as the translation process ends, the `twirl` function is killed using the saved PID.

The only thing left to do is to perform the desired action on each of the pdisk identification lights. We do this by starting yet another `for` loop. This time we use command substitution to produce a list of pdisks by listing the pdisk list file with the `cat` command. On each loop iteration the `ssaidentify` command is executed for each pdisk in the list file. The `all_varied_on_pdisks` function is shown in Listing 21-7.

```
function all_varied_on_pdisks
{
trap 'kill -9 $TWIRL_PID; return 1' 1 2 3 15

cat /dev/null > $HDISKFILE
cat /dev/null > $PDISKFILE

echo "\nGathering a list of Varied on system SSA disks...
Please wait...\c"

VG_LIST=$(lsvg -o) # Get the list of Varied ON Volume Groups

for VG in $VG_LIST
do
        lspv | grep $VG >> $HDISKFILE # List of Varied ON PVs
done

twirl & # Gives the user some feedback during long processing times...

TWIRL_PID=$!

echo "\nTranslating hdisk(s) into the associated pdisk(s)
         ...Please Wait...\c"

for DISK in $(cat $HDISKFILE) # Translate hdisk# into pdisk#(s)
do
     # Checking for an SSA disk
     /usr/sbin/ssaxlate -l $DISK # 2>/dev/null 1>/dev/null
     if (($? == 0))
     then
         /usr/sbin/ssaxlate -l $DISK >> $PDISKFILE # Add to pdisk List
     fi
done

kill -9 $TWIRL_PID # Kill the user feedback function...
echo "\b  "     # Clean up the screen by overwriting the last character

echo "\nTurning $STATE all VARIED ON system pdisks...Please Wait...\n"

# Act on each pdisk individually...

for PDISK in $(cat $PDISKFILE)
```

Listing 21-7 all_varied_on_pdisks function listing

```
do
   echo "Turning $STATE ==> $PDISK"
   /usr/sbin/ssaidentify -l $PDISK -${SWITCH} \
        | echo "Turning $STATE PDISK Failed"
done
echo "\n\t...TASK COMPLETE...\n"
}
```

Listing 21-7 (*continued*)

Notice that there is a `trap` at the beginning of this function in Listing 21-7. Because we are using the `twirl` function for user feedback we need a way to kill off the rotating line, so we added a `trap` inside the function. In the next step we initialized both of the list files to empty files. Then the fun starts. This is where we filter through all of the hdisks to find the ones that are in currently varied-on volume groups. With this hdisk list we loop through each of the disks looking for SSA disks. As we find each hdisk it is translated into a pdisk and added to the pdisk list. With all of the pdisks of interest found, we loop through each one and turn on/off the SSA identification lights.

The last function is `list_of_disks`, which acts on one or more hdisks or pdisks that are specified on the command line when the shell script is executed. In the main body of the shell script we do all of the parsing of the command-line arguments because if you tried to parse the command line inside a function the parsing would act on the *function's* argument, not the shell script's arguments. Therefore this is a short function.

In the main body of the shell script a variable, `PDISKLIST`, is populated with a list of pdisks. Because the user can specify hdisks or pdisks or both on the command line, the only verification that has been done is on the hdisks only, when they were translated to pdisks. We need to do a sanity check to make sure that each of the pdisks we act on has a character special file in the `/dev` filesystem. This is done using the **-c** switch in an `if...then` test. If the pdisk listed has a character special file associated with it, an attempt is made to turn the SSA identification light on/off; otherwise, the user is notified that the specified pdisk is not defined on the system. The `list_of_disks` function is shown in Listing 21-8.

```
function list_of_disks
{
   # TURN ON/OFF INDIVDUAL LIGHTS:
   # Loop through each of the disks that was passed to this script
   # via the positional parameters greater than $1, i.e., $2, $3, $4...
   # We first determine if each of the parameters is a pdisk or an
   # hdisk. For each hdisk passed to the script we first need to
   # translate the hdisk definition into a pdisk definition.  This
   # script has been set up to accept a combinition of hdisks and
   # pdisks.
   #
   # We will either turn the identifier lights on or off, specified by
   # the $SWITCH variable for each pdisk#:
```

Listing 21-8 list_of_disks function listing

```
    #
    #    Turn lights on:  -y
    #    Turn lights off: -n
    #
    # as the $SWITCH value to the "ssaidentify" command, as used below...

    echo "\n"

    # The disks passed to this script can be all hdisks, all pdisks,
    # or a combination of pdisks and hdisks; it just does not matter.
    # We translate each hdisk into the associated pdisk(s).


echo "\nTurning $STATE individual SSA disk lights...\n"

for PDISK in $PDISKLIST
do
     # Is it a real pdisk??
     if [ -c /dev/${PDISK} ] 2>/dev/null
     then # Yep - act on it...

          /usr/sbin/ssaidentify -l $PDISK -${SWITCH} >/dev/null
          if (($? == 0))
          then
                /usr/bin/ssaxlate -l $PDISK -${SWITCH}
                if (($? == 0))
                then
                     echo "Light on $PDISK is $STATE"
                else
                     echo "Turning $STATE $PDISK Failed"
                fi
          fi
     else
else
          echo "\nERROR: $PDISK is not a defined device on $THISHOST\n"
     fi
done

echo "\n...TASK COMPLETE...\n"
}
```

Listing 21-8 (*continued*)

Notice in the boldface text in Listing 21-8 where we do the test to see if the pdisk listed is a real pdisk by using the `-c` switch in the `if` statement. We have covered the rest of the function, so let's move on to the main body of the shell script.

The Full Shell Script

This is a good point to show the entire shell script and go through the details at the end of the listing. The `SSAidentify.ksh` shell script is shown in Listing 21-9.

```
#!/bin/ksh
#
# SCRIPT: SSAidentify.ksh
#
# AUTHOR: Randy Michael
#
# DATE: 11/7/2007
#
# REV: 2.5.A
#
# PURPOSE: This script is used to turn on, or off, the
# identify lights on the system's SSA disks
#
# REV LIST:
#    11/27/2007: Added code to allow the user to turn on/off
#    individual pdisk lights
#
#    12/10/2007: Added code to accept a combination of pdisks
#    and hdisks.  For each hdisk passed the script translates
#    the hdisk# into the associated pdisk#(s).
#
#    12/10/2007: Added code to ALLOW using the currently VARIED ON
#    Volume Group's disks (-v switch), as opposed to ALL DEFINED
#    SSA disks, which is the default behavior.  Very helpful in an
#    HACMP environment.
#
#    12/11/2007: Added the "twirl" function to give the user feedback
#    during long processing periods, i.e., translating a few hundred
#    hdisks into associated pdisks.  The twirl function is just a
#    rotating cursor, and it twirls during the translation processing.
#
# set -n   # Uncomment to check syntax without any execution
# set -x   # Uncomment to debug this script

SCRIPTNAME=$(basename $0)

##############################################

function usage
```

Listing 21-9 SSAidentify.ksh shell script listing

```
{
echo "\nUSAGE ERROR...
\nMAN PAGE ==> $SCRIPTNAME  -?
\nTo Turn ALL Lights Either ON or OFF:
\nUSAGE: SSAidentify.ksh [-v] [on] [off]
EXAMPLE: SSAidentify.ksh -v  on
\nWill turn ON ALL of the system's currently VARIED ON
SSA identify lights. NOTE: The default is all DEFINED SSA disks
\nTo Turn SPECIFIC LIGHTS Either ON or OFF Using EITHER
the pdisk#(s) AND/OR the hdisk#(s):
\nUSAGE: SSAidentify.ksh [on] [off] pdisk{#1} [hdisk{#2}]...
EXAMPLE: SSAidentify.ksh on hdisk36 pdisk44 pdisk47
\nWill turn ON the lights to all of the associated pdisk#(s)
that hdisk36 translates to and PDISKS pdisk44 and pdisk47.
\nNOTE: Can use all pdisks, all hdisks or BOTH hdisk
and pdisk together if you want..."

exit 1
}

################################################

function man_page
{
MAN_FILE="/tmp/man_file.out"
>$MAN_FILE

# Text for the man page...

echo "\n\t\tMAN PAGE FOR SSAidentify.ksh SHELL SCRIPT\n
This script is used to turn on, or off, the system's SSA disk drive
identification lights.  You can use this script in the following ways:\n
To turn on/off ALL DEFINED SSA drive identification lights, ALL
VARIED-ON SSA
drive identification lights (-v switch), AN INDIVIDUAL SSA drive
identification
light or A LIST OF SSA drive identification lights.\n
SSA disk drives can be specified by EITHER the pdisk OR the hdisk, or
a COMBINATION OF BOTH.  The script translates all hdisks into the
associated pdisk(s) using the system's /usr/sbin/ssaxlate command
and turns
the SSA identification light on/off using the system's /usr/sbin/
ssaidentify
command.\n

This script has four switches that control its action:\n
-? - Displays this man page.\n
on - Turns the SSA identify light(s) ON.\n
```

Listing 21-9 (*continued*)

```
off - Turns the SSA identify light(s) OFF.\n
-v - Specifies to only act on SSA disks that are in currently varied-on
volume groups.  The default action is to act on ALL DEFINED SSA disks.\n
NOTE: This switch is ignored for turning on/off individual SSA drive
lights, only valid when turning on/off ALL lights.  This option is very
helpful in an HACMP environment because ALL DEFINED, the default action,
will turn on/off all of the SSA drive lights even if the SSA disk is in
a volume group that is not currently varied-on.  This can be confusing
in an HA cluster.\n Using this script is very straightforward.  The
following examples show the correct use of this script:\n" >> $MAN_FILE
echo "\nUSAGE: SSAidentify.ksh [-v] [on] [off] [pdisk#/hdisk#]
[pdisk#/hdisk# list]
\n\nTo Turn ALL Lights Either ON or OFF:
\nUSAGE: SSAidentify.ksh [-v] [on] [off]
\nEXAMPLE: $SCRIPTNAME  on
\nWill turn ON ALL of the system's DEFINED SSA identify lights.
This is the default.
EXAMPLE: SSAidentify.ksh -v  on
\nWill turn ON ALL of the system's currently VARIED-ON
SSA identify lights.  OVERRIDES THE DEFAULT ACTION OF ALL DEFINED
SSA DISKS
\nTo Turn SPECIFIC LIGHTS Either ON or OFF Using EITHER
the pdisk#(s) AND/OR the hdisk#(s):
\nUSAGE: $SCRIPTNAME [on] [off] pdisk{#1} [hdisk{#2}]...
\nEXAMPLE: $SCRIPTNAME on hdisk36 pdisk44 pdisk47
\nWill turn ON the lights to all of the associated pdisk#(s)
that hdisk36 translates to and PDISKS pdisk44 and pdisk47.
\nNOTE: Can use all pdisks, all hdisks or BOTH hdisk
and pdisk together if you want...\n\n" >> $MAN_FILE

more $MAN_FILE

# End of man_page function
}

###############################################

function cleanup
{
echo "\n...Exiting on a trapped signal...EXITING STAGE LEFT...\n"

kill $TWIRL_PID

# End of cleanup function
}

###############################################
```

Listing 21-9 (*continued*)

```
function twirl
{
TCOUNT="0"      # For each TCOUNT the line twirls one increment

while :         # Loop forever...until you break out of the loop
do
       TCOUNT=$(expr ${TCOUNT} + 1) # Increment the TCOUNT

       case ${TCOUNT} in
           "1")    echo '-'"\b\c"
                   sleep 1
                   ;;
           "2")    echo '\\'"\b\c"
                   sleep 1
                   ;;
           "3")    echo "|\b\c"
                   sleep 1
                   ;;
           "4")    echo "/\b\c"
                   sleep 1
                   ;;
           *)      TCOUNT="0" ;;  # Reset the TCOUNT to "0", zero.
       esac
done
# End of twirl function
}

###########################################

function all_defined_pdisks
{
   # TURN ON/OFF ALL LIGHTS:
   # Loop through each of the system's pdisks by using the "lsdev"
   # command with the "-Cc pdisk" switch while using "awk" to extract
   # out the actual pdisk number.  We will either
   # turn the identifier lights on or off, specified by the
   # $SWITCH variable:
   #
   #    Turn lights on:  -y
   #    Turn lights off: -n
   #
   # as the $SWITCH value to the "ssaidentify" command, as used below...

echo "\nTurning $STATE ALL of the system's pdisks...Please Wait...\n"

for PDISK in $(lsdev -Cc pdisk -s ssar -H | awk '{print $1}' | grep pdisk)
do
     echo "Turning $STATE ==> $PDISK"
```

Listing 21-9 (*continued*)

```
     ssaidentify -l $PDISK -${SWITCH} || echo "Turning $STATE $PDISK
     Failed"
done
echo "\n...TASK COMPLETE...\n"

}

##########################################

function all_varied_on_pdisks
{
trap 'kill -9 $TWIRL_PID; return 1' 1 2 3 15

cat /dev/null > $HDISKFILE

echo "\nGathering a list of Varied on system SSA disks...Please
wait...\c"

VG_LIST=$(lsvg -o) # Get the list of Varied ON Volume Groups

for VG in $(echo $VG_LIST)
do
        lspv | grep $VG >> $HDISKFILE # List of Varied ON PVs
done

twirl & # Gives the user some feedback during long processing times...

TWIRL_PID=$!

echo "\nTranslating hdisk(s) into the associated pdisk(s)...Please
Wait... \c"

for DISK in $(cat $HDISKFILE) # Translate hdisk# into pdisk#(s)
do
     # Checking for an SSA disk
     /usr/sbin/ssaxlate -l $DISK # 2>/dev/null 1>/dev/null

     if (($? == 0))
     then
          /usr/sbin/ssaxlate -l $DISK >> $PDISKFILE # Add to pdisk List
     fi
done

kill -9 $TWIRL_PID # Kill the user feedback function...
echo "\b  "


echo "\nTurning $STATE all VARIED-ON system pdisks...Please Wait...\n"
```

Listing 21-9 (*continued*)

```
for PDISK in $(cat $PDISKFILE)
do # Act on each pdisk individually...
    echo "Turning $STATE ==> $PDISK"
    /usr/sbin/ssaidentify -l $PDISK -${SWITCH} || echo "Turning $STATE
$PDISK Failed"
done

echo "\n\t...TASK COMPLETE...\n"

}

###########################################

function list_of_disks
{
# TURN ON/OFF INDIVDUAL LIGHTS:
# Loop through each of the disks that was passed to this script
# via the positional parameters greater than $1, i.e., $2, $3, $4...
# We first determine if each of the parameters is a pdisk or an hdisk.
# For each hdisk passed to the script we first need to translate
# the hdisk definition into a pdisk definition.  This script has
# been set up to accept a combination of hdisks and pdisks.
#
# We will either turn the identifier lights on or off, specified by
# the $SWITCH variable for each pdisk#:
#
#    Turn lights on:  -y
#    Turn lights off: -n
#
# as the $SWITCH value to the "ssaidentify" command.

echo "\n"

# The disks passed to this script can be all hdisks, all pdisks
# or a combination of pdisks and hdisks; it just does not matter.
# We translate each hdisk into the associated pdisk(s).


echo "\nTurning $STATE individual SSA disk lights...\n"

for PDISK in $PDISKLIST
do
     # Is it a real pdisk??
     if [ -c /dev/${PDISK} ] 2>/dev/null
     then # Yep - act on it...

          /usr/sbin/ssaidentify -l $PDISK -${SWITCH}
          if [ $? -eq 0 ]
```

Listing 21-9 (*continued*)

```
          then
                /usr/bin/ssaxlate -l $PDISK -${SWITCH}
                if (($? == 0))
                then
                     echo "Light on $PDISK is $STATE"
                else
                     echo "Turning $STATE $PDISK Failed"
                fi
          fi
     else
          echo "\nERROR: $PDISK is not a defined device on $THISHOST\n"
     fi
done

echo "\n...TASK COMPLETE...\n"
}

############################################
############ BEGINNING OF MAIN ############
############################################

# Set a trap...

# Remember...Cannot trap a "kill -9" !!!

trap 'cleanup; exit 1' 1 2 3 15

############################################

# Check for the correct number of arguments (1)

if (($# == 0))
then
     usage
fi

############################################

# See if the system has any pdisks defined before proceeding

PCOUNT=$(lsdev -Cc pdisk -s ssar | grep -c pdisk)

if ((PCOUNT == 0))
then
     echo "\nERROR: This system has no SSA disks defined\n"
     echo "\t\t...EXITING...\n"
     exit 1
fi
```

Listing 21-9 (*continued*)

```
################################################

# Make sure that the ssaidentify program is
# executable on this system...

if [ ! -x /usr/sbin/ssaidentify ]
then
     echo "\nERROR: /usr/sbin/ssaidentify is NOT an executable"
     echo "program on $THISHOST"
     echo "\n...EXITING...\n"
     exit 1
fi

################################################

# Make sure that the ssaxlate program is
# executable on this system...

if [ ! -x /usr/sbin/ssaxlate ]
then
     echo "\nERROR: /usr/sbin/ssaxlate is NOT an executable"
     echo "program on $THISHOST"
     echo "\n...EXITING...\n"
     exit 1
fi

################################################
################################################
#
# Okay, we should have valid data at this point
# Let's do a light show.
#
################################################
################################################

# Always use the UPPERCASED value for the $STATE, $MODE,
# and $PASSED variables...


typeset -u MODE
MODE="DEFINED_DISKS"
typeset -u STATE
STATE=UNKNOWN
typeset -u PASSED

# Use lowercase for the argument list
typeset -l ARGUMENT
```

Listing 21-9 (*continued*)

```
# Grab the system hostname

THISHOST=$(hostname)

# Define the hdisk and pdisk FILES

HDISKFILE="/tmp/disklist.out"
>$HDISKFILE
PDISKFILE="/tmp/pdisklist.identify"
>$PDISKFILE

# Define the hdisk and pdisk list VARIABLES

HDISKLIST=
PDISKLIST=

# Use getopts to parse the command-line arguments

while getopts ":vV" ARGUMENT 2>/dev/null
do
      case $ARGUMENT in

           v|V)      MODE="VARIED_ON"
                     ;;
           \?)       man_page
                     ;;
      esac
done

###############################################

# Decide if we are to turn the lights on or off...

(echo $@ | grep -i -w on  >/dev/null) && STATE=ON
(echo $@ | grep -i -w off >/dev/null) && STATE=OFF


case $STATE in

ON)
 # Turn all of the lights ON...
     SWITCH="y"
     ;;
OFF)
     # Turn all of the lights OFF...
     SWITCH="n"
     ;;
*)
```

Listing 21-9 (*continued*)

```
     # Unknown Option...
     echo "\nERROR: Please indicate the action to turn lights ON or OFF\n"
      usage
      exit 1
     ;;
esac

################################################
################################################
########## PLAY WITH THE LIGHTS ###############
################################################
################################################

if (($# == 1)) && [[ $MODE = "DEFINED_DISKS" ]]
then
      # This function will turn all lights on/off

      all_defined_pdisks

elif [[ $MODE = "VARIED_ON" ]] && (($# = 2))
then
      # This function will turn on/off SSA disk lights
      # in currently varied-on volume groups only

      all_varied_on_pdisks

# Now check for hdisk and pdisk arguments

elif [ $MODE = DEFINED_DISKS ] && (echo $@ | grep disk >/dev/null) \
                                && (($# >= 2))
then
      # If we are here we must have a list of hdisks
      # and/or pdisks

      # Look for hdisks and pdisks in the command-line arguments

      for DISK in $(echo $@ | grep disk)
      do
           case $DISK in
           hdisk*) HDISKLIST="$HDISKLIST $DISK"
                   ;;
           pdisk*) PDISKLIST="$PDISKLIST $DISK"
                   ;;
           *)      :  # No-Op - Do nothing
                   ;;
           esac
      done
```

Listing 21-9 (*continued*)

```
      if [[ ! -z "$HDISKLIST" ]] # Check for hdisks to convert to pdisks
      then

      # We have some hdisks that need to be converted to pdisks
      # so start converting the hdisks to pdisks

            # Give the user some feedback

            echo "\nConverting hdisks to pdisk definitions"
            echo "\n     ...Please be patient...\n"

            # Start converting the hdisks to pdisks

            for HDISK in $HDISKLIST
            do
                 PDISK=$(ssaxlate -l $HDISK)
                 if (($? == 0))
                 then
                       echo "$HDISK translates to ${PDISK}"
                 else
                      echo "ERROR: hdisk to pdisk translation FAILED for
$HDISK"
                 fi
                 # Build a list of pdisks
                                          # Add pdisk to the pdisk list
                 PDISKLIST="$PDISKLIST $PDISK"
             done
      fi

      if [[ -z "$PDISKLIST" ]]
      then
           echo "\nERROR: You must specify at least one hdisk or pdisk\n"
           man_page
           exit 1
      else
            # Turn on/off the SSA identification lights

            list_of_disks
      fi
fi

###############################################
#          END OF SCRIPT                      #
###############################################
```

Listing 21-9 (*continued*)

Let's start at the `BEGINNING OF MAIN` in Listing 21-9. The very first thing that we do is set a `trap`. This `trap` is set for exit codes 1, 2, 3, 5, and 15. On any of these captured signals the `cleanup` function is executed, and then the shell script exits with a return code of 1. It is nice to be able to clean up before the shell script just exits.

In the next series of tests we first make sure that there is at least one argument present on the command line. If no arguments are given, the script presents the `usage` function, which displays proper usage and exits. If we pass the argument test then I thought it would be a good idea to see if the system has any SSA disks defined on the system. For this step we use the `PCOUNT=$(lsdev -Cc pdisk -s ssar | grep -c pdisk)`. The `grep -c` returns the count of SSA disks found on the system and assigns the value to the `PCOUNT` variable. If the value is zero there are no SSA disks, so inform the user and `exit`. If we do have some SSA disks, the next thing we do is make sure that the `ssaidentify` and `ssaxlate` commands exist and are executable on this system. At this point we know we are in an SSA environment, so we define and initialize all of the script's variables.

Then we get to use the `getopts` function to parse the command-line arguments. We expect and recognize just two arguments, `-v` and `-V`, to specify varied-on volume groups only. Any other argument, specified by a preceding hyphen, **-**, displays the `man_page` function. Anything else on the command line is ignored by the `getopts` function, which is a shell built-in function.

On the command line we *must* have either `on` or `off` present, or we do not have enough information to do anything. We check the command-line arguments by echoing out the full list and grepping for `on` and `off`. At the next `case` statement the `$STATE` variable is tested. If on or off was not found, the `usage` function is displayed and the script exits. If we get past this point we know that we have the minimal data to do some work.

When we start playing with the lights we have to do some tests to decide what action we need to take and on what set of SSA disks. The first one is simple. If we have only one command-line argument and it is either `on` or `off`, then we know to turn on or off all defined SSA disk-identification lights on the system without regard to volume group status. So, here we run the `all_defined_pdisks` function. If we have two arguments on the command line and one of them is `-v` or `-V`, we know to act only on SSA disks in currently varied-on volume groups by turning every one of the SSA identification lights on or off.

The last option is to have hdisks or pdisks listed on the command line. For this option we know to act on only the disks that the user specified and to turn on or off only these disks. Because we allow both hdisks and pdisks we need to convert everything to pdisk definitions before we call the `list_of_disks` function. To do this we `echo` the entire list of command-line arguments and `grep` for the word `disk`. Using this list in a `case` statement, we can detect the presence of an hdisk or a pdisk. For each one found it is added to either the `HDISKLIST` or the `PDISKLIST` variables. After the test we check to see if the `HDISKLIST` variable has anything assigned, which means that the variable is not null. If there are entries, we convert each hdisk to its

associated pdisk and build up the pdisk list in the `PDISKLIST` variable. When the list is complete, and it is not an empty list, we call the `list_of_disks` function. That is it for this shell script.

Other Things to Consider

I cannot always fit all of the options into a chapter, and this chapter is no exception. Here are a few things to consider to modify this shell script.

Error Log

When I created this shell script it was for a personal need because I have so many SSA disk trays. For my purposes I did not need an error log, but you may find one necessary. In the places that I sent everything to the bit bucket, especially standard error or file descriptor 2, redirect this output to append to an error log. This may help you find something in the system that you missed.

Cross-Reference

Because it is rare for the hdisk and pdisk associations to match by numbers, you may find that a shell script to cross-reference the numbers is beneficial. You should be able to knock this out in about one hour. Look through the code where I first test the hdisk to see if it is an SSA disk and then do the translation. Using these few lines of code you can build a nice little cross-reference sheet for your staff.

Root Access and sudo

Both of the SSA commands need root privilege to execute. If your systems have strict root access rules you may just want to define this shell script in your `/etc/sudoers` file. Please *never* edit this file directly! There is a special wrapper program around the **vi** editor in the `/usr/local/sbin` directory called **visudo**. This command starts a `vi` session and opens up the `/etc/sudoers` file automatically. When you are finished editing and save the file, this program checks the `/etc/sudoers` file for errors.

Summary

In this chapter we learned a few new things about controlling the SSA subsystem on an AIX machine. These principles apply to any other UNIX system utilizing SSA. As always, there are many different ways to write a shell script, and some are lean and mean with no comments. I like to make the shell scripts easier to understand and maintain. But I do have a few things that you may want to consider.

I hope you learned something in this chapter. In the next chapter we will look at techniques of pinging hosts and notifying staff if any hosts are not reachable. See you in the next chapter!

Lab Assignment

1. Add a command-line switch, `-c`, to the **SSAidentify.ksh** script in Listing 21-9 that will execute a new function to produce a cross-reference that matches pdisks to hdisks. This information should be both displayed and saved in a file.

CHAPTER 22

Automated Hosts Pinging with Notification of Failure

In every shop there is a critical need to keep the servers serving. For system availability, the quicker you know that a system is unreachable, the quicker you can act to resolve the problem and reduce company losses. At the lowest level of system access, we can **ping** each machine in the ''critical machine'' list. If the `ping` works, it will tell you if the network adapter is working, but it does not guarantee that the machine is booted and applications are working. For this level of checks you need to actually access the application or operating system.

In this chapter we are going to create a shell script that will `ping` hosts using a list of machines, which is stored in a separate file that is easily edited. Other options to this scenario include pinging all the machines in the `/etc/hosts` file, using **ftp** to transfer a file, querying a database, or interacting with an application, to name a few. Our interest in this chapter is to work at the lowest level and use the `ping` command to ensure that the machines are reachable from the network. When a machine is found unreachable, we send notification to alert staff that the machine is down. Due to the fact that in some shops the network can become saturated with network traffic, we are going to add an extra level of testing on a failed `ping` test, which we will get into later in this chapter. But before we go any further let's look at the command syntax for each of our operating systems (AIX, HP-UX, Linux, OpenBSD, and Solaris) to see if we can find a command syntax that will produce the same output for all of the operating systems that we are working with.

Syntax

As always, we need the correct command syntax before we can write a shell script. Our goal is to find the command syntax that produces the same output for each operating system. For this shell script we want to `ping` each host multiple times to ensure that the

node is reachable; the default is three pings. The standard output we want to produce on each OS is shown here:

```
# ping -c3 dino
PING dino: (10.10.10.4): 56 data bytes
64 bytes from 10.10.10.4: icmp_seq=0 ttl=255 time=2 ms
64 bytes from 10.10.10.4: icmp_seq=1 ttl=255 time=1 ms
64 bytes from 10.10.10.4: icmp_seq=2 ttl=255 time=1 ms

----dino PING Statistics----
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 1/1/2 ms
```

This is the command, and the output is from an AIX machine. Notice the `PING Statistics` at the bottom of the command output, where I have highlighted `3 packets received`. This is the output line that we are interested in for every operating system. Now, how do we produce the same output for each OS? Instead of leaving you in the dark I am just going to list each one in Table 22-1, showing you how to `ping` the host `dino`.

In Table 22-1 notice that AIX, Linux, and OpenBSD have the same command syntax. For HP-UX and Solaris notice the two numbers, 56 and 3. The 56 specifies the packet size to send on each ping, and the 3 is the number of times to try to reach the host. For a packet size, 56 is a standard packet, and we are not going to change from this standard. It is important to know the differences in command structure for each operating system because we are creating one shell script and we will `ping` each node using a function, which selects the correct command to execute based on the UNIX flavor. To find the OS, we use the `uname` command. By using the output of the `uname` command in a `case` statement, we are assured that the correct command is executed on any of the five operating systems. This is really all we have for the syntax, but we need to do some checks and create some variables, so we are going to build the shell script around these commands, listed in Table 22-1.

Table 22-1 Ping Command for Each Operating System

OPERATING SYSTEM	PING COMMAND
AIX	`# ping -c3 dino`
HP-UX	`# ping dino 56 3`
Linux	`# ping -c3 dino`
OpenBSD	`# ping -c3 dino`
Solaris	`# ping -s dino 56 3`

Creating the Shell Script

In scripting this solution we want to add a couple of options for convenience. The first option is to have a means of stopping the pinging without interrupting the scheduled script execution, which is usually executed through a cron table entry. The second option is to have a means of stopping the *notification* for nodes that are unreachable. For each of these we can use a flag variable that must have a value of `TRUE` to enable the option. There are many times that we want to disable these two options, but the main reason is during a maintenance window when many of the machines are unreachable at the same time. If you have only one or two machines that are down, then commenting out the node name(s) in the `ping.list` file, which contains a list of nodes to `ping`, is preferable. You can also comment out the cron table entry to disable the monitoring altogether.

Now we need to define the pinging technique that we want to use. I like to use a two-level approach in checking for a system's reachability. In a two-level testing scenario, when a node is unreachable we go to sleep for a few seconds and try the test again. We do this to eliminate ''false positives'' due to a heavy network load. This is a major concern at some shops where I have worked, and finger-pointing back and forth between the network team and the Systems Administrators always happens, so I try to stay out of this argument. This second-level test adds just a few seconds to the testing window for each unreachable node. This is a relatively simple shell script to create, so keep reading!

Define the Variables

The first thing that we want to do in almost any shell script is to define the variables and files that are used in the script. We have already discussed two variables, which enable pinging and notification. For pinging we use the `PINGHOSTS` variable, and `MAILOUT` as the variable to permit or disable notification. Additionally, for ease of testing we are going to **typeset** both of these variables to force all text assignments to these variables to uppercase, as shown here:

```
typeset -u PINGHOSTS
typeset -u MAILOUT
PINGHOSTS=TRUE
MAILOUT=TRUE
```

We can also `typeset` the variables and assign the values in the same step, as shown here:

```
typeset -u PINGHOSTS=true
typeset -u MAILOUT=true
```

Notice that I assign a lowercase `true` to both variables, but when you print or test the variables you will see that the assignments have been changed to uppercase characters:

```
# echo $MAILOUT
TRUE
```

There are a few more variables that we also need to define, including `PING_COUNT` and `PACKET_SIZE`, that specify the number of times to `ping` the target host and the packet size for each packet, which we discussed earlier.

```
integer PING_COUNT=3
integer PACKET_SIZE=56
```

Notice the *integer* notation used to define these variables as integers. This notation produces the exact same results that the `typeset -i` command produces.

Next we need the UNIX flavor that this shell script is running. This shell script recognizes AIX, HP-UX, Linux, OpenBSD, and Solaris. For this step we use the `uname` command, as shown here:

```
UNAME=$(uname)
```

In this `UNAME` assignment we used command substitution to assign the result of the `uname` command to the variable `UNAME`.

The next two steps in this definition section involve defining the `PINGFILE` and `MAILFILE` file assignments. The `PINGFILE` contains a list of nodes that we want to `ping`. The shell script is expecting one node, or hostname, per line as shown here:

```
yogi
booboo
bamBam
mrranger
fred
```

If you no longer want to `ping` a node in the list file, you can comment the host out using a hash mark (`#`). For this shell script I specified that the `ping` list is located in `/usr/local/bin/ping.list`.

Similarly, the `MAILFILE` has a list of email addresses that are to be notified when a node is not reachable. We can also set up a `sendmail` alias. Our email list is located in `/usr/local/bin/mail.list`. The variable assignments are shown here:

```
PINGFILE="/usr/local/bin/ping.list" # List of nodes to ping
MAILFILE="/usr/local/bin/mail.list" # List of persons to notify
```

For these two files we are going to check for a nonzero length file, which implies the file exists and its size is greater than zero bytes. If the `$PINGFILE` does not exist,

we need to send an ERROR message to the user and exit the shell script because we do not have a list of nodes to ping. If the $MAILFILE does not exist, we are just going to display a message to notify the user that there will not be any email notification sent for unreachable nodes.

We also need a file to hold the data that is emailed out when a node is unreachable. The file is located in /tmp/pingfile.out and is assigned to the PING_OUTFILE variable:

```
PING_OUTFILE="/tmp/pingfile.out" # File for emailed notification
>$PING_OUTFILE  # Initialize to an empty file
```

Notice how we created an empty file by redirecting nothing to the file, which is pointed to by the $PING_OUTFILE variable. You could also use cat /dev/null to accomplish the same task, as shown here:

```
cat /dev/null > $PING_OUTFILE
```

Next we need three variables that are to hold numeric values — at least we hope they are numeric. The first variable is called INTERVAL, and it contains a value specifying the number of seconds to sleep before trying to ping an unreachable node for the second time. I like to use three seconds:

```
integer INTERVAL="3" # Number of seconds to sleep between retries
```

As we discussed before, in our standard ping output we are interested in the PING Statistics line of output. Specifically, we want to extract the numeric value for the "3 packets received", which should be greater than zero if the node is reachable. To hold the value for the number of pings received back, we need two variables, one for the first try and one for the second attempt, in case the node is unreachable the first time. These two variables are PINGSTAT and PINGSTAT2 and are initialized to NULL, as shown here:

```
PINGSTAT=    # Number of pings received back from pinging a node
PINGSTAT2=   # Number of pings received back on the second try
```

The last variable we need to assign is the hostname of the machine that is running this script. We need the hostname because we may have two hosts pinging each node in case one pinging node fails. For this variable we again use command substitution, as shown here:

```
THISHOST=`hostname`     # The hostname of this machine
```

Notice that this time we used the back tics (`command`) instead of the dollar-double-parentheses method ($(command)) for command substitution. Both command-substitution options produce the same result, which is yogi on this machine.

Creating a Trap

To start out our shell script we are going to set a **trap**, which allows us to take some kind of action when an exit signal is captured, such as a user pressing Ctrl+C. We can capture most exit signals *except* for `kill -9`. The only *action* that we want to take in this shell script is to inform the user that the shell script has detected an `exit` signal and the script is exiting. This `trap` is added in this shell script so that you get used to putting traps in all of your shell scripts. We are going to capture `exit` signals 1, 2, 3, 5, and 15 only. You can add many more, but it is overkill in this case. For a complete list of `exit` signals, use the `kill -l (lowercase L)` command. The command syntax for the trap is shown here:

```
trap 'echo "\nExiting on a trapped signal...\n";exit 1' 1 2 3 5 15
```

Using this `trap` command statement, the following message is displayed before the shell script exits with `exit` signal `1`.

```
Exiting on a trapped signal...
```

The Whole Shell Script

We have all of the initializations complete and know what the `ping` syntax is for each operating system, so let's look at the whole shell script and cover some other issues at the end of Listing 22-1. Pay close attention to the boldface text.

```
#!/usr/bin/ksh
#
# SCRIPT: pingnodes.ksh
# AUTHOR: Randy Michael
# DATE: 02-20-2007
#
# PURPOSE:  This script is used to ping a list of nodes and
# send email notification (or alphanumeric page) of any unreachable
# nodes.
#
# REV: 1.0.A
#
# REV.LIST:
#
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check command syntax without any execution
#
#####################################################

# Set a trap and clean up before a trapped exit...
# REMEMBER: you CANNOT trap "kill -9"
```

Listing 22-1 pingnodes.ksh shell script

```
trap 'echo "\n\nExiting on trapped signal...\n" \
        ;exit 1' 1 2 3 15

#########################################################

# Define and initialize variables here...

PING_COUNT="3"       # The number of times to ping each node
PACKET_SIZE="56"     # Packet size of each ping

typeset -u PINGNODES # Always use the UPPERCASE value for $PINGNODES
PINGNODES="TRUE"   # To enable or disable pinging FROM this node - "TRUE"

typeset -u MAILOUT   # Always use the UPPERCASE value for $MAILOUT
MAILOUT="TRUE"       # TRUE enables outbound mail notification of events

UNAME=$(uname)       # Get the Unix flavor of this machine

PINGFILE="/usr/local/bin/ping.list" # List of nodes to ping

if [ -s $PINGFILE ]
then
      # Ping all nodes in the list that are not commented out and blank
      PINGLIST=$(grep -v '^#' $PINGFILE)
else
      echo "\nERROR: Missing file - $PINGFILE"
      echo "\nList of nodes to ping is unknown...EXITING...\n"
      exit 2
fi

MAILFILE="/usr/local/bin/mail.list" # List of persons to notify

if [ -s $MAILFILE ]
then
       # Ping all nodes in the list that are not commented out and blank
        MAILLIST=$(cat $MAILFILE | egrep -v '^#')
else
        echo "\nERROR: Missing file - $MAILFILE"
        echo "\nList of persons to notify is unknown...\n"
        echo "No one will be notified of unreachable nodes...\n"
fi

PING_OUTFILE="/tmp/pingfile.out" # File for emailed notification
>$PING_OUTFILE  # Initialize to an empty file

integer INTERVAL="3" # Number of seconds to sleep between retries

# Initialize the next two variables to NULL
```

Listing 22-1 (*continued*)

```
PINGSTAT=    # Number of pings received back from pinging a node
PINGSTAT2=   # Number of pings received back on the second try

THISHOST=`hostname`     # The hostname of this machine

#########################################################
############ DEFINE FUNCTIONS HERE ######################
#########################################################

function ping_host
{
# This function pings a single node based on the Unix flavor

# set -x # Uncomment to debug this function
# set -n # Uncomment to check the syntax without any execution

# Look for exactly one argument, the host to ping

if (( $# != 1 ))
then
     echo "\nERROR: Incorrect number of arguments - $#"
     echo "       Expecting exactly one argument\n"
     echo "\t...EXITING...\n"
     exit 1
fi

HOST=$1 # Grab the host to ping from ARG1.

# This next case statement executes the correct ping
# command based on the Unix flavor

case $UNAME in

AIX|OpenBSD|Linux)
           ping -c${PING_COUNT} $HOST 2>/dev/null
           ;;
HP-UX)
           ping $HOST $PACKET_SIZE $PING_COUNT 2>/dev/null
           ;;
SunOS)
           ping -s $HOST $PACKET_SIZE $PING_COUNT 2>/dev/null
           ;;
*)
           echo "\nERROR: Unsupported Operating System - $(uname)"
           echo "\n\t...EXITING...\n"
```

Listing 22-1 (*continued*)

```
            exit 1
esac
}

#########################################################

function ping_nodes
{
#########################################################
#
# Ping the other systems check
#
# This can be disabled if you do not want every node to be pinging all
# of the other nodes.  It is not necessary for all nodes to ping all
# other nodes, although you do want more than one node doing the pinging
# just in case the pinging node is down.  To activate pinging the
# "$PINGNODES" variable must be set to "TRUE".  Any other value will
#  disable pinging from this node.
#

# set -x # Uncomment to debug this function
# set -n # Uncomment to check command syntax without any execution

if [[ $PINGNODES = "TRUE" ]]
then
     echo     # Add a single line to the output

     # Loop through each node in the $PINGLIST

     for HOSTPINGING in $PINGLIST # Spaces between nodes in the
                                  # list are assumed
     do
          # Inform the user what is going on

          echo "Pinging --> ${HOSTPINGING}...\c"

          # If the pings received back are equal to "0" then you have a
          # problem.

          # Ping $PING_COUNT times, extract the value for the pings
          # received back.


          PINGSTAT=$(ping_host $HOSTPINGING | grep transmitted \
                     | awk '{print $4}')

          # If the value of $PINGSTAT is NULL, then the node is
          # unknown to this host
```

Listing 22-1 (*continued*)

```
          if [[ -z "$PINGSTAT" && "$PINGSTAT" = '' ]]
          then
               echo "Unknown host"
               continue
          fi
          if (( PINGSTAT == 0 ))
          then  # Let's do it again to make sure it really is unreachable

               echo "Unreachable...Trying one more time...\c"
               sleep $INTERVAL
               PINGSTAT2=$(ping_host $HOSTPINGING | grep transmitted \
                         | awk '{print $4}')

               if (( PINGSTAT2 == 0 ))
               then # It REALLY IS unreachable...Notify!!
                    echo "Unreachable"
                    echo "Unable to ping $HOSTPINGING from $THISHOST" \
                          | tee -a $PING_OUTFILE
               else
                    echo "OK"
               fi
          else
               echo "OK"
          fi

     done
fi
}

#######################################################

function send_notification
{
if [ -s $PING_OUTFILE -a  "$MAILOUT" = "TRUE" ];
then
        case $UNAME in
        AIX|HP-UX|Linux|OpenBSD) SENDMAIL="/usr/sbin/sendmail"
        ;;
        SunOS) SENDMAIL="/usr/lib/sendmail"
        ;;
        esac

        echo "\nSending email notification"
        $SENDMAIL -f randy@$THISHOST $MAILLIST < $PING_OUTFILE
fi
}
```

Listing 22-1 (*continued*)

```
################################################
############ START of MAIN #####################
################################################


ping_nodes
send_notification


# End of script
```

Listing 22-1 (*continued*)

Now we get to the fun stuff! Let's start out with the three functions, because they do all of the work anyway. The first function is `ping_host`. The idea here is to set up a `case` statement, and based on the response from the `uname` command, which was assigned to the `UNAME` variable in the definitions section, we execute the specific `ping` command for the particular UNIX flavor. If an unlisted UNIX flavor is found, an `ERROR` message is given to the user, and this shell script exits with a return code `1`. We must do this because we have no idea what the correct syntax for a `ping` command should be for an unknown operating system.

The `ping_host` function is called from the `ping_nodes` function on every loop iteration. Inside the `ping_nodes` function we first ensure that the `$PINGNODES` variable is set to `TRUE`; otherwise, the pinging of nodes is disabled.

We use the `$PINGFILE` file to load a variable, `PINGLIST`, with a list of nodes that we want to `ping`. This extra step is done to give the user the ability to comment out specific node(s) in the `$PINGFILE`. Without this ability you would leave the user in a state of annoyance for all of the notifications because of a single node being down for a period of time. The command to strip out the commented lines and leave the remaining nodes in the list is shown here:

```
PINGLIST=$(grep -v '^#' $PINGFILE)
```

Notice how this command substitution works. We use `grep` with the `-v` switch. The `-v` switch tells `grep` to list everything *except* for the following pattern, which is `'^#'` in this case. Now let's look at the `^#` part. When we put a caret character (`^`) in front of a pattern in this `grep` statement, we are ignoring any line that *begins with* a hash mark (`#`) in the `$PINGFILE`. The caret (`^`) means *begins with*.

A `for` loop is started using the `$PINGLIST` variable as a list, which contains each host in the `/usr/local/bin/ping.list` file that is *not* commented out. For each host in the listing we `echo` to the screen the target hostname and call the `ping_host` function inside of a command-substitution statement on each loop iteration, which is shown here:

```
echo "Pinging --> ${HOSTPINGING}...\c"
PINGSTAT=$(ping_host $HOSTPINGING | grep transmitted | awk '{print $4}')
```

For each node in the $PINGLIST the echo statement and the command-substitution statement are executed. There are three possible results for the command-substitution statement, and we test for two; the last one is assumed. (1) The PINGSTAT value is 0, zero. If the packets received are 0, zero, then we sleep for $INTERVAL seconds and try to reach the node again, this time assigning the packets received to the PINGSTAT2 variable. (2) The PINGSTAT value is NULL. This results when you try to ping a node that is unknown to the system. In this case we echo to the screen Unknown host and continue to the next node in the list. (3) The PINGSTAT value is nonzero and non-NULL, which means that the ping was successful. Please study each of these tests in the ping_nodes function.

Notice the tests used in the if statements. Each of these is a mathematical test, so we use the double parentheses method of testing, as shown here:

```
if (( PINGSTAT == 0 ))
```

There are two things to notice in this if statement. The first is that there is no dollar sign ($) in front of the PINGSTAT variable. The dollar sign is not needed in a mathematical test when using the double parentheses method because the shell assumes that any nonnumeric string is a variable for this type of mathematical test. The second point I want to make in the preceding if statement is the use of the double equal signs (==). Using this type of mathematical test, a single equal sign is an *assignment*, not an equality test. This sounds a little strange, but you can actually assign a value to a variable in a test. To test for equality in the ((math test)) method, always use double equal signs (==) with this test method.

The last function in this shell script is the send_notification function. This function is used to send an email notification to each address listed in the /usr/local/bin/mail.list file, which is pointed to by the MAILFILE variable. Before attempting any notification, the function tests to see if the $PING_OUTFILE file has anything in it or if its size is greater than zero bytes. The second test is to ensure that the MAILOUT variable is set to TRUE. If the $PING_OUTFILE has some data and the MAILOUT variable is set to TRUE, the function will attempt to notify each email address in the $MAILFILE.

In the send_notification function, notice that I am using the sendmail command, as opposed to the mail or mailx commands. I use the sendmail command because I worked at a shop where I had a lot of trouble getting mail through the firewall because I was sending the mail as root. You need some valid email address, and I found a solution by using the sendmail command because I can specify a valid user who *sent* the email. The command I used is shown here:

```
sendmail -f randy@$THISHOST $MAILLIST < $PING_OUTFILE
```

In this statement the -f <user@THISHOST> specifies who is sending the email. We can also use the following mailx command syntax to accomplish the same task:

```
mailx -r randy@$THISHOST $MAILLIST < $PING_OUTFILE
```

In this statement, the -r <user@THISHOST> specifies who is sending the email. The $MAILLIST is the list of persons who should receive the email, and the < $PING_OUTFILE input redirection is the body text of the email, which is stored in

a file. I still have one little problem, though. The `sendmail` command is not always located in the same directory, and sometimes it is not in the `$PATH`. On AIX, HP-UX, Linux, and OpenBSD, the `sendmail` command is located in `/usr/sbin`. On Solaris the `sendmail` command is located in the `/usr/lib` directory. To get around this little problem we need a little `case` statement that utilizes the `$UNAME` variable that we used in the `ping_host` function. With a little modification we have the function shown in Listing 22-2.

```
function send_notification
{
if [ -s $PING_OUTFILE -a  "$MAILOUT" = "TRUE" ];
then
        case $UNAME in
        AIX|HP-UX|Linux) SENDMAIL="/usr/sbin/sendmail"
        ;;
        SunOS) SENDMAIL="/usr/lib/sendmail"
        ;;
        esac

        echo "\nSending email notification"
        $SENDMAIL -f randy@$THISHOST $MAILLIST < $PING_OUTFILE
fi
}
```

Listing 22-2 send_notification function listing

Notice that we used a single line for AIX, HP-UX, Linux, and OpenBSD in the `case` statement. At the end of the function we use the `$SENDMAIL` variable to point to the correct full path of the `sendmail` command for the specific operating system.

Let's not forget to look at the `pingnodes.ksh` shell script in action! In the following output, shown in Listing 22-3, the node `dino` is unknown to the system, and the `mrranger` node is powered down, so there is no response from the `ping` to the system.

```
# ./pinghostfile.ksh.new

Pinging --> yogi...OK
Pinging --> bambam...OK
Pinging --> booboo...OK
Pinging --> dino...Unknown host
Pinging --> wilma...OK
Pinging --> mrranger...Unreachable...Trying one more time...Unreachable
Unable to ping mrranger from yogi

Sending email notification
```

Listing 22-3 pingnodes.ksh shell script in action

From the output in Listing 22-3, notice the result of pinging the node `dino`. I commented out the hostname `dino` in the `/etc/hosts` file. By doing so I made the node unknown to the system because DNS is not configured on this system. The `mrranger` node is powered down, so it is known but not reachable. Notice the difference in the outputs for these two similar, but very different, situations. Please study the code related to both of these tests in the `ping_nodes` function.

Other Options to Consider

As always, we can improve on any shell script, and this one is no exception. I have listed some options that you may want to consider.

$PINGLIST Variable-Length-Limit Problem

In this scripting solution we gave the user the capability to comment out specific nodes in the `$PINGFILE`. We assigned the list of nodes, which is a list without the comments, to a variable. This is fine for a relatively short list of nodes, but a problem arises when the maximum variable length, which is usually 2,048 bytes, is exceeded. If you have a long list of nodes that you want to `ping` and you notice that the script never gets to the end of the `ping` list, you have a problem. Or if you see a funny-looking node name, which is probably a hostname that has been cut off by the variable limit and associated with a system error message, you have a problem. To resolve this issue, define a new file to point to the `PINGLIST` variable, and then we will use the *file* to store the ping list data instead of a *variable*. To use `PINGLIST` as a file, add/change the following lines.

Add this line:

```
PINGLIST=/tmp/pinglist.out
```

Change this line:

```
PINGLIST=$(cat $PINGFILE | grep -v '^#')
```

to this line:

```
cat $PINGFILE | grep -v '^#' > $PINGLIST
```

Change this line:

```
for HOSTPINGING in $(echo $PINGLIST)
```

to this line:

```
for HOSTPINGING in $(cat $PINGLIST)
```

Using the file to store the `ping` list data removes the variable assignment limit. This modified shell script is located on this book's companion web site (`www.wiley.com/go/michael2e`). The script name is `pingnodes_using_a_file.ksh`.

Ping the /etc/hosts File Instead of a List File

This may be overkill for any large shop, but it is easy to modify the shell script to accomplish this task. You want to make the following change to the shell script after completing the tasks in the previous section, ''$PINGLIST Variable-Length-Limit Problem,'' to the shell script shown in Listing 22-1.

Change these lines:

```
if [ -s $PINGFILE ]
then
PINGLIST=$(cat $PINGFILE | grep -v '^#')
```

to these lines:

```
if [ -s /etc/hosts ]
then
      # Ping all nodes in the /etc/hosts file
cat /etc/hosts | sed /^#/d | sed /^$/d | grep -v 127.0.0.1 \
               | awk '{print $2}' > $PINGLIST
```

In this changed code we `cat` the `/etc/hosts` file and pipe the output to a `sed` statement, `sed /^#/d`. This `sed` statement removes every line in the `/etc/hosts` file that begins with a pound sign (#). The output of this `sed` statement is then piped to another `sed` statement, `sed /^$/d`, which removes all of the blank lines in the `/etc/hosts` file (the blank lines are specified by the `^$`). This `sed` output is sent to a `grep` command that removes the loopback address (127.0.0.1) from the list. Finally, the remaining output is piped to an `awk` statement that extracts the `hostname` out of the second field. The resulting output is redirected to the `$PINGLIST` file.

Before you `sed` purists gig me on using pipes, a more proper `sed` statement has the form:

```
sed /^#/d /etc/hosts | sed /^$/d | grep -v 127.0.0.1 \
                     | awk '{print $2}' > $PINGLIST
```

Notice that we removed the `cat /etc/hosts |` and just added the filename as the last argument to the first `sed` command.

The modified shell script to ping the `/etc/hosts` file is included on the web site that accompanies the book (`www.wiley.com/go/michael2e`). Just download the script and function package. The filename we want to modify is `pinghostsfile.ksh`.

Logging

I have not added any logging capability to this shell script. Adding a log file, in addition to user notification, can help you find trends of when nodes are unreachable. Adding a log file is not too difficult to do. The first step is to define a unique log filename in the definitions section and assign the filename to a variable, maybe `LOGFILE`. In the script test for the existence of the file, using a test similar to the following statement will work.

Add these lines:

```
LOGPATH=/usr/local/log
LOGFILE=${LOGPATH}/pingnodes.log
if [ ! -s $LOGFILE ]
then
     if [ ! -d $LOGPATH ]
     then
          echo "\nCreating directory ==> $LOGPATH\c"
          mkdir /usr/local/log
          if (( $? != 0 ))
          then
            echo "\nUnable to create the $LOGPATH directory...EXITING \n"
             exit 1
          fi
          chown $USER /usr/local/log
          chmod 755 $LOGPATH
          echo
     fi
     echo "\nCreating Logfile ==> $LOGFILE\c"
     cp /dev/null > $LOGFILE
     chown $USER $LOGFILE
     echo
fi
```

After adding these lines of code, use the `tee -a $LOGFILE` command in a pipe to both display the text on the screen and log the data in the `$LOGFILE`.

Notification of "Unknown Host"

You may want to add notification, and maybe logging too, for nodes that are not known to the system. This usually occurs when the machine cannot resolve the node name into an IP address. This can be caused by the node not being listed in the `/etc/hosts` file, failure of the DNS lookup, or a typo in a hostname definition. You can check DNS using the `nslookup` command. Check all three conditions when you get the `Unknown host` message. Currently, this shell script only echoes this information to the screen. You may want to add this message to the notification.

Notification Method

In this shell script we use email notification. I like email notification, but if you have a network failure this is not going to help you. To get around the ''network down'' problem with email, you may want to set up a modem, for *dial-out* only, to dial your alphanumeric pager number and leave you a message. At least you will always get the message. I have had times, though, when I received the message two hours later due to a message overflow to the modem.

You may just want to change the notification to another method, such as SNMP traps. If you execute this shell script from an enterprise management tool, the response

required back to the program is usually an SNMP trap. Refer to the documentation of the program you are using for details.

Automated Execution Using a Cron Table Entry

I know you do not want to execute this shell script from the command line every 15 minutes yourself! I use a `root` cron table entry to execute this shell script every 15 minutes, 24 hours a day, Monday through Saturday, and 8:00 a.m. to midnight on Sunday; of course, this requires two cron table entries. Because weekly backups and reboots happen early Sunday morning, I do not want to be awakened every Sunday morning when a machine reboots, so I have a special cron entry for Sunday. Both `root` cron table entries shown execute this script every 15 minutes:

```
5,20,35,50 * * * 1-6 /usr/local/bin/pingnodes.ksh >/dev/null 2>&1
5,20,35,50 8-23 * * 0   /usr/local/bin/pingnodes.ksh </dev/null 2>&1
```

The first entry executes the `pingnodes.ksh` shell script at 5, 20, 35, and 50 minutes of every hour from Monday through Saturday. The second entry executes the `pingnodes.ksh` shell script at 5, 20, 35, and 50 minutes from 8:00 a.m. until 11:59 p.m., with the last `ping` test running at 11:50 p.m. Sunday.

Summary

In this chapter we took a different approach than we have in some other shell scripts in this book. Instead of creating a different function for each operating system, we created a single shell script and then used a separate function to execute the correct command syntax for the specific operating system. The `uname` command is a very useful tool for shell scripting solutions for various UNIX flavors in a single shell script.

I hope you enjoyed this chapter. I think we covered some unique ways to solve the scripting problems that arise when programming for multiple UNIX flavors in the same script. In the next chapter we will dive into the task of taking a system *snapshot*. The idea is to get a point-in-time system configuration for later comparison if a system problem has you puzzled. See you in the next chapter!

Lab Assignments

1. Write a shell script that will `ping` all hosts listed in the `/etc/hosts` file that are not commented out with a pound sign (`#`), or just download the `pinghostsfile.ksh` shell script from `www.wiley.com/go/michael2e`. Modify this shell script to allow *exceptions* capability, as we used in Chapter 17, ''Filesystem Monitoring,'' so that we can omit hosts from the `ping` monitoring process. Name this new shell script `ping_hosts_exceptions.ksh`.

2. Modify the `ping_hosts_exceptions.ksh` script to add logging for unreachable hosts with a date/time stamp. Name this new script `ping_hosts_exceptions_logging.ksh`.
3. Create a `sendmail` alias named `net_support` to replace the `$MAILLIST` variable functionality. Don't forget to run the `newaliases` command!

   BONUS: Modify the `pingnodes.ksh` shell script in Listing 22-1 to troubleshoot a failed ping. The modifications should include the following:

   a. If the `ping` fails, try doing a DNS lookup; if successful, `ping` the IP address instead of the hostname.

   b. Keep a list of unreachable hosts and try to analyze if you have a total network failure, or just one segment or subnet is down. HINT: Use the `ifconfig -a` and `netstat -rn` commands to extract each adapter's network adapter IP and gateway to isolate the outage. If *all* nodes are unreachable, then log it!

CHAPTER 23

Creating a System-Configuration Snapshot

Have you ever rebooted a system and it came up in an unusual state? Any time that you reboot a system, you run a risk that the system will not come back up properly. When problems arise it is nice to have before and after pictures of the state of the machine. In this chapter we are going to look at some options for shell scripts that execute a series of commands to take a *snapshot* of the state of the machine. Some of the things to consider for this system snapshot include filesystems that are mounted, NFS mounts, processes that are running, network statistics and configuration, routing tables, and a list of defined system resources, just to name a few. This is different from gathering a snapshot of performance statistics, which is gathered over a period of time. All we are looking for is system-configuration data and the system's state at a point in time, specifically before the system is rebooted or when it is running in a normal state with all of the applications running properly.

With this information captured before a system reboot, you have a better chance of fixing a reboot problem quickly and reducing down time. I like to store snapshot information in a directory called `/usr/local/reboot` with the command names used for filenames. For this shell script all of the system information is stored in a single file with a section header added for each command output. Overall, this is not a difficult shell script to write, but gathering the list of commands that you want to run can sometimes be a challenge. For example, if you want to gather an application's configuration you need to find the commands that will produce the desired output. I always prefer having too much information, rather than not enough information, to troubleshoot a problem.

In this chapter I have put together a list of commands and created a bunch of functions to execute in the shell script. The commands selected are the most critical for troubleshooting an AIX machine; however, you will need to tailor this set of commands to suit your particular needs, operating system, and environment. Every shop is different, but they are all the same in some sense, especially when it comes to troubleshooting a problem. Let's look at some commands and the syntax that is required.

Syntax

As always, we need the commands and the proper syntax for these commands before we can write a shell script. The commands presented in this section are just a sample of the information that you can gather from the system. This set of commands is for an AIX system, but most apply to other UNIX flavors with modified syntax. The list of AIX commands is shown in Listing 23-1.

```
# Hostname of the machine
hostname
OR
uname -n
# UNIX flavor
uname -s
# AIX OS version
oslevel
# AIX maintenance level patch set
instfix -i | grep AIX_ML
OR
oslevel -r
oslevel -s # For AIX 5.3 and later
# Print system configuration
ptrconf
# Time zone for this system
cat /etc/environment | grep TZ | awk -F'=' '{print $2}'
# Real memory in the system
echo "$(bootinfo -r)KB"
OR
lsattr -El -a realmem | awk '{print $2}'
# Machine type/architecture
uname -M
OR - Depending on the architecture
uname -p
# List of defined system devices
lsdev -C
# Long directory listing of /dev
ls -l /dev
# List of all defined disks
lsdev -Cc disk
# List of all defined pdisks for SSA disks
lsdev -Cc pdisk
# List of defined tape drives
lsdev -Cc tape
# List of defined CD-ROMs
lsdev -Cc cdrom
# List of all defined adapters
```

Listing 23-1 System-snapshot commands for AIX

```
lsdev -Cc adapter
# List of network routing table
netstat -rn
# Network adapter statistics
netstat -i
# Filesystem Statistics
df -k
AND
mount
# List of defined Volume Groups
lsvg | sort -r
# List of varied-on Volume Groups
lsvg -o | sort -r
# List of Logical Volumes in each Volume Group
for VG in $(lsvg -o | sort -r)
do
     lsvg -l $VG
done
# Paging space definitions and usage
lsps -a
AND
lsps -s
# List of all hdisks in the system
lspv
# Disk drives listed by Volume Group assignment
for VG in $(lsvg -o | sort -r)
do
     lsvg -p $VG
done
# List the HACMP configuration, if installed
if [ -x /usr/sbin/cluster/utilities/cllsif ]
then
     /usr/sbin/cluster/utilities/cllsif
     echo "\n"
fi

if [ -x /usr/sbin/cluster/utilities/clshowres ]
then
     /usr/sbin/cluster/utilities/clshowres
fi
# List of all defined printers
lpstat -W | tail +3
AND
cat /etc/qconfig
# List of active processes
ps -ef
# Show SNA configuration, if installed
sna -d s
```

Listing 23-1 (*continued*)

```
if (($? != 0))
then
     lssrc -s sna -l
fi
# List of udp and x25 processes, if any
ps -ef | egrep 'udp|x25' | grep -v grep
# Short listing of the system configuration
lscfg
# Long listing of the system configuration
lscfg -vp
# List of all system installed filesets
lslpp -L
# List of broken or inconsistent filesets
lppchk -v 2>&1
# List of the last 100 users to log in to the system
last | tail -100
```

Listing 23-1 (*continued*)

As you can see in Listing 23-1, we can add anything that we want to the snapshot shell script to get as much detail as needed to troubleshoot a problem. Every environment is different, so this list of commands should be modified, or added to, to suit the needs of your shop. Additional tests include a list of databases that are running, application configurations, specific application processes that are critical, and a `ping` list of machines that are critical to the operation of any applications. You can add anything that you want or need here. Always try to gather more information than you think you may need to troubleshoot a problem.

Using this snapshot technique allows us to go back and look at what the system looked like under normal conditions and load. By looking at the snapshot script output file, the problem usually stands out when comparing it to the currently running system that has a problem.

Creating the Shell Script

For this shell script we are going to take the commands shown in Listing 23-1 and create a function for each one. Using functions greatly simplifies both creating and modifying the entire shell script. When we want to add a new test, or configuration output, we just create a new function and add the function-name in the main body of the shell script exactly where we want it to run. In this shell script all of the function definitions use the POSIX, or C-like, function statement, as shown here:

```
get_last_logins ()
{
Commands to execute
}
```

A lot of script programmers like this function-definition technique. I prefer defining a function using the `function` statement method, as shown here:

```
function get_last_logins
{
Commands to execute
}
```

This last method of defining a function is more intuitive to understand for the people who will follow in your footsteps and modify this shell script. I hope you noticed the use of the word *will* in the last sentence. No matter what the shell script does, there is always someone who will come along, after you have moved on to bigger and better things, who will modify the shell script. It is usually not because there is a problem with the script coding, but more likely a need for added functionality. For the people who follow me, I like to make sure that the shell script is easy to follow and understand. Use your own judgment and preference when defining functions in a shell script; just be consistent.

Because we have all of the commands listed in Listing 23-1, let's look at the entire shell script in Listing 23-2 and see how we created all of these functions.

```
#!/usr/bin/ksh
#
# SCRIPT: AIXsysconfig.ksh
#
# AUTHOR: Randy Michael
# REV: 2.1.A
# DATE: 06/14/2007
#
# PLATFORM: AIX only
#
# PURPOSE: Take a snapshot of the system for later comparison
#    in the event of system problems. All data is stored in
#    /usr/local/reboot in the file defined to the $SYSINFO_FILE
#    variable below.
#
#
# REV LIST:
#    7/11/2007: Changed this script to use a single output file
#               that receives data from a series of commands
#               within a bunch of functions.
#
#    10/11/2007: Added the following commands to capture
#                the AIX technology level (TL) and patch set,
#                and print the system configuration
#
#                oslevel -s   # Show TL and patch levels
#
```

Listing 23-2 AIXsysconfig.ksh shell script listing

```
#                prtconf  # Print the system configuration
#
#############
#
# set -x  # Uncomment to debug this script
# set -n  # Uncomment to verify command syntax without execution
#
##################################################
######### DEFINE VARIABLES HERE ##################
##################################################

THISHOST=$(/usr/bin/hostname)
DATETIME=$(date +%m%d%y_%H%M%S)
WORKDIR="/usr/local/reboot"
SYSINFO_FILE="${WORKDIR}/sys_snapshot.${THISHOST}.$DATETIME"

##################################################
############ DEFINE FUNCTIONS HERE ###############
##################################################

get_host ()
{
# Hostname of this machine

hostname

# uname -n works too
}

##################################################

get_OS ()
{
# Operating System - AIX or exit

uname -s
}

##################################################

get_OS_level ()
{
# Query for the operating system release and version level

oslevel -r

OSL=$(oslevel -r | cut -c1-2)
if (( OSL >= 53 ))
```

Listing 23-2 (*continued*)

```
then
echo "Technology Level:       $(oslevel -s)"
fi
}

################################################

get_ML_for_AIX ()
{
# Query the system for the maintenance level patch set

instfix -i | grep AIX_ML
}

################################################

print_sys_config ()
{
prtconf
}

################################################

get_TZ ()
{
# Get the time zone that the system is operating in.

cat /etc/environment | grep TZ | awk -F'=' '{print $2}'
}

################################################

get_real_mem ()
{
# Query the system for the total real memory

echo "$(bootinfo -r)KB"

# lsattr -El sys0 -a realmem | awk '{print $2}'  Works too
}

################################################

get_arch ()
{
# Query the system for the hardware architecture. Newer
# machines use the -M switch and the older Micro-Channel
# architecture (MCA) machines use the -p option for
```

Listing 23-2 (*continued*)

```
# the "uname" command.

ARCH=$(uname -M)
if [[ -z "$ARCH" && "$ARCH" = '' ]]
then
     ARCH=$(uname -p)
fi

echo "$ARCH"
}

################################################

get_devices ()
{
# Query the system for all configured devices

lsdev -C
}

################################################

get_long_devdir_listing ()
{
# Long listing of the /dev directory. This shows the
# device major and minor numbers and raw device ownership

ls -l /dev
}

################################################

get_tape_drives ()
{
# Query the system for all configured tape drives

lsdev -Cc tape
}

################################################

get_cdrom ()
{
# Query the system for all configured CD-ROM devices

lsdev -Cc cdrom
}
```

Listing 23-2 (*continued*)

```
################################################

get_adapters ()
{
# List all configured adapters in the system

lsdev -Cc adapter
}

################################################

get_routes ()
{
# Save the network routes defined on the system

netstat -rn
}

################################################

get_netstats ()
{
# Save the network adapter statistics

netstat -i
}

################################################

get_fs_stats ()
{
# Save the file system statistics

df -k
echo "\n"
mount
}

################################################

get_VGs ()
{
# List all defined Volume Groups

lsvg | sort -r
}
```

Listing 23-2 (*continued*)

```
################################################

get_varied_on_VGs ()
{
# List all varied-on Volume Groups

lsvg -o | sort -r
}

################################################

get_LV_info ()
{
# List the Logical Volumes in each varied-on Volume Group

for VG in $(get_varied_on_VGs)
do
     lsvg -l $VG
done
}

################################################

get_paging_space ()
{
# List the paging space definitions and usage

lsps -a
echo "\n"
lsps -s
}

################################################

get_disk_info ()
{
# List of all "hdisk"s (hard drives) on the system

lspv
}

################################################

get_VG_disk_info ()
{
# List disks by Volume Group assignment

for VG in $(get_varied_on_VGs)
```

Listing 23-2 (*continued*)

```
do
     lsvg -p $VG
done
}

################################################

get_HACMP_info ()
{
# If the System is running HACMP then save the
# HACMP configuration

if [ -x /usr/sbin/cluster/utilities/cllsif ]
then
     /usr/sbin/cluster/utilities/cllsif
     echo "\n\n"
fi

if [ -x /usr/sbin/cluster/utilities/clshowres ]
then
     /usr/sbin/cluster/utilities/clshowres
fi
}

################################################

get_printer_info ()
{
# Wide listing of all defined printers

lpstat -W | tail +3
}

################################################

get_process_info ()
{
# List of all active processes

ps -ef
}

################################################

get_sna_info ()
{
# If the system is using SNA save the SNA configuration
```

Listing 23-2 (*continued*)

```
sna -d s               # Syntax for 2.x SNA
if (( $? != 0 ))
then
     lssrc -s sna -l   # must be SNA 1.x
fi
}

################################################

get_udp_x25_procs ()
{
# Listing of all "udp" and "x25" processes, if
# any are running

ps -ef | egrep 'udp|x25' | grep -v grep
}

################################################

get_sys_cfg ()
{
# Short listing of the system configuration

lscfg
}

################################################

get_long_sys_config ()
{
# Long detailed listing of the system configuration

lscfg -vp
}

################################################

get_installed_filesets ()
{
# Listing of all installed LPP filesets (system installed)

lslpp -L
}

################################################

check_for_broken_filesets ()
{
```

Listing 23-2 (*continued*)

```
# Check the system for broken filesets

lppchk -vm3 2>&1
}

################################################

last_logins ()
{
# List the last 100 system logins

last | tail -100
}

################################################
############## START OF MAIN  ##################
################################################

# Check for AIX as the operating system

if [[ $(get_OS) != 'AIX' ]]
then
     echo "\nERROR: Incorrect operating system. This
       shell script is written for AIX.\n"
     echo "\n\t...EXITING...\n"

     exit 1
fi

################################################

# Define the working directory and create this
# directory if it does not exist.

if [ ! -d $WORKDIR ]
then
     mkdir -p $WORKDIR >/dev/null 2>&1
     if (($? != 0))
     then
          echo "\nERROR: Permissions do not allow you to create the
       $WORKDIR directory. This script must exit.
       Please create the $WORKDIR directory and
       execute this script again.\n"
          echo "\n\t...EXITING...\n"
          exit 2
     fi
fi
```

Listing 23-2 (*continued*)

```
################################################

{   # Everything enclosed between this opening bracket and the
    # later closing bracket is both displayed on the screen and
    # also saved in the log file defined as $SYSINFO_FILE.


echo "\n\n[ $(basename $0) - $(date) ]\n"

echo "Saving system information for $THISHOST..."

echo "\nSystem:\t\t\t$(get_host)"
echo "Time Zone:\t\t$(get_TZ)"
echo "Real Memory:\t\t$(get_real_mem)"
echo "Machine Type:\t\t$(get_arch)"
echo "Operating System:\t$(get_OS)"
echo "AIX Version Level:\t$(get_OS_level)"
echo "\nCurrent Maintenance/Technology Level:\n \
$(get_ML_for_AIX)"

echo "\n#####################################################\n"
echo "Print System Configuration\n"
print_sys_config
echo "\n#####################################################\n"
echo "Installed and Configured Devices\n"
get_devices
echo "\n#####################################################\n"
echo "Long Device Directory Listing - /dev\n"
get_long_devdir_listing
echo "\n#####################################################\n"
echo "System Tape Drives\n"
get_tape_drives
echo "\n#####################################################\n"
echo "System CD-ROM Drives\n"
get_cdrom
echo "\n#####################################################\n"
echo "Defined Adapters in the System\n"
get_adapters
echo "\n#####################################################\n"
echo "Network Routes\n"
get_routes
echo "\n#####################################################\n"
echo "Network Interface Statictics\n"
get_netstats
echo "\n#####################################################\n"
echo "Filesystem Statistics\n"
get_fs_stats
echo "\n#####################################################\n"
```

Listing 23-2 (*continued*)

```
echo "Defined Volume Groups\n"
get_VGs
echo "\n####################################################\n"
echo "Varied-on Volume Groups\n"
get_varied_on_VGs
echo "\n####################################################\n"
echo "Logical Volume Information by Volume Group\n"
get_LV_info
echo "\n####################################################\n"
echo "Paging Space Information\n"
get_paging_space
echo "\n####################################################\n"
echo "Hard Disks Defined\n"
get_disk_info
echo "\n####################################################\n"
echo "Volume Group Hard Drives\n"
get_VG_disk_info
echo "\n####################################################\n"
echo "HACMP Configuration\n"
get_HACMP_info
echo "\n####################################################\n"
echo "Printer Information\n"
get_printer_info
echo "\n####################################################\n"
echo "Active Process List\n"
get_process_info
echo "\n####################################################\n"
echo "SNA Information\n"
get_sna_info
echo "\n####################################################\n"
echo "x25 and udp Processes\n"
get_udp_x25_procs
echo "\n####################################################\n"
echo "System Configuration Overview\n"
get_sys_cfg
echo "\n####################################################\n"
echo "Detailed System Configuration\n"
get_long_sys_config
echo "\n####################################################\n"
echo "System Installed Filesets\n"
get_installed_filesets
echo "\n####################################################\n"
echo "Looking for Broken Filesets\n"
check_for_broken_filesets
echo "\n####################################################\n"
echo "List of the last 100 users to login to $THISHOST\n"
last_logins
```

Listing 23-2 (*continued*)

```
echo "\n\nThis report is saved in: $SYSINFO_FILE \n"

# Send all output to both the screen and the $SYSINFO_FILE
# using a pipe to the "tee -a" command"

} | tee -a $SYSINFO_FILE
```

Listing 23-2 (*continued*)

As you can see in Listing 23-2, we have a lot of functions in this shell script. When I created these functions, I tried to place each one in the order that I wanted to execute in the shell script. This is not necessary as long as you do *not* try to use a function before it is defined. Because a shell script is interpreted, as opposed to a compiled language like C and C++, the flow goes from the top to the bottom. It makes sense that you have to define a function in the code above where the function is used. If we slip up and the function is defined *below* where it is used, we may or may not get an error message. Getting an error message depends on what the function is supposed to do and how the function is executed in the shell script.

From the top of the shell script in Listing 23-2 we first define the variables that we need. The `hostname` of the machine is always nice to know, and it is required for the report-file definition and in the report itself. Next we create a date/time stamp. This `$DATETIME` variable is used in the report-file definition as well. We want the date *and* time because this script may be executed more than once in a single day. Next we define the working directory. I like to use `/usr/local/reboot`, but you can use any directory that you want. Finally, we define the report file, which is assigned to the `$SYSINFO_FILE` variable.

The next section is where all of the functions are defined. Notice that some of these functions contain only a single command, and some have a bit more code. In a shell script like this one it is a good idea to place every command in a separate function. Using this method allows you to change the commands to a different operating system simply by editing some functions and leaving the basic shell script operation intact. There are too many functions in this shell script to go over them one at a time, but an output of this shell script is shown in Listing 23-3. For details on the specific AIX commands please refer to the AIX documentation and `man` pages on an AIX system.

At `START OF MAIN` we begin the real work. The first step is to ensure that the operating system is AIX. If this shell script is executed on another UNIX flavor, a lot of the commands will fail. If a non-AIX UNIX flavor is detected, the user receives an error message and the script exits with a return code of 1, one. Step two is to test for the existence of the `$WORKDIR` directory, which is defined as `/usr/local/reboot` in this shell script. If the directory does not exist, an attempt is made to create the directory. Not all users will have permission to create a directory here. If the directory creation fails, the user receives an error message and is asked to create the directory manually and run the shell script again.

If the operating system is AIX and the `$WORKDIR` exists, we create the report file and begin creating the report. Notice that the entire list of functions and commands for the report is enclosed in braces, `code`. Then, after the final brace, at the end of the shell

script, all of the output is piped to the `tee -a $SYSINFO_FILE` command. Using this pipe to the `tee -a $SYSINFO_FILE` command allows the user to see the report as it is being created and the output is written to the `$SYSINFO_FILE` file. Enclosing *all* of the code for the report within the braces saves a lot of effort to get the output to the screen and to the report file. The basic syntax is shown here:

```
####### BEGINNING OF MAIN ########
{

report command
report command
.
.
.
report command

} | tee -a $SYSINFO_FILE
```

Within the braces we start by setting up the report header information, which includes the hostname, time zone, real memory, machine type, operating system, operating system version, and the technology level and patch levels of the operating system version. When the header is complete, the script executes the functions listed in the `DEFINE FUNCTIONS HERE` section. As I stated before, I tried to define the functions in the order of execution. Before each function is executed, a line of hash marks is written out to separate each report section, and then some section header information is written for the specific task. At the end, and just before the ending brace, the report filename is shown to the user to indicate where the report file is located.

Let's take a look at an abbreviated report output in Listing 23-3.

```
[ AIXsysconfig.ksh - Tue Nov 13 12:27:16 EST 2007 ]

Saving system information for yogi...

System:             yogi
Time Zone:          EST5EDT
EST5EDT,M3.2.0,M11.1.0
Real Memory:        1048576KB
Machine Type:       IBM,7029-6C3
Operating System:   AIX
AIX Version Level:  5300-06
Technology Level:   5300-06-02-0727

Current Maintenance/Technology Level:
    All filesets for 5.3.0.0_AIX_ML were found.
    All filesets for 5300-01_AIX_ML were found.
    All filesets for 5300-02_AIX_ML were found.
```

Listing 23-3 AIXsysconfig.ksh shell script in action

```
    All filesets for 5300-03_AIX_ML were found.
    All filesets for 5300-04_AIX_ML were found.
    All filesets for 5300-05_AIX_ML were found.
    All filesets for 5300-06_AIX_ML were found.

################################################

Print System Configuration

System Model: IBM,7029-6C3
Machine Serial Number: 10P1234
Processor Type: PowerPC_POWER4
Number Of Processors: 1
Processor Clock Speed: 1200 MHz
CPU Type: 64-bit
Kernel Type: 64-bit
LPAR Info: 1 NULL
Memory Size: 1024 MB
Good Memory Size: 1024 MB
Platform Firmware level: 3F070425
Firmware Version: IBM,RG070425_d79e20_r
Console Login: enable
Auto Restart: true
Full Core: false

Network Information
     Host Name: yogi
     IP Address: 192.168.1.100
     Sub Netmask: 255.255.255.0
     Gateway: 192.168.1.1
     Name Server:
     Domain Name: tampa.rr.com

Paging Space Information
     Total Paging Space: 512MB
     Percent Used: 1%

Volume Groups Information
==============================================================================
rootvg:
PV_NAME           PV STATE          TOTAL PPs   FREE PPs
FREE DISTRIBUTION
hdisk0            active            542         482
108..87..70..108..109
hdisk1            active            542         272
60..00..00..103..109
==============================================================
```

Listing 23-3 (*continued*)

```
INSTALLED RESOURCE LIST

The following resources are installed on the machine.
+/- = Added or deleted from Resource List.
*   = Diagnostic support not available.

  Model Architecture: chrp
  Model Implementation: Multiple Processor, PCI bus

+ sys0                                System Object
+ sysplanar0                          System Planar
* pci1              U0.1-P1           PCI Bus
* pci6              U0.1-P1           PCI Bus
* pci7              U0.1-P1           PCI Bus
* pci8              U0.1-P1           PCI Bus
+ dpmpa0            U0.1-P1-I3        IBM 2-Port Multiprotocol
Adapter (331121b9)
+ hdlc0             U0.1-P1-I3/Q0     IBM HDLC Network Device Driver
+ hdlc1             U0.1-P1-I3/Q1     IBM HDLC Network Device Driver
* pci9              U0.1-P1           PCI Bus
+ ent1              U0.1-P1/E2        10/100/1000 Base-TX PCI-X
Adapter (14106902)
* pci10             U0.1-P1           PCI Bus
* pci0              U0.1-P1           PCI Bus
* isa0              U0.1-P1-X1        ISA Bus
+ fda0              U0.1-P1-X1/D1     Standard I/O Diskette Adapter
* siokma0           U0.1-P1-X1/K1     Keyboard/Mouse Adapter
+ sioka0            U0.1-P1-X1/K1     Keyboard Adapter
+ sioma0            U0.1-P1-X1/K1     Mouse Adapter
+ ppa0              U0.1-P1-X1/R1     CHRP IEEE1284 (ECP) Parallel
Port Adapter
+ sa0               U0.1-P1-X1/S1     Standard I/O Serial Port
+ tty0              U0.1-P1-X1/S1-L0  Asynchronous Terminal
+ sa1               U0.1-P1-X1/S2     Standard I/O Serial Port
+ sa2               U0.1-P1-X1/S3     Standard I/O Serial Port
* ide0             U0.1-P1-X1/Q6     ATA/IDE Controller Device
+ cd0               U0.1-P1-X1/Q6-A0  IDE DVD-ROM Drive
* pci2              U0.1-P1           PCI Bus
* pci3              U0.1-P1           PCI Bus
+ ent0              U0.1-P1/E1        10/100 Mbps Ethernet PCI
Adapter II (1410ff01)
* pci4              U0.1-P1           PCI Bus
+ sisscsia0         U0.1-P1           PCI-X Dual Channel Ultra320
SCSI Adapter
+ scsi0             U0.1-P1/Z1        PCI-X Dual Channel Ultra320
SCSI Adapter bus
+ hdisk0          U0.1-P1/Z1-A5     16 Bit LVD SCSI Disk Drive (36400 MB)
```

Listing 23-3 (*continued*)

```
+ hdisk1           U0.1-P1/Z1-A8     16 Bit LVD SCSI Disk Drive
(36400 MB)
+ ses0             U0.1-P1/Z1-AF     SCSI Enclosure Services Device
+ scsi1            U0.1-P1/Z2        PCI-X Dual Channel Ultra320
SCSI Adapter bus
* pci5             U0.1-P1           PCI Bus
+ L2cache0                           L2 Cache
+ mem0                               Memory
+ proc1            U0.1-P1           Processor

################################################

Installed and Configured Devices

L2cache0   Available               L2 Cache
aio0       Available               Asynchronous I/O (Legacy)
cd0        Available 1G-19-00      IDE DVD-ROM Drive
dlc8023    Available               IEEE Ethernet (802.3) Data Link
Control
dlcether   Available               Standard Ethernet Data Link Control
dlcfddi    Available               FDDI Data Link Control
dlcqllc    Available               X.25 QLLC Data Link Control
dlcsdlc    Available               SDLC Data Link Control
dpmpa0     Available 1f-08         IBM 2-Port Multiprotocol Adapter
(331121b9)
en0        Available 1L-08         Standard Ethernet Network Interface
en1        Defined   1j-08         Standard Ethernet Network Interface
ent0       Available 1L-08         10/100 Mbps Ethernet PCI
Adapter II (1410ff01)
ent1       Available 1j-08         10/100/1000 Base-TX PCI-X
Adapter (14106902)
et0        Defined   1L-08         IEEE 802.3 Ethernet Network Interface
et1        Defined   1j-08         IEEE 802.3 Ethernet Network Interface
fda0       Available 01-D1         Standard I/O Diskette Adapter
.
. (skipping forward)
.
.
hdisk0     Available 1S-08-00-5,0  16 Bit LVD SCSI Disk Drive
hdisk1     Available 1S-08-00-8,0  16 Bit LVD SCSI Disk Drive
hdlc0      Available 1f-08-00      IBM HDLC Network Device Driver
hdlc1      Available 1f-08-01      IBM HDLC Network Device Driver
ide0       Available 1G-19         ATA/IDE Controller Device
inet0      Available               Internet Network Extension
isa0       Available 1G-18         ISA Bus
iscsi0     Available               iSCSI Protocol Device
lo0        Available               Loopback Network Interface
lvdd       Available               LVM Device Driver
```

Listing 23-3 (*continued*)

```
mem0       Available               Memory
mpc0       Available               SDLC COMIO Device Driver Emulator
mpc1       Available               SDLC COMIO Device Driver Emulator
paging00   Defined                 N/A
pci0       Available               PCI Bus
pci1       Available               PCI Bus
pci2       Available 1G-10         PCI Bus
pci3       Available 1G-12         PCI Bus
pci4       Available 1G-14         PCI Bus
pci5       Available 1G-16         PCI Bus
pci6       Available 1Y-10         PCI Bus
pci7       Available 1Y-12         PCI Bus
pci8       Available 1Y-13         PCI Bus
posix_aio0 Defined                 Posix Asynchronous I/O
ppa0       Available 01-R1         CHRP IEEE1284 (ECP) Parallel
Port Adapter
proc1      Available 00-01         Processor
pty0       Available               Asynchronous Pseudo-Terminal
rcm0       Defined                 Rendering Context Manager Subsystem
rootvg     Defined                 N/A
sa0        Available 01-S1         Standard I/O Serial Port
sa1        Available 01-S2         Standard I/O Serial Port
sa2        Available 01-S3         Standard I/O Serial Port
scsi0      Available 1S-08-00      PCI-X Dual Channel Ultra320
SCSI Adapter bus
scsi1      Available 1S-08-01      PCI-X Dual Channel Ultra320
SCSI Adapter bus
ses0       Available 1S-08-00-15,0 SCSI Enclosure Services Device
sioka0     Available 01-K1-00      Keyboard Adapter
siokma0    Available 01-K1         Keyboard/Mouse Adapter
sioma0     Available 01-K1-01      Mouse Adapter
sisscsia0  Available 1S-08         PCI-X Dual Channel Ultra320
SCSI Adapter
sys0       Available               System Object
sysplanar0 Available               System Planar
tty0       Available 01-S1-00-00   Asynchronous Terminal

################################################

Long Device Directory Listing - /dev

total 40
drwxrwx---   2 root     system         4096 Nov 13 12:27 .SRC-unix
crw-rw----   1 root     system       10,  0 Apr 13 2005  IPL_rootvg
srwxrwxrwx   1 root     system            0 Nov 13 11:48 SRC
crw-------   1 root     system       10,  0 Nov 13 11:36 __vg10
cr--r----T   1 root     system        8,  0 Apr 13 2005  audit
br--r--r--   1 root     system       22,  0 Apr 13 2005  cd0
```

Listing 23-3 (*continued*)

```
crw-rw-rw-   1 root     system       13,  0 Apr 13 2005  clone
crw--w--w-   1 root     system        4,  0 Apr 13 2005  console
crw-rw-rwT   1 root     system       50,  0 Apr 15 2005  dlc8023
crw-rw-rwT   1 root     system       49,  0 Apr 15 2005  dlcether
crw-rw-rwT   1 root     system       48,  0 Apr 15 2005  dlcfddi
crw-rw-rwT   1 root     system       52,  0 Nov 12 14:40 dlcmpc
crw-rw-rwT   1 root     system       53,  0 Nov 13 10:39 dlcqllc
crw-rw-rwT   1 root     system       47,  0 Apr 15 2005  dlcsdlc
crw-rw-rwT   1 root     system       46,  0 Apr 15 2005  dlctoken
crw-rw-rw-   1 root     system       13, 31 Apr 13 2005  echo
crw--w--w-   1 root     system        6,  0 Nov 13 11:49 error
crw-------   1 root     system        6,  1 Apr 13 2005  errorctl
brw-rw----   1 root     system       10, 11 May  5 2005  fslv00
brw-rw----   1 root     system       10, 12 Nov 12 15:37 fslv01
brw-rw----   1 root     system       10,  8 Apr 13 2005  hd1
brw-rw----   1 root     system       10,  9 Apr 13 2005  hd10opt
brw-rw----   1 root     system       10,  5 Apr 13 2005  hd2
brw-rw----   1 root     system       10,  7 Apr 13 2005  hd3
brw-rw----   1 root     system       10,  4 Nov 13 11:36 hd4
brw-rw----   1 root     system       10,  1 Nov 13 11:48 hd5
brw-rw----   1 root     system       10,  2 Apr 13 2005  hd6
brw-rw----   1 root     system       10,  3 Apr 13 2005  hd8
brw-rw----   1 root     system       10,  6 Apr 13 2005  hd9var
brw-------   1 root     system       23,  0 Nov 13 11:22 hdisk0
brw-------   1 root     system       23,  1 Nov 13 11:22 hdisk1
.
. (skipping forward)
.
.
crw-rw-rw-   1 root     system       29,  3 Apr 13 2005  ptyp3
crw-rw-rw-   1 root     system       29,  4 Apr 13 2005  ptyp4
crw-rw-rw-   1 root     system       29,  5 Apr 13 2005  ptyp5
crw-rw-rw-   1 root     system       29,  6 Apr 13 2005  ptyp6
crw-rw-rw-   1 root     system       29,  7 Apr 13 2005  ptyp7
crw-rw-rw-   1 root     system       29,  8 Apr 13 2005  ptyp8
crw-rw-rw-   1 root     system       29,  9 Apr 13 2005  ptyp9
crw-rw-rw-   1 root     system       29, 10 Apr 13 2005  ptypa
crw-rw----   1 root     system       10,  0 Apr 13 2005  rootvg
crw-rw----   1 root     system       10, 10 Apr 13 2005  rpaging00
crw-rw-rw-   1 root     system       13, 14 Apr 13 2005  sad
crw-rw-rw-   1 root     system       19,  1 Apr 13 2005  scsi0
crw-rw-rw-   1 root     system       19,  2 Apr 13 2005  scsi1
crw-rw-rw-   1 root     system       25,  0 Apr 13 2005  ses0
crw-rw-rw-   1 root     system       19,  0 Nov 13 10:26 sisscsia0
crw-rw-rw-   1 root     system       13, 15 Apr 13 2005  slog
crw-rw-rwT   1 root     system       44,  3 Nov 13 11:48 sna
crw-rw-rwT   1 root     system       41,  3 Nov 13 11:48 sna_trace
```

Listing 23-3 (*continued*)

```
.
. (skipping forward)
.
.
crw-rw-rw-   1 root     system        2,  3 Apr 13 2005  zero

################################################

System Tape Drives


################################################

System CD-ROM Drives

cd0 Available 1G-19-00 IDE DVD-ROM Drive

################################################

Defined Adapters in the System

dpmpa0    Available 1f-08    IBM 2-Port Multiprotocol Adapter (331121b9)
ent0      Available 1L-08    10/100 Mbps Ethernet PCI
Adapter II (1410ff01)
ent1      Available 1j-08    10/100/1000 Base-TX PCI-X
Adapter (14106902)
fda0      Available 01-D1    Standard I/O Diskette Adapter
ide0      Available 1G-19    ATA/IDE Controller Device
ppa0      Available 01-R1    CHRP IEEE1284 (ECP) Parallel Port
Adapter
sa0       Available 01-S1    Standard I/O Serial Port
sa1       Available 01-S2    Standard I/O Serial Port
sa2       Available 01-S3    Standard I/O Serial Port
sioka0    Available 01-K1-00 Keyboard Adapter
siokma0   Available 01-K1    Keyboard/Mouse Adapter
sioma0    Available 01-K1-01 Mouse Adapter
sisscsia0 Available 1S-08    PCI-X Dual Channel Ultra320 SCSI Adapter

################################################

Network Routes

Routing tables
Destination       Gateway          Flags   Refs     Use  If   Exp  Groups

Route tree for Protocol Family 2 (Internet):
default           192.168.1.1     UG        3      7497 en0      -      -
```

Listing 23-3 (*continued*)

```
127/8             127.0.0.1         U         3       100 lo0      -      -
192.168.62.0       192.168.62.25      UHSb      0         0 en0

################################################

Network Interface Statistics

Name  Mtu   Network    Address            Ipkts Ierrs   Opkts Oerrs  Coll

en0   1500  link#2     0.9.6b.2e.7c.da      8898     0     7508     0     0
en0   1500  172.27.62   ift00s              8898     0     7508     0     0
lo0   16896 link#1                          4559     0     4562     0     0
lo0   16896 127        localhost            4559     0     4562     0     0
lo0   16896 ::1                            4559     0     4562     0     0

################################################

Filesystem Statistics

Filesystem    1024-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4           131072    107820   18%     2257     9% /
/dev/hd2          1245184     85020   94%    24985    52% /usr
/dev/hd9var        524288    494852    6%      391     1% /var
/dev/hd3           131072    119048   10%       62     1% /tmp
/dev/hd1            65536     63680    3%       92     1% /home
/proc                   -         -    -        -     -  /proc
/dev/hd10opt       131072     16960   88%     3187    43% /opt
/dev/fslv00       1048576   1008184    4%      523     1% /apps
/dev/fslv01      13762560   7541816   46%     1983     1% /install


 node  mounted    mounted over  vfs       date     options
------ ---------- ------------ ------ ------------ ----
        /dev/hd4     /          jfs2   Nov 13 11:47 rw,log=/dev/hd8
        /dev/hd2     /usr       jfs2   Nov 13 11:47 rw,log=/dev/hd8
        /dev/hd9var  /var       jfs2   Nov 13 11:47 rw,log=/dev/hd8
        /dev/hd3     /tmp       jfs2   Nov 13 11:47 rw,log=/dev/hd8
        /dev/hd1     /home      jfs2   Nov 13 11:48 rw,log=/dev/hd8
        /proc        /proc      procfs Nov 13 11:48 rw
        /dev/hd10opt /opt       jfs2   Nov 13 11:48 rw,log=/dev/hd8
        /dev/fslv00  /apps      jfs2   Nov 13 11:48 rw,log=/dev/hd8
        /dev/fslv01  /install jfs2     Nov 13 11:48 rw,log=/dev/hd8

################################################

Defined Volume Groups

rootvg
```

Listing 23-3 (*continued*)

```
################################################

Varied-on Volume Groups

rootvg

################################################

Logical Volume Information by Volume Group

rootvg:
LV NAME         TYPE        LPs   PPs   PVs  LV STATE      MOUNT POINT
hd5             boot        1     2     2    closed/syncd  N/A
hd6             paging      5     10    2    open/syncd    N/A
hd8             jfs2log     1     2     2    open/syncd    N/A
hd4             jfs2        2     4     2    open/syncd    /
hd2             jfs2        19    38    2    open/syncd    /usr
hd9var          jfs2        8     16    2    open/syncd    /var
hd3             jfs2        2     4     2    open/syncd    /tmp
hd1             jfs2        1     2     2    open/syncd    /home
hd10opt         jfs2        2     4     2    open/syncd    /opt
paging00        paging      3     6     2    open/syncd    N/A
fslv00          jfs2        16    32    2    open/syncd    /apps
fslv01          jfs2        210   210   1    open/syncd    /install

################################################

Paging Space Information

Page Space      Physical Volume   Volume Group    Size %Used Active
Auto  Type
paging00        hdisk0            rootvg         192MB     2   yes
yes    lv
hd6             hdisk1            rootvg         320MB     1   yes
yes    lv


Total Paging Space   Percent Used
      512MB               1%

################################################

Hard Disks Defined

hdisk0     000b123d3bf5657c       rootvg        active
hdisk1     000b123dfed5d3ca       rootvg        active

################################################
```

Listing 23-3 (*continued*)

```
Volume Group Hard Drives

rootvg:
PV_NAME    PV STATE   TOTAL PPs  FREE PPs  FREE DISTRIBUTION
hdisk0     active       542       482      108..87..70..108..109
hdisk1     active       542       272      60..00..00..103..109

################################################

HACMP Configuration


################################################

Printer Information


################################################

Active Process List

UID    PID   PPID   C    STIME   TTY TIME CMD
root      1      0   0 11:47:57    - 0:00 /etc/init
root  77920      1   0 11:48:38    - 0:00 /usr/sbin/syncd 60
root  98316      1   0 11:48:38    - 0:00 /usr/lib/errdemon
root 426198      1   0 11:48:38    - 0:00 /usr/ccs/bin/shlap64
root 430126      1   0 11:48:46    - 0:00 /usr/sbin/srcmstr
super 438298 528400   0 11:51:44   - 0:00 sshd: super@pts/0
root 446478 430126   0 11:48:54    - 0:00 /usr/sbin/portmap
root 471232 430126   0 11:48:54    - 0:00 /usr/sbin/inetd
root 475352      1   0 11:48:48    - 0:00 snadaemon64
root 479276 475352   0 11:48:49    - 0:00 snaslpdae -p11 -a
root 483566 475352   0 11:48:48    - 0:00 snaerrlog -p7
.
. (skipping forward)
.
.
root 647302 635004   0 12:00:49 pts/1 0:00 -ksh

################################################

SNA Information

    Local             Partner        Mode      Link
    LU name           LU name        name     station     State
---------------- ---------------- -------- ----------- ----------
SNA is not active.  Restart SNA and retry your command.
0513-085 The sna Subsystem is not on file.
```

Listing 23-3 (*continued*)

```
################################################

x25 and udp Processes


################################################

System Configuration Overview

INSTALLED RESOURCE LIST

The following resources are installed on the machine.
+/- = Added or deleted from Resource List.
*   = Diagnostic support not available.

  Model Architecture: chrp
  Model Implementation: Multiple Processor, PCI bus

+ sys0                              System Object
+ sysplanar0                        System Planar
* pci1              U0.1-P1         PCI Bus
* pci6              U0.1-P1         PCI Bus
* pci7              U0.1-P1         PCI Bus
* pci8              U0.1-P1         PCI Bus
+ hdlc0             U0.1-P1-I3/Q0   IBM HDLC Network Device Driver
+ hdlc1             U0.1-P1-I3/Q1   IBM HDLC Network Device Driver
* pci9              U0.1-P1         PCI Bus
* pci10             U0.1-P1         PCI Bus
* pci0              U0.1-P1         PCI Bus
* isa0              U0.1-P1-X1      ISA Bus
+ fda0              U0.1-P1-X1/D1   Standard I/O Diskette Adapter
* siokma0           U0.1-P1-X1/K1   Keyboard/Mouse Adapter
+ sioka0            U0.1-P1-X1/K1   Keyboard Adapter
+ sioma0            U0.1-P1-X1/K1   Mouse Adapter
+ sa0               U0.1-P1-X1/S1   Standard I/O Serial Port
+ tty0              U0.1-P1-X1/S1-L0  Asynchronous Terminal
+ sa1               U0.1-P1-X1/S2   Standard I/O Serial Port
+ sa2               U0.1-P1-X1/S3   Standard I/O Serial Port
* ide0              U0.1-P1-X1/Q6   ATA/IDE Controller Device
+ cd0               U0.1-P1-X1/Q6-A0  IDE DVD-ROM Drive
* pci2              U0.1-P1         PCI Bus
* pci3              U0.1-P1         PCI Bus
* pci4              U0.1-P1         PCI Bus
+ ses0              U0.1-P1/Z1-AF   SCSI Enclosure Services Device
* pci5              U0.1-P1         PCI Bus
+ L2cache0                          L2 Cache
+ mem0                              Memory
+ proc1             U0.1-P1         Processor
```

Listing 23-3 (*continued*)

```
################################################

Detailed System Configuration

INSTALLED RESOURCE LIST WITH VPD

The following resources are installed on your machine.

  Model Architecture: chrp
  Model Implementation: Multiple Processor, PCI bus

  sys0                                System Object
  sysplanar0                          System Planar
  pci1              U0.1-P1           PCI Bus

        Device Specific.(YL)........U0.1-P1

  pci6              U0.1-P1           PCI Bus

        Device Specific.(YL)........U0.1-P1

  pci7              U0.1-P1           PCI Bus

        Device Specific.(YL)........U0.1-P1

  pci8              U0.1-P1           PCI Bus

        Device Specific.(YL)........U0.1-P1

  hdlc0             U0.1-P1-I3/Q0     IBM HDLC Network Device Driver
  hdlc1             U0.1-P1-I3/Q1     IBM HDLC Network Device Driver
  pci9              U0.1-P1           PCI Bus

        Device Specific.(YL)........U0.1-P1

  ent1              U0.1-P1/E2        10/100/1000 Base-TX PCI-X
Adapter (14106902)

      10/100/1000 Base-TX PCI-X Adapter:
        Part Number.................00P3056
        FRU Number..................00P3056
        EC Level....................H11635A
        Manufacture ID..............YL1021
        Network Address.............00096BBE7FEE
        ROM Level (alterable).......GOL002
        Device Specific.(YL)........U0.1-P1/E2

  pci10             U0.1-P1           PCI Bus
```

Listing 23-3 (*continued*)

```
      Device Specific.(YL)........U0.1-P1

.
. (skipping forward)
.
.
hdisk0      U0.1-P1/Z1-A5  16 Bit LVD SCSI Disk Drive (36400 MB)

      Manufacturer................IBM
      Machine Type and Model......ST336607LC
      FRU Number..................00P3068
      ROS Level and ID............43353048
      Serial Number...............000BCAF0
      EC Level....................H12094
      Part Number.................00P2676
      Device Specific.(Z0)........000003129F00013E
      Device Specific.(Z1)........1217C511
      Device Specific.(Z2)........0002
      Device Specific.(Z3)........04216
      Device Specific.(Z4)........0001
      Device Specific.(Z5)........22
      Device Specific.(Z6)........H12094

hdisk1      U0.1-P1/Z1-A8  16 Bit LVD SCSI Disk Drive (36400 MB)

      Manufacturer................IBM
      Machine Type and Model......ST336607LC
      FRU Number..................00P3068
      ROS Level and ID............43353048
      Serial Number...............000BC353
      EC Level....................H12094
      Part Number.................00P2676
      Device Specific.(Z0)........000003129F00013E
      Device Specific.(Z1)........1217C511
      Device Specific.(Z2)........0002
      Device Specific.(Z3)........04216
      Device Specific.(Z4)........0001
      Device Specific.(Z5)........22
      Device Specific.(Z6)........H12094

.
. (skipping forward)
.
.

PLATFORM SPECIFIC

Name:  IBM,7029-6C3
```

Listing 23-3 (*continued*)

```
      Model:  IBM,7029-6C3
      Node:  /
      Device Type:  chrp

        Platform Firmware:
          ROM Level (alterable).......3F070425
          Version.....................RS6K
          System Info Specific.(YL)...U0.1-P1-X1/Y1
        Physical Location: U0.1-P1-X1/Y1

        System Firmware:
          ROM Level (alterable).......RG070425_d79e20_regatta
          Version.....................RS6K
          System Info Specific.(YL)...U0.1-P1-X1/Y2
        Physical Location: U0.1-P1-X1/Y2

        System VPD:
          Machine/Cabinet Serial No...10P1234
          Machine Type/Model..........7029-6C3
          Manufacture ID..............IBM980
          Version.....................RS6K
          Op Panel Installed..........Y
          Brand.......................I0
          System Info Specific.(YL)...U0.1
        Physical Location: U0.1

        PS CEC OP PANEL :
          Serial Number...............YL1124567P9D
          EC Level....................H64013
          Customer Card ID Number.....28D3
          FRU Number..................  97P3352
          Action Code, Timestamp......BD 200210290851
          Version.....................RS6K
          System Info Specific.(YL)...U0.1-L1
        Physical Location: U0.1-L1

        1 WAY BACKPLANE :
          Serial Number...............YL1124567P27
          Part Number.................80P2749
          Customer Card ID Number.....26F4
          CCIN Extender...............1
          FRU Number..................  80P2749
          Version.....................RS6K
          System Info Specific.(YL)...U0.1-P1
        Physical Location: U0.1-P1
```

Listing 23-3 (*continued*)

```
  .
  . (skipping forward)
  .
  .
################################################
System Installed Filesets

Fileset               Level   State Type Description (Uninstaller)
----------------------------------------------------------------------------
X11.Dt.ToolTalk        5.3.0.60  C   F  AIX CDE ToolTalk Support
X11.Dt.bitmaps         5.3.0.0   C   F  AIX CDE Bitmaps
X11.Dt.helpmin         5.3.0.0   C   F  AIX CDE Minimum Help Files
X11.Dt.helprun         5.3.0.0   C   F  AIX CDE Runtime Help
X11.Dt.lib             5.3.0.60  C   F  AIX CDE Runtime Libraries
X11.Dt.rte             5.3.0.60  C   F  AIX Common Desktop
                                        Environment (CDE) 1.0
X11.adt.motif           5.3.0.50  C  F  AIXwindows Application
                                         Development Toolkit Motif
X11.apps.aixterm        5.3.0.60  C  F  AIXwindows aixterm
                                        Application
X11.apps.clients        5.3.0.60  C  F  AIXwindows Client
                                        Applications
X11.apps.custom         5.3.0.0   C  F  AIXwindows Customizing Tool
X11.apps.rte            5.3.0.60  C  F  AIXwindows Runtime
                                        Configuration Applications
X11.apps.xterm          5.3.0.0   C  F  AIXwindows xterm
                                        Application
X11.base.common         5.3.0.0   C  F  AIXwindows Runtime Common
                                        Directories
X11.base.lib            5.3.0.61  A  F  AIXwindows Runtime
                                        Libraries
X11.base.rte            5.3.0.61  A  F  AIXwindows Runtime
                                        Environment
X11.loc.en_US.base.rte  5.3.0.0   C  F  AIXwindows Locale
                                        Configuration - U.S.
                                        English
  X11.motif.lib         5.3.0.60  C  F  AIXwindows Motif Libraries
  X11.motif.mwm         5.3.0.60  C  F  AIXwindows Motif Window
                                        Manager
  bos.64bit             5.3.0.62  A  F  Base Operating System
                                        64 bit Runtime
  bos.acct              5.3.0.60  C  F   Accounting Services
  bos.adt.base          5.3.0.61  A  F   Base Application
                                         Development Toolkit
  bos.adt.graphics      5.3.0.60  C  F   Base Application
```

Listing 23-3 (*continued*)

```
                                          Development Graphics
                                          Include Files
  bos.adt.include       5.3.0.62  A  F    Base Application
                                          Development Include Files
  bos.adt.lib           5.3.0.60  C  F    Base Application
                                          Development Libraries
  bos.adt.libm          5.3.0.60  C  F    Base Application
                                          Development Math Library
  bos.adt.prof          5.3.0.62  A  F    Base Profiling Support
bos.cdmount             5.3.0.50  C  F    CD/DVD Automount Facility
bos.diag.com            5.3.0.62  A  F    Common Hardware
                                          Diagnostics
bos.diag.rte            5.3.0.62  A  F    Hardware Diagnostics
  .
  . (skipping forward)
  .
  .
wget                    1.9-1     C  R    A utility for retrieving
                                          files using the HTTP or
                                          FTP protocols. (/bin/rpm)


State codes:
 A -- Applied.
 B -- Broken.
 C -- Committed.
 E -- EFIX Locked.
 O -- Obsolete.  (partially migrated to newer version)
 ? -- Inconsistent State...Run lppchk -v.

Type codes:
 F -- Installp Fileset
 P -- Product
 C -- Component
 T -- Feature
 R -- RPM Package
 E -- Interim Fix

##################################################

Looking for Broken Filesets


##################################################
```

Listing 23-3 (*continued*)

```
List of the last 100 users to login to ift00s

randy    pts/0     dino             Mar 27 14:01 - 14:22  (00:21)
randy    pts/0     dino             Mar 27 13:34 - 13:39  (00:05)
randy    pts/1     dino             Mar 27 09:47 - 09:51  (00:03)
randy    ftp       dino             Mar 27 09:46 - 09:48  (00:01)
root     pts/0     192.168.37.224   Mar 26 10:39 - 10:08  (23:29)
root     pts/0     booboo           Mar 21 12:38 - 12:40  (00:01)
root     pts/0     booboo           Mar 21 12:34 - 12:35  (00:01)
root     pts/0     booboo           Mar 21 12:32 - 12:33  (00:00)
root     pts/0     booboo           Mar 20 15:41 - 15:46  (00:05)
randy    pts/1     dino             Mar 20 15:37 - 10:20  (18:43)
root     pts/0     booboo           Mar 20 15:36 - 15:38  (00:01)
reboot   ~                         Mar 20 15:34
randy    pts/1     dino             Mar 20 15:10 - crash  (00:24)
randy    pts/1     dino             Mar 20 14:19 - 14:49  (00:30)
randy    pts/1     dino             Mar 20 12:56 - 13:06  (00:10)
randy    pts/1     dino             Mar 20 10:43 - 10:51  (00:08)
randy    pts/1     dino             Mar 19 14:43 - 14:45  (00:02)
root     pts/0     booboo           Mar 19 14:33 - 15:53  (01:20)
root     pts/0     booboo           Mar 19 14:07 - 14:30  (00:22)
root     pts/1     booboo           Mar 16 13:37 - 10:52 (2+21:15)
root     pts/1     booboo           Mar 16 13:14 - 13:21  (00:06)
randy    pts/0     dino             Mar 16 12:59 - 15:20  (02:21)
randy    ftp       192.168.62.26    Mar 14 15:13 - 15:13  (00:00)
randy    pts/0     dino             Mar 14 08:08 - 13:50 (1+05:41)
randy    pts/0     dino             Mar 14 08:06 - 08:08  (00:02)
randy    pts/1     dino             Mar 13 15:22 - 08:06  (16:44)
randy    pts/1     dino             Mar 13 13:47 - 14:20  (00:33)
root     pts/0     192.168.63.17    Feb 02 10:34 - 10:39  (00:05)
root     pts/0     booboo           Feb 01 17:23 - 17:43  (00:19)
root     pts/0     booboo           Feb 01 13:20 - 13:22  (00:01)
root     pts/0     booboo           Feb 01 11:23 - 11:24  (00:01)
randy    pts/0     192.168.63.64    Jan 24 16:01 - 16:01  (00:00)
reboot   ~                         Jun 11 12:08
shutdown tty0                      May 05 18:19
root     pts/0     booboo           May 05 18:16 - 18:19  (00:02)
reboot   ~                         Apr 24 08:03
shutdown tty0                      Apr 21 17:55
reboot   ~                         Feb 26 05:38
.
. (skipping forward)
.
.
```

Listing 23-3 (*continued*)

```
root     tty0                      Apr 13 11:10 - down   (00:00)
reboot   ~                         Apr 13 10:58

wtmp begins       Apr 13 10:58


This report is saved in:
/usr/local/reboot/sys_snapshot.yogi.111307_122716
```

Listing 23-3 (*continued*)

From Listing 23-3 you can see that we collected a lot of information about the system configuration. This is just a sample of what you can collect, and I will leave the specifics of the information you gather up to you. For each function that you add or change, be sure to test the response. Sometimes you may be surprised that you do not see any output. Some of the command output shown in Listing 23-3 does not have any output, because my little system does not have the hardware that the query is looking for. If you expect output and there is not any, try redirecting standard error to standard output by using the following syntax:

```
command 2>&1
```

Many commands send information-type output to standard error, specified by file descriptor 2, instead of standard output, specified by file descriptor 1. First try the command without this redirection.

Other Options to Consider

There can always be improvements to any shell script. The shell script presented in this chapter is intended to be an example of the process of gathering system information. You always want to query the system for as much information as you can. Notice that I did not add any database or application configuration/statistics gathering here. The amount of information gathered is up to you. As I said before, every shop is different, but they are all the same when troubleshooting a problem. The `AIXsysconfig.ksh` shell script looks only at system-level statistics and configuration, so there is a large gap that you need to fill in. This gap is where your specific application comes into play. Look at your database and application documentation for the best method of gathering information about these products. By running the configuration-gathering script at least once a week, you will save yourself a lot of effort *when* a problem arises.

Summary

In this chapter we strictly looked at AIX. The process is the same for any UNIX flavor, but the information gathered will vary in each shop. No rocket science is needed here,

but you do need a good understanding of how your system is configured. You need to understand the applications and databases and what determines a failed application. You may be looking for a set of processes, or it could be a database query with an SQL statement. These are the things that need research on your part to make this type of shell script really beneficial.

In the next chapter we are going to move on to installing, configuring, and using `sudo`. The `sudo` program stands for *super user do*, and it allows us to set up specific commands that a user can execute as `root`. I hope you enjoyed this chapter, and I'll see you in the next chapter!

Lab Assignment

1. Bruce Hamilton's Rosetta Stone for UNIX can be found at `http://bhami.com/rosetta.html`. The web site shows equivalent commands for various UNIX operating systems. Write an equivalent shell script to `AIXsysconfig.ksh`, but substitute your particular UNIX flavor — for example, `Linuxsysconfig.ksh`, `OpenBSDsysconfig.ksh`, and so on.

CHAPTER 24

Compiling, Installing, Configuring, and Using sudo

The main job of any good Systems Administrator is to protect the *root* password. No matter how firm and diligent we are about protecting the root password, we always have the application-support group and DBAs wanting `root` access for one reason or another. But, alas, there is a way to give specific users the ability to run selected commands, or *all* commands, as the `root` user without the need to know the `root` password. Facilitating this restricted root access is a *free software* program called sudo, which stands for *superuser do*. In this chapter we are going to show how to compile, install, configure, and use the `sudo` program. You can download the current distribution at `http://sudo.ws` (`www.sudo.org` was already taken).

Because `sudo` is not a shell script you may be asking, ''Why is `sudo` included in *this* book?'' I am including the `sudo` chapter because I have not found any reference to `sudo` in any scripting book, and it is a nice tool to use. We will cover a short shell script at the end of this chapter showing how to use `sudo` in a shell script.

The Need for sudo

In UNIX the `root` user is almighty and has absolutely no restrictions. All security is bypassed, and anyone with `root` access can perform any task, with some possibly resulting in major damage to the system, without any restrictions at all. UNIX systems do *not* ask, ''Are you sure?'' They just run the command specified by the `root` user and assume you know what you are doing. The `sudo` program allows the Systems Administrator to set up specific commands (or all commands) to be executed as the `root` user and specify only certain users (or groups of users) to execute the individual commands. Additionally, with `sudo` we have the ability to execute commands to *run as* another user. In addition, all commands and command arguments are logged either to a defined file, the system **syslog**, or a central syslog server, or as many as you configure for each system. The logging allows the Systems Administrator to have an

audit trail and to monitor user sudo activities as well as failed sudo attempts! The user executes a restricted command by preceding the command with the word sudo, as in this example:

```
sudo chmod 600 /etc/sudoers
Password:
```

When a user executes the preceding command, a password prompt is displayed. The password that the sudo program is asking for is *not* the root password but the password of the user who wants root access. When the password is entered, the /etc/sudoers file is searched to determine if root authority should be granted to run the specified command. If both the password is correct and the /etc/sudoers search grants access, the command will execute with root authority. After this initial sudo command, the user may submit more sudo commands without the need for a password until a sudo timeout, typically five minutes without issuing another sudo command. After the timeout period the user will again be prompted for his or her password when a sudo command is entered. We can also configure commands to be executed in sudo without a password. We will look at each method.

Configuring sudo on Solaris

If you are running Solaris, sudo should already be installed on the system. If you cannot find the files in any of the normal locations, you need to add a few soft links. To get sudo working on Solaris, you need to link the /opt/csw/bin/sudo file to /usr/bin/sudo. Then you need to link the /opt/csw/etc/sudoers file to /etc/sudoers. Finally, you need to link the /opt/csw/sbin/visudo file to /usr/sbin/visudo. You create these soft links using the following commands:

```
ln -s /opt/csw/bin/sudo  /usr/bin/sudo
ln -s /opt/csw/etc/sudoers  /etc/sudoers
ln -s /opt/csw/sbin/visudo  /usr/sbin/visudo
```

After creating these links, as root, edit the /etc/sudoers file using visudo. For details, see the ''Configuring sudo'' section later in this chapter.

Downloading and Compiling sudo

The sudo program can be downloaded from various FTP mirror sites. The main sudo download web site is located at http://sudo.ws/sudo/download.html. The sudo program is *free software* and is distributed under a ISC-style license. As of this writing the current stable version of sudo is 1.6.9p9 and was released December 3, 2007. Todd Miller currently maintains the sudo program, and if you would like to tip Todd for his fine work, you can do so by clicking the Make a Donation button on the sudo main page (http://sudo.ws).

There are two ways to download the files. You can download the precompiled binaries for your UNIX flavor and version or download the source code distribution and compile the sudo program for your particular machine. I always download the

source code and compile it on each individual system. The process takes just a few minutes, and you can be assured that it will run on your system. If you have a boatload of systems to install `sudo` on, you may want to consider using the precompiled binaries and pushing the binaries out to each system, or writing a shell script to push and install the product! Either way you choose, you will need only about 6 MB of free space to work with. Once `sudo` is installed you can remove the downloaded files if you need to regain the disk space. In this chapter we are going to download the source code and compile `sudo` for a particular system.

Compiling sudo

To compile `sudo`, you will need a C compiler. `gcc` is preferred, but `cc` works fine. You can download `gcc` from one of the mirror sites listed at `http://gcc.gnu.org/mirrors.html`.

The `sudo` source code distribution is in a compressed `tar` format, where `gzip` is used for compression. A file compressed using `gzip` has a `.gz` extension — for example, `sudo-1.6.9p9.tar.gz`. When you download the file, put the software distribution in a directory that has at least 6 MB of free space. In our example we will use `/usr/local`, which is a separate filesystem from `/usr` on my machine. You *must* have `root` access to compile, install, and configure `sudo`!

After the `sudo` distribution file is placed in a work directory, the first step is to uncompress the source code tarball file:

```
[root@yogi local]# ls -l sudo-1.6.9p9.tar.gz
-rw-r--r--  1 root root    581462 Dec 13 12:01 sudo-1.6.9p9.tar.gz
[root@yogi local]# gunzip sudo-1.6.9p9.tar.gz
[root@yogi local]# ls -l sudo-1.6.9p9.tar
-rw-r--r--  1 root root   2611200 Dec 13 12:01 sudo-1.6.9p9.tar
```

The compressed `sudo` distribution file is 581,462 bytes. After the `gunzip` command uncompresses the file, it grows to 2,611,200 bytes. This tells us that `gzip` produces a compression ratio of about 4:1 for this particular archive.

When we *untar* the archive, a subdirectory will be created called `sudo-1.6.9p9` that will contain all of the source code, license, readme, manuals, configure, and `Makefile` files. In the directory containing the `sudo-1.6.6.tar` file, in our case `/usr/local`, issue the following command:

```
tar -xvf sudo-1.6.9p9.tar
```

The extraction of the files is shown in Listing 24-1.

```
[root@yogi local]# tar -xvf sudo-1.6.9p9.tar
sudo-1.6.9p9/alloc.c
sudo-1.6.9p9/alloca.c
sudo-1.6.9p9/check.c
```

Listing 24-1 Untarring the sudo distribution

```
sudo-1.6.9p9/closefrom.c
sudo-1.6.9p9/def_data.c
sudo-1.6.9p9/defaults.c
sudo-1.6.9p9/env.c
sudo-1.6.9p9/err.c
sudo-1.6.9p9/fileops.c
sudo-1.6.9p9/find_path.c
sudo-1.6.9p9/fnmatch.c
sudo-1.6.9p9/getcwd.c
sudo-1.6.9p9/getprogname.c
sudo-1.6.9p9/getspwuid.c
sudo-1.6.9p9/gettime.c
sudo-1.6.9p9/glob.c
sudo-1.6.9p9/goodpath.c
sudo-1.6.9p9/interfaces.c
sudo-1.6.9p9/ldap.c
sudo-1.6.9p9/lex.yy.c
sudo-1.6.9p9/lsearch.c
sudo-1.6.9p9/logging.c
sudo-1.6.9p9/memrchr.c
sudo-1.6.9p9/mkstemp.c
sudo-1.6.9p9/parse.c
sudo-1.6.9p9/parse.lex
sudo-1.6.9p9/parse.yacc
sudo-1.6.9p9/set_perms.c
sudo-1.6.9p9/sigaction.c
sudo-1.6.9p9/snprintf.c
sudo-1.6.9p9/strcasecmp.c
sudo-1.6.9p9/strerror.c
sudo-1.6.9p9/strlcat.c
sudo-1.6.9p9/strlcpy.c
sudo-1.6.9p9/sudo.c
sudo-1.6.9p9/sudo_noexec.c
sudo-1.6.9p9/sudo.tab.c
sudo-1.6.9p9/sudo_edit.c
sudo-1.6.9p9/testsudoers.c
sudo-1.6.9p9/tgetpass.c
sudo-1.6.9p9/utimes.c
sudo-1.6.9p9/visudo.c
sudo-1.6.9p9/zero_bytes.c
sudo-1.6.9p9/auth/afs.c
sudo-1.6.9p9/auth/aix_auth.c
sudo-1.6.9p9/auth/bsdauth.c
sudo-1.6.9p9/auth/dce.c
sudo-1.6.9p9/auth/fwtk.c
sudo-1.6.9p9/auth/kerb4.c
sudo-1.6.9p9/auth/kerb5.c
sudo-1.6.9p9/auth/pam.c
```

Listing 24-1 (*continued*)

```
sudo-1.6.9p9/auth/passwd.c
sudo-1.6.9p9/auth/rfc1938.c
sudo-1.6.9p9/auth/secureware.c
sudo-1.6.9p9/auth/securid.c
sudo-1.6.9p9/auth/securid5.c
sudo-1.6.9p9/auth/sia.c
sudo-1.6.9p9/auth/sudo_auth.c
sudo-1.6.9p9/compat.h
sudo-1.6.9p9/def_data.h
sudo-1.6.9p9/defaults.h
sudo-1.6.9p9/ins_2001.h
sudo-1.6.9p9/ins_classic.h
sudo-1.6.9p9/ins_csops.h
sudo-1.6.9p9/ins_goons.h
sudo-1.6.9p9/insults.h
sudo-1.6.9p9/interfaces.h
sudo-1.6.9p9/logging.h
sudo-1.6.9p9/parse.h
sudo-1.6.9p9/sudo.h
sudo-1.6.9p9/sudo.tab.h
sudo-1.6.9p9/version.h
sudo-1.6.9p9/auth/sudo_auth.h
sudo-1.6.9p9/emul/err.h
sudo-1.6.9p9/emul/fnmatch.h
sudo-1.6.9p9/emul/search.h
sudo-1.6.9p9/emul/utime.h
sudo-1.6.9p9/emul/glob.h
sudo-1.6.9p9/emul/timespec.h
sudo-1.6.9p9/BUGS
sudo-1.6.9p9/CHANGES
sudo-1.6.9p9/HISTORY
sudo-1.6.9p9/INSTALL
sudo-1.6.9p9/INSTALL.configure
sudo-1.6.9p9/LICENSE
sudo-1.6.9p9/Makefile.in
sudo-1.6.9p9/PORTING
sudo-1.6.9p9/README
sudo-1.6.9p9/README.LDAP
sudo-1.6.9p9/TROUBLESHOOTING
sudo-1.6.9p9/UPGRADE
sudo-1.6.9p9/aclocal.m4
sudo-1.6.9p9/acsite.m4
sudo-1.6.9p9/aixcrypt.exp
sudo-1.6.9p9/config.guess
sudo-1.6.9p9/config.h.in
sudo-1.6.9p9/config.sub
sudo-1.6.9p9/configure
sudo-1.6.9p9/configure.in
```

Listing 24-1 (*continued*)

```
sudo-1.6.9p9/def_data.in
sudo-1.6.9p9/fnmatch.3
sudo-1.6.9p9/indent.pro
sudo-1.6.9p9/install-sh
sudo-1.6.9p9/ltmain.sh
sudo-1.6.9p9/mkdefaults
sudo-1.6.9p9/mkinstalldirs
sudo-1.6.9p9/pathnames.h.in
sudo-1.6.9p9/sample.pam
sudo-1.6.9p9/sample.syslog.conf
sudo-1.6.9p9/sample.sudoers
sudo-1.6.9p9/schema.OpenLDAP
sudo-1.6.9p9/schema.iPlanet
sudo-1.6.9p9/sudo.cat
sudo-1.6.9p9/sudo.man.in
sudo-1.6.9p9/sudo.pod
sudo-1.6.9p9/sudoers
sudo-1.6.9p9/sudoers.cat
sudo-1.6.9p9/sudoers.man.in
sudo-1.6.9p9/sudoers.pod
sudo-1.6.9p9/sudoers2ldif
sudo-1.6.9p9/visudo.cat
sudo-1.6.9p9/visudo.man.in
sudo-1.6.9p9/visudo.pod
sudo-1.6.9p9/auth/API
```

Listing 24-1 (*continued*)

As you can see in Listing 24-1, a new subdirectory was created called `sudo-1-6-9p9`. After the program distribution file is uncompressed and untarred, we can proceed to the installation process. This is not a difficult process, so if you have never worked with the `make` command and `Makefile` before, don't worry. The first step is to configure the `Makefile` for your system. As you might expect, this is done with the `configure` command. The `configure` command comes with the `sudo` distribution. First, change directories to where the source code is located, in our example `/usr/local/sudo-1.6.9p9`, and run the `configure` command:

```
cd /usr/local/sudo-1.6.9p9
./configure
```

The `configure` command goes through system checks and builds a `Makefile` and the `config.h` file used to build `sudo` for your system. The `configure` command output for my Linux Fedora system is shown in Listing 24-2.

```
[root@yogi sudo-1.6.9p9]# ./configure
configure: Configuring Sudo version 1.6.9
checking whether to lecture users the first time they run sudo... yes
```

Listing 24-2 Example of running the configure command

```
checking whether sudo should log via syslog or to a file by default...
syslog
checking which syslog facility sudo should log with... local2
checking at which syslog priority to log commands... notice
checking at which syslog priority to log failures... alert
checking how long a line in the log file should be... 80
checking whether sudo should ignore '.' or '' in $PATH... no
checking whether to send mail when a user is not in sudoers... yes
checking whether to send mail when user listed but not for this host...
no
checking whether to send mail when a user tries a disallowed command...
no
checking who should get the mail that sudo sends... root
checking for bad password prompt... Password:
checking for bad password message... Sorry, try again.
checking whether to expect fully qualified hosts in sudoers... no
checking for umask programs should be run with... 0022
checking for default user to run commands as... root
checking for editor that visudo should use... vi
checking whether to obey EDITOR and VISUAL environment variables... no
checking number of tries a user gets to enter their password... 3
checking time in minutes after which sudo will ask for a password
again... 5
checking time in minutes after the password prompt will time out... 5
checking whether to use per-tty ticket files... no
checking whether to include insults... no
checking whether to override the user's path... no
checking whether to get ip addresses from the network interfaces... yes
checking whether stow should be used... no
checking whether to do user authentication by default... yes
checking whether to disable running the mailer as root... no
checking whether to disable shadow password support... no
checking whether root should be allowed to use sudo... yes
checking whether to log the hostname in the log file... no
checking whether to invoke a shell if sudo is given no arguments... no
checking whether to set $HOME to target user in shell mode... no
checking whether to disable 'command not found' messages... no
checking for egrep... egrep
checking for gcc... gcc
checking for C compiler default output file name... a.out
checking whether the C compiler works... yes
checking whether we are cross compiling... no
checking for suffix of executables...
checking for suffix of object files... o
checking whether we are using the GNU C compiler... yes
checking whether gcc accepts -g... (cached) no
checking for gcc option to accept ISO C89... none needed
checking for library containing strerror... none required
```

Listing 24-2 (*continued*)

```
checking how to run the C preprocessor... gcc -E
checking build system type... i686-pc-linux-gnu
checking host system type... i686-pc-linux-gnu
checking target system type... i686-pc-linux-gnu
checking for a sed that does not truncate output... /bin/sed
checking for grep that handles long lines and -e... /bin/grep
checking for egrep... /bin/grep -E
checking for ld used by gcc... /usr/bin/ld
checking if the linker (/usr/bin/ld) is GNU ld... yes
checking for /usr/bin/ld option to reload object files... -r
checking for BSD-compatible nm... /usr/bin/nm -B
checking whether ln -s works... yes
checking how to recognize dependent libraries... pass_all
checking for ANSI C header files... yes
checking for sys/types.h... yes
checking for sys/stat.h... yes
checking for stdlib.h... yes
checking for string.h... yes
checking for memory.h... yes
checking for strings.h... yes
checking for inttypes.h... yes
checking for stdint.h... yes
checking for unistd.h... yes
checking dlfcn.h usability... yes
checking dlfcn.h presence... yes
checking for dlfcn.h... yes
checking the maximum length of command line arguments... 98304
checking command to parse /usr/bin/nm -B output from gcc object... ok
checking for objdir... .libs
checking for ar... ar
checking for ranlib... ranlib
checking for strip... strip
checking if gcc supports -fno-rtti -fno-exceptions... no
checking for gcc option to produce PIC... -fPIC
checking if gcc PIC flag -fPIC works... yes
checking if gcc static flag -static works... yes
checking if gcc supports -c -o file.o... yes
checking whether the gcc linker (/usr/bin/ld) supports shared libraries
... yes
checking whether -lc should be explicitly linked in... no
checking dynamic linker characteristics... GNU/Linux ld.so
checking how to hardcode library paths into programs... immediate
checking whether stripping libraries is possible... yes
checking if libtool supports shared libraries... yes
checking whether to build shared libraries... yes
checking whether to build static libraries... no
configure: creating libtool
checking path to sudo_noexec.so... ${exec_prefix}/libexec/sudo_noexec.so
```

Listing 24-2 (*continued*)

```
checking for uname... uname
checking for tr... tr
checking for nroff... nroff
checking whether gcc needs -traditional... no
checking for an ANSI C-conforming const... yes
checking for working volatile... yes
checking for bison... bison -y
checking for mv... /bin/mv
checking for bourne shell... /bin/sh
checking for sendmail... /usr/sbin/sendmail
checking for vi... /bin/vi
checking for ANSI C header files... (cached) yes
checking for dirent.h that defines DIR... yes
checking for library containing opendir... none required
checking whether time.h and sys/time.h may both be inclued... yes
checking malloc.h usability... yes
checking malloc.h presence... yes
checking for malloc.h... yes
checking paths.h usability... yes
checking paths.h presence... yes
checking for paths.h... yes
checking utime.h usability... yes
checking utime.h presence... yes
checking for utime.h... yes
checking netgroup.h usability... no
checking netgroup.h presence... no
checking for netgroup.h... no
checking sys/sockio.h usability... no
checking sys/sockio.h presence... no
checking for sys/sockio.h... no
checking sys/bsdtypes.h usability... no
checking sys/bsdtypes.h presence... no
checking for sys/bsdtypes.h... no
checking sys/select.h usability... yes
checking sys/select.h presence... yes
checking for sys/select.h... yes
checking err.h usability... yes
checking err.h presence... yes
checking for err.h... yes
checking POSIX termios... yes
checking for mode_t... yes
checking for uid_t in sys/types.h... yes
checking for sig_atomic_t... yes
checking for sigaction_t... no
checking for struct timespec... yes
checking for struct in6_addr... yes
checking for size_t... yes
checking for ssize_t... yes
```

Listing 24-2 (*continued*)

```
checking for dev_t... yes
checking for ino_t... yes
checking for full void implementation... yes
checking max length of uid_t... 10
checking for long long... yes
checking for long and long long equivalence... no
checking for sa_len field in struct sockaddr... no
checking return type of signal handlers... void
checking type of array argument to getgroups... gid_t
checking for size_t... yes
checking for getgroups... yes
checking for working getgroups... yes
checking for strchr... yes
checking for strrchr... yes
checking for memchr... yes
checking for memcpy... yes
checking for memset... yes
checking for sysconf... yes
checking for tzset... yes
checking for strftime... yes
checking for setrlimit... yes
checking for initgroups... yes
checking for getgroups... (cached) yes
checking for fstat... yes
checking for gettimeofday... yes
checking for setlocale... yes
checking for getaddrinfo... yes
checking for setresuid... yes
checking for seteuid... yes
checking for getifaddrs... yes
checking for freeifaddrs... yes
checking for getcwd... yes
checking for glob... yes
checking for GLOB_BRACE and GLOB_TILDE in glob.h... yes
checking for lockf... yes
checking for waitpid... yes
checking for innetgr... yes
checking for getdomainname... yes
checking for lsearch... yes
checking for utimes... yes
checking for futimes... yes
checking for working fnmatch with FNM_CASEFOLD... yes
checking for isblank... yes
checking for memrchr... yes
checking for strerror... yes
checking for strcasecmp... yes
checking for sigaction... yes
checking for strlcpy... no
```

Listing 24-2 (*continued*)

```
checking for strlcat... no
checking for closefrom... no
checking whether F_CLOSEM is declared... no
checking for mkstemp... yes
checking for snprintf... yes
checking for vsnprintf... yes
checking for asprintf... yes
checking for vasprintf... yes
checking for struct stat.st_mtim... yes
checking for two-parameter timespecsub... no
checking for socket... yes
checking for inet_addr... yes
checking for syslog... yes
checking for working alloca.h... yes
checking for alloca... yes
checking for getprogname... no
checking for __progname... yes
checking for main in -ldl... yes
checking security/pam_appl.h usability... yes
checking security/pam_appl.h presence... yes
checking for security/pam_appl.h... yes
checking whether to use PAM session support... yes
checking for dgettext... yes
checking for log file location... /var/log/sudo.log
checking for timestamp file location... /var/run/sudo
configure: using the following authentication methods: pam
configure: creating ./config.status
config.status: creating Makefile
config.status: creating sudo.man
config.status: creating visudo.man
config.status: creating sudoers.man
config.status: creating config.h
config.status: creating pathnames.h
configure: You will need to customize sample.pam and install it as
/etc/pam.d/sudo
```

Listing 24-2 (*continued*)

After the `configure` command completes without error, you have a customized `Makefile` for your system. You can, if you need to, edit the `Makefile` and change the default paths and the compiler to use. Now that we have a new customized `Makefile` we can now compile the `sudo` program on the system. Issue the following command, assuming you are still in the `/usr/local/sudo-1.6.9p9` directory:

```
make
```

The **make** command is located in `/usr/bin/make` on most systems, and it uses the `Makefile` in the current directory to compile, in our case `/usr/local/sudo-1.6.9p9/Makefile`. The `make` command output is shown in Listing 24-3. Notice that my system uses the `gcc` compiler.

```
[root@yogi sudo-1.6.9p9]# make
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  check.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  env.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  getspwuid.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  gettime.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  goodpath.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  fileops.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  find_path.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  interfaces.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  logging.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  parse.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  set_perms.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  sudo.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  sudo_edit.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  tgetpass.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  zero_bytes.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  ./auth/sudo_auth.c
```

Listing 24-3 Command output — make command

```
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  ./auth/pam.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  sudo.tab.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  lex.yy.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  alloc.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  defaults.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  strlcpy.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  strlcat.c
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  closefrom.c
gcc -o sudo check.o env.o getspwuid.o gettime.o goodpath.o fileops.o
find_path.o interfaces.o logging.o parse.o set_perms.o sudo.o
sudo_edit.o tgetpass.o zero_bytes.o  sudo_auth.o pam.o
sudo.tab.o lex.yy.o alloc.o defaults.o strlcpy.o strlcat.o closefrom.o
-lpam -ldl
gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\"
-D_PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0
-DSUDOERS_GID=0 -DSUDOERS_MODE=0440  visudo.c
gcc -o visudo visudo.o fileops.o gettime.o goodpath.o find_path.o sudo.
tab.o lex.yy.o alloc.o defaults.o strlcpy.o strlcat.o closefrom.o
/bin/sh ./libtool --mode=compile gcc -c -I. -I.  -O2 -D_GNU_SOURCE -D_
PATH_SUDOERS=\"/ etc/sudoers\" -D_PATH_SUDOERS_TMP=\"/etc/
sudoers.tmp\" -DSUDOERS_UID=0 -DSUDOERS_GID=0 -DSUDOERS_MODE=0440
./sudo_noexec.c
mkdir .libs
 gcc -c -I. -I. -O2 -D_GNU_SOURCE -D_PATH_SUDOERS=\"/etc/sudoers\" -D_
PATH_SUDOERS_TMP=\"/etc/sudoers.tmp\" -DSUDOERS_UID=0 -DSUDOERS_GID=0
-DSUDOERS_MODE=0440 ./sudo_noexec.c  -fPIC -DPIC -o .libs/sudo_noexec.o
/bin/sh ./libtool --mode=link gcc  -o sudo_noexec.la sudo_noexec.lo
-avoid -version -rpath /usr/local/libexec
gcc -shared  .libs/sudo_noexec.o   -Wl,-soname -Wl,sudo_noexec.so -o
.libs/sudo_noexec.so
creating sudo_noexec.la
(cd .libs && rm -f sudo_noexec.la && ln -s ../sudo_noexec.la
sudo_noexec.la)
```

Listing 24-3 (*continued*)

After the `make` command completes, we have custom compiled code for our system, but we still have one more installation step to complete before we are ready to configure `sudo`. This last step is to install the compiled files created with the `make` command. The next command handles the installation of `sudo`:

```
make install
```

Remember that the `make` command is usually located in `/usr/bin` and should be in your `$PATH`. The output of the `make install` command for my machine is shown in Listing 24-4.

```
[root@yogi sudo-1.6.9p9]# make install
/bin/sh ./mkinstalldirs /usr/local/bin \
    /usr/local/sbin /etc \
    /usr/local/share/man/man8 /usr/local/share/man/man5 \
    /usr/local/libexec
/bin/sh ./install-sh -c -O 0 -G 0 -M 4111 -s sudo /usr/local/bin/sudo
rm -f /usr/local/bin/sudoedit
ln /usr/local/bin/sudo /usr/local/bin/sudoedit
/bin/sh ./install-sh -c -O 0 -G 0 -M 0111 -s visudo /usr/local/sbin/
visudo
/bin/sh ./libtool --mode=install /bin/sh ./install-sh -c sudo_
noexec.la /usr/local/libexec
/bin/sh ./install-sh -c .libs/sudo_noexec.so /usr/local/libexec/
sudo_noexec.so
/bin/sh ./install-sh -c .libs/sudo_noexec.lai /usr/local/libexec/
sudo_noexec.la
test -f /etc/sudoers || \
    /bin/sh ./install-sh -c -O 0 -G 0 -M 0440 \
      ./sudoers /etc/sudoers
/bin/sh ./install-sh -c -O 0 -G 0 -M 0444 ./sudo.man /usr/local/share/
man/man8/sudo.8
ln /usr/local/share/man/man8/sudo.8 /usr/local/share/man/man8/
sudoedit.8
/bin/sh ./install-sh -c -O 0 -G 0 -M 0444 ./visudo.man /usr/local/share/
man/man8/visudo.8
/bin/sh ./install-sh -c -O 0 -G 0 -M 0444 ./sudoers.man /usr/local/share/
man/man5/sudoers.5
```

Listing 24-4 Command output — make install

If you did not have any failures during the compilation and installation processes, then `sudo` is installed but not yet configured. In the next section we will look at two sample configuration files.

Configuring sudo

Configuring `sudo` is where a lot of people get a bit confused. The configuration is not too difficult if you take small steps and test each part as you build the configuration

file. If you look in the /etc directory after the installation is complete, you will see a file called sudoers. The sudoers file is used to configure the commands and users for the sudo program. Be very careful to *never directly edit* the sudoers file! A special program is supplied that has a wrapper around the vi editor called **visudo**, or *vi sudo*.

The visudo program resides in /usr/local/sbin by default. The nice thing about visudo is that it checks the /etc/sudoers file for any errors before saving the file. If errors are detected, the visudo program will tell you exactly what the error is, and in most cases the line the error is on. If you directly edit the /etc/sudoers file and you make a mistake, the editor will just let you save the file, with the mistake, and it can be difficult to find the error. If you save the sudoers file with an error in it, sudo may not work at all for any users. The visudo program checks for the correct file format and ensures that the command/user references are consistent. If you make a mistake with a username, the visudo editor will not catch the mistake, but this type of error should be easy to find and correct after an initial run.

I am presenting enclosing two samples of a /etc/sudoers file for you to use as a template in Listings 24-5 and 24-6.

NOTE The sudoers file in Listing 24-5 is used with the permission of Todd Miller at http://sudo.ws and is included in the sudo distribution as a sample. Thank you, Todd!

```
#
# Sample /etc/sudoers file.
#
# This file MUST be edited with the 'visudo' command as root.
#
# See the sudoers man page for the details on how to write a sudoers file.
#

##
# User alias specification$
##
User_Alias    FULLTIMERS = millert, mikef, dowdy
User_Alias    PARTTIMERS = bostley, jwfox, crawl
User_Alias    WEBMASTERS = will, wendy, wim

##
# Runas alias specification
##
Runas_Alias  OP = root, operator
Runas_Alias  DB = oracle, sybase

##
# Host alias specification
##
```

Listing 24-5 Sample /etc/sudoers file #1

```
Host_Alias    SPARC = bigtime, eclipse, moet, anchor:\
              SGI = grolsch, dandelion, black:\
              ALPHA = widget, thalamus, foobar:\
              HPPA = boa, nag, python
Host_Alias    CUNETS = 128.138.0.0/255.255.0.0
Host_Alias    CSNETS = 128.138.243.0, 128.138.204.0/24, 128.138.242.0
Host_Alias    SERVERS = master, mail, www, ns
Host_Alias    CDROM = orion, perseus, hercules

##
# Cmnd alias specification
##
Cmnd_Alias    DUMPS = /usr/sbin/dump, /usr/sbin/rdump, /usr/sbin/
restore, \
                      /usr/sbin/rrestore, /usr/bin/mt
Cmnd_Alias    KILL = /usr/bin/kill
Cmnd_Alias    PRINTING = /usr/sbin/lpc, /usr/bin/lprm
Cmnd_Alias    SHUTDOWN = /usr/sbin/shutdown
Cmnd_Alias    HALT = /usr/sbin/halt, /usr/sbin/fasthalt
Cmnd_Alias    REBOOT = /usr/sbin/reboot, /usr/sbin/fastboot
Cmnd_Alias    SHELLS = /usr/bin/sh, /usr/bin/csh, /usr/bin/ksh, \
                       /usr/local/bin/tcsh, /usr/bin/rsh, \
                       /usr/local/bin/zsh
Cmnd_Alias    SU = /usr/bin/su
Cmnd_Alias    VIPW = /usr/sbin/vipw, /usr/bin/passwd, /usr/bin/chsh, \
                     /usr/bin/chfn

##
# Override builtin defaults
##
Defaults                syslog=auth
Defaults:FULLTIMERS     !lecture
Defaults:millert        !authenticate
Defaults@SERVERS        log_year, logfile=/var/log/sudo.log

##
# User specification
##

# root and users in group wheel can run anything on any machine
# as any user

root          ALL = (ALL) ALL
%wheel        ALL = (ALL) ALL

# full time sysadmins can run anything on any machine without a password
FULLTIMERS    ALL = NOPASSWD: ALL
```

Listing 24-5 (*continued*)

```
# part time sysadmins may run anything but need a password
PARTTIMERS   ALL = ALL

# jack may run anything on machines in CSNETS
jack         CSNETS = ALL

# lisa may run any command on any host in CUNETS (a class B network)
lisa         CUNETS = ALL

# operator may run maintenance commands and anything in /usr/oper/bin/
operator     ALL = DUMPS, KILL, PRINTING, SHUTDOWN, HALT, REBOOT,\
             /usr/oper/bin/

# joe may su only to operator
joe          ALL = /usr/bin/su operator

# pete may change passwords for anyone but root on the hp snakes
pete         HPPA = /usr/bin/passwd [A-z]*, !/usr/bin/passwd root

# bob may run anything on the sparc and sgi machines as any user
# listed in the Runas_Alias "OP" (ie: root and operator)
bob          SPARC = (OP) ALL : SGI = (OP) ALL

# jim may run anything on machines in the biglab netgroup
jim          +biglab = ALL

# users in the secretaries netgroup need to help manage the printers
# as well as add and remove users
+secretaries  ALL = PRINTING, /usr/bin/adduser, /usr/bin/rmuser

# fred can run commands as oracle or sybase without a password
fred         ALL = (DB) NOPASSWD: ALL

# on the alphas, john may su to anyone but root and flags are not allowed
john         ALPHA = /usr/bin/su [!-]*, !/usr/bin/su *root*

# jen can run anything on all machines except the ones
# in the "SERVERS" Host_Alias
jen          ALL, !SERVERS = ALL

# jill can run any commands in the directory /usr/bin/, except for
# those in the SU and SHELLS aliases.
jill         SERVERS = /usr/bin/, !SU, !SHELLS

# steve can run any command in the directory /usr/local/op_commands/
# as user operator.
steve        CSNETS = (operator) /usr/local/op_commands/
```

Listing 24-5 (*continued*)

```
# matt needs to be able to kill things on his workstation when
# they get hung.
matt          valkyrie = KILL

# users in the WEBMASTERS User_Alias (will, wendy, and wim)
# may run any command as user www (which owns the web pages)
# or simply su to www.
WEBMASTERS    www = (www) ALL, (root) /usr/bin/su www

# anyone can mount/unmount a CD-ROM on the machines in the CDROM alias
ALL           CDROM = NOPASSWD: /sbin/umount /CDROM,\
              /sbin/mount -o nosuid\,nodev /dev/cd0a /CDROM
```

Listing 24-5 (*continued*)

I want to point out how we set up specific commands to be executed without a password. The `NOPASSWD:` specification tells `sudo` to not prompt for a password for the specified commands. I extracted the following definition for the `User_Alias FULLTIMERS`:

```
# full time sysadmins can run anything on any machine without a password
FULLTIMERS    ALL = NOPASSWD: ALL
```

The statement says to allow all the users defined in the `FULLTIMERS sudo User_Alias` to execute `ALL` commands without being prompted by `sudo` for a password. To allow a user to execute the `vi` command with root authority without a password, use the following syntax in the `/etc/sudoers` file:

```
# root_editors can edit any file with vi on the machine without a password
ROOTEDITOR    VI = NOPASSWD: /usr/bin/vi
```

Let's look at the second sample `/etc/sudoers` file, shown in Listing 24-6.

```
# sudoers file.
#
# This file MUST be edited with the 'visudo' command as root.
#
# See the sudoers man page for the details on how to write a sudoers file.
#
# Users Identification:
#
# All ROOT access:
#
# d7742 - Michael
#
# Restricted Access to: mount umount and exportfs
#
#
```

Listing 24-6 Sample /etc/sudoers file #2

```
# Restricted Access to: Start and stop Fasttrack Web Server
#
# d3920 - Park
# d7525 - Brinker
# d7794 - Doan
#
# Restricted OPERATIONS access
#
# d6331 - Sutter
# d6814 - Martin
# d8422 - Smith
# d9226 - Milando
# d9443 - Summers
# d0640 - Lawson
# d2105 - Fanchin
# d2188 - Grizzle
# d3408 - Foster
# d3551 - Dennis
# d3883 - Nations
# d6290 - Alexander
# d2749 - Mayo
# d6635 - Wright
# d3916 - Chatman
# d6782 - Scott
# d6810 - Duckery
# d6811 - Wells
# d6817 - Gilliam
# d5123 - Crynick
# d7504 - Davis
# d7505 - McCaskey
# d7723 - Rivers
#
# Host alias specification

Host_Alias   LOCAL=yogi

# User alias specification

User_Alias   NORMAL=d7742,d7537,d7526,d6029,d7204,d1076,d7764,d7808
User_Alias   ADMIN=e17742,d7211,d6895,d8665,d7539,b003
User_Alias   ORACLE=d7742
User_Alias   SAP=d7742
User_Alias OPERATOR=d7742,d6895,d6331,d6814,d8422,d9226,d9443,d0640,
d2105,d2188,d3408,d3551,d3883,d6290,d2749,d6635,d3916,d6782,d6810,
d6811,d6817,d5123,d7504,d7505,d7723
User_Alias FASTTRACK=d3920,d7525,d7794

# Cmnd alias specification
```

Listing 24-6 (*continued*)

```
Cmnd_Alias   MNT=/usr/bin/mount
Cmnd_Alias   UMNT=/usr/bin/umount
Cmnd_Alias   EXP_FS=/usr/bin/exportfs
Cmnd_Alias   KILL=/usr/bin/kill
Cmnd_Alias   ROOT_SU=/usr/bin/su -
Cmnd_Alias   SU_ROOT=/usr/bin/su - root
Cmnd_Alias   SUROOT=/usr/bin/su root
Cmnd_Alias   ORACLE_SU=/usr/bin/su - oracle
Cmnd_Alias   SAP_SU=/usr/bin/su - sap
Cmnd_Alias   TCPDUMP=/usr/sbin/tcpdump
Cmnd_Alias   ERRPT=/usr/bin/errpt
Cmnd_Alias   SVRMGRL=/oracle/product/8.0.5/bin/svrmgrl
Cmnd_Alias   RSH_UPDATE=/usr/local/bin/rsh_update.ksh
Cmnd_Alias   START_FT_YOGI=/usr/netscape/httpd-yogi/start
Cmnd_Alias   STOP_FT_YOGI=/usr/netscape/httpd-yogi/stop
Cmnd_Alias   START_FT_DINO=/usr/netscape/httpd-dino/start
Cmnd_Alias   STOP_FT_DINO=/usr/netscape/httpd-dino/stop
Cmnd_Alias   START_WSADM=/usr/netscape/start-admin
Cmnd_Alias   STOP_WSADM=/usr/netscape/stop-admin

# User privilege specification

# FULL ROOT ACCESS!!!!!! (BE CAREFUL GRANTING FULL ROOT!!!!!!!)
root  ALL=(ALL) ALL
# This next user is not prompted for a password by sudo
d7742 ALL= NOPASSWD: ALL # Michael

# Only mount, umount and exportfs
NORMAL       LOCAL=MNT,UMNT,EXP_FS

# Some Limited Sys Admin Functions
ADMIN        LOCAL=MNT,UMNT,KILL,ORACLE_SU,SAP_SU,TCPDUMP,ERRPT,
ROOT_SU: \
      LOCAL=SU_ROOT,SUROOT,EXP_FS

# Some Operator Functions
OPERATOR LOCAL=RSH_UPDATE

# Some FastTrack/WebAdm Functions
FASTTRACK LOCAL=START_FT_E1,STOP_FT_E1,START_FT_E2,STOP_FT_E2,
START_WSADM,
STOP_WSADM

# Override Defaults

# Change the default location of the SUDO log file
Defaults     logfile=/var/adm/sudo.log
```

Listing 24-6 (*continued*)

As you can see by the two sample /etc/sudoers files, you can get as detailed as you want. As you look at these files, notice that there are four kinds of aliases: User_Alias, Runas_Alias, Host_Alias, and Cmnd_Alias. The use of each alias type is listed next.

A User_Alias is a list that can contain any combination of usernames, UID (with a ''#'' prefix), system groups (with a ''%'' prefix), netgroups (with a ''+'' prefix), and other user-defined aliases. Any of these can be prefixed with the NOT operator, ''!'', to negate the entry.

A Runas_Alias can contain any of the same elements as the User_Alias; the only difference is that you use Runas_Alias instead of User_Alias in the configuration. The Runas_Alias allows execution of a command as a user other than root.

A Host_Alias is a list of hostnames, IP addresses, or netgroups (with a ''+'' prefix). The Host_Alias also supports the NOT operator, ''!'', to negate an entry. You will need to use the fully qualified DNS name if the hostname command on any machine returns the name of the machine in a fully qualified DNS format. The visudo editor will not catch this ''error.''

A Cmnd_Alias is list of one or more commands specified by a *full pathname*, not just the filename. You can also specify directories and other aliases to commands. The command alone will allow command arguments to the command, but you can disable command arguments using double quotes (''''). If a directory is specified a user can execute any command within that directory, but *not* any subdirectories. Wildcards are allowed, but be very careful to ensure that the wildcard is working as expected.

I am not going to discuss every piece of sudo because very detailed documentation is included with the sudo distribution. Our next step is to look at how to use sudo and how to use sudo in a shell script.

Using sudo

We use sudo by preceding the command that we want to run with the word sudo. As an example, if my user ID is rmichael and I want to gain root access for the first time, I will follow the steps illustrated in Listing 24-7.

```
[root@yogi /]# PATH=$PATH:/usr/local/bin
[root@yogi /]# export PATH
[root@yogi /]# sudo su - root

We trust you have received the usual lecture from the local System
Administrator. It usually boils down to these two things:

        #1) Respect the privacy of others.
        #2) Think before you type.

Password:
[root@yogi /]#
```

Listing 24-7 Using sudo for the first time

Notice the short lecture that is displayed in Listing 24-7. This lecture message is displayed only the first time `sudo` is used by each user. In the password field the user responds with his or her normal user-account password, *not* the `root` password. You should be careful granting full `root` permission like this. Allowing a user to `su` to `root` via the `sudo` program does not leave an audit trail of what the user did as `root`! You should still have the root history file if the user did not delete or edit the file. Also notice in Listing 24-7 that I added `/usr/local/bin` to my `$PATH`. By default the `sudo` command is located in the `/usr/local/bin` directory, but most shops do not add this directory to the `$PATH` environment variable as a normal path when setting up user accounts. Just make sure that *all sudo users* have the `sudo` command in the `$PATH` or that they need to provide the full pathname to the `sudo` command.

Using sudo in a Shell Script

You can also use `sudo` in a shell script. As you create the shell script, add the `sudo` command as a prefix to each command that you want to execute as `root`. The script in Listing 24-8 uses the `sudo` command to allow the Operations Team to reset passwords.

On an AIX system you can manage user passwords with the `pwdadm` command. In this particular shell script we want our Operations Team to be able to change a user's password from a menu selection in a shell script. The bold text shown in Listing 24-8 points out the use of `sudo` and also the use of the `tput` command for reverse video, which we will study further in Chapter 15, ''hgrep: Highlighted grep Script.''

```
#!/usr/bin/ksh
#
# SCRIPT: chpwd_menu.ksh
# AUTHOR: Randy Michael
# DATE: 11/05/2007
# PLATFORM: AIX
# REV: 1.1.P
#
# PURPOSE: This script was created for the Operations Team
#          to change user passwords. This shell script uses
#          "sudo" to execute the "pwdadm" command as root.
#          Each member of the Operations Team needs to be
#          added to the /etc/sudoers file. CAUTION: When
#          editing the /etc/sudoers file always use the
#          /usr/local/sbin/visudo program editor!!!
#          NEVER DIRECTLY EDIT THE sudoers FILE!!!!
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
```

Listing 24-8 chpwd_menu.ksh shell script

```
#
#########################################################
#          DEFINE FUNCTIONS HERE
#########################################################

function chg_pwd
{
USER_NAME="$1"

echo "\nThe next password prompt is for YOUR NORMAL PASSWORD"
echo "NOT the new password..."

# The next command turns off the checking of the password history

/usr/local/bin/sudo /usr/bin/pwdadm -f NOCHECK $USER_NAME
if [ $? -ne 0 ]
then
        echo "\nERROR: Turning off password history failed..."
        usage
        exit 1
fi

# The next command changes the user's password

/usr/local/bin/sudo /usr/bin/pwdadm $USER_NAME
if [ $? -ne 0 ]
then
        echo "\nERROR: Changing $USER_NAME password failed..."
        usage
        exit 1
fi

# The next command forces the user to change his or her password
# at the next login.

/usr/local/bin/sudo /usr/bin/pwdadm -f ADMCHG $USER_NAME

return 0
}

#########################################################
#                    START OF MAIN
#########################################################

OPT=0      # Initialize to zero

clear      # Clear the screen
```

Listing 24-8 (*continued*)

```
while < $OPT != 99 > # Start a loop
do

# Draw reverse image bar across the top of the screen
# with the system name.

clear
tput smso
echo "                          $(hostname)                          "
tput sgr0
echo ""

# Draw menu options.

echo "\n\n\n\n\n\n\n"

print "10. Change Password"

echo "\n\n\n\n\n\n\n\n\n"

print "99. Exit Menu"

# Draw reverse image bar across bottom of screen,
# with error message, if any.

tput smso
echo "             $MSG                    "
tput sgr0

# Prompt for menu option.

read OPT

# Assume invalid selection was taken.  Message is always
# displayed, so blank it out when a valid option is selected.

MSG="       Invalid option selected         "
# Option 10 - Change Password

if [ $OPT -eq 10 ]
then
        echo "\nUsername for password change? \c"
        read USERNAME
        grep $USERNAME /etc/passwd >/dev/null 2>&1
        if [ $? -eq 0 ]
        then
              chg_pwd $USERNAME
              if [ $? -eq 0 ]
```

Listing 24-8 (*continued*)

```
                then
                     MSG="$USERNAME password successfully changed"
                else
                     MSG="ERROR: $USERNAME password change failed"
                fi
          else
                MSG="   ERROR: Invalid username $USERNAME   "
          fi
fi

# End of Option 99 Loop

done

# Erase menu from screen upon exiting.

clear
```

Listing 24-8 (*continued*)

The `chpwd_menu.ksh` shell script in Listing 24-8 displays a menu on the screen that has only two options: change a user's password or exit. This shell script uses the `sudo` program to execute the `pwdadm` command as the `root` user. The `pwdadm` command is used for password administration in AIX and has options to turn password history checking off and to force password changes on the next login attempt. The `pwdadm` command is executed three times in the `chg_pwd` function within the shell script. The first time `pwdadm` is executed as `root` we turn off the checking of the password history. Notice that I added a comment to the staff that the next password prompt is for *their normal user password*, not the root user password. I turn off the history checking because the password that the Operation Team is going to enter is a temporary password. The next time the user logs in, the system will prompt for a new password, and at this stage the password history will be checked. The second time that `pwdadm` is executed, the password is actually changed by the Operations Team member. The third time `pwdadm` is executed, the user is forced to change his or her password the next time they log in. Each time `sudo` is used to execute `pwdadm` as `root`.

Also notice the `tput` commands. The `tput` command has many options to control the cursor and the terminal. In this script we are using reverse video to display the hostname of the machine in the menu title bar at the top and to display messages at the bottom of the menu. There is much more on the `tput` command options in Chapter 15.

Logging to the syslog with sudo

System messages on UNIX can be logged using `syslogd`. The logged messages consist of at least a time and a hostname field, and normally a program name field, too, but the amount of information is determined by the configuration file `/etc/syslog.conf`.

When a system message is logged, `syslogd` determines where to log the message by referencing the `/etc/syslog.conf` file. We can set up `sudo` to log messages using `syslogd` by adding a line or two to the `/etc/syslog.conf` file.

The `/etc/syslog.conf` file consists of a list of rules that determine the *facility* to log, the detail level of logging, and the file or remote log host to send the message. Every rule consists of two fields: a selector field and the action field. Any type of white space, one or more spaces or tabs, can separate these fields. The selector field specifies the facility and priority for the specified action. The facility can be any of the following keywords: `auth`, `authpriv`, `cron`, `daemon`, `kern`, `lpr`, `mail`, `mark`, `news`, `security` (same as `auth`), `syslog`, `user`, `uucp`, and `local0` through `local7`. By default, `sudo` logs to the `syslogd` facility `local2`. However, the facility is changeable, so we need to query `sudo` to see how it is configured on the system. We can check the facility `sudo` is configured to use by executing `sudo -V` (uppercase V). The `-V` (version) switch tells `sudo` to print the version number and exit, if the user is not root. If the user is root, the `-V` switch will print the defaults `sudo` was compiled with, as well as the machine's local network addresses. An example is shown in Listing 24-9.

```
[root@yogi ~]# sudo -V
Sudo version 1.6.9p9

Sudoers path: /etc/sudoers
Authentication methods: 'pam'
Syslog facility if syslog is being used for logging: local2
Syslog priority to use when user authenticates successfully: notice
Syslog priority to use when user authenticates unsuccessfully: alert
Send mail if the user is not in sudoers
Lecture user the first time they run sudo
Require users to authenticate by default
Root may run sudo
Allow some information gathering to give useful error messages
Set the LOGNAME and USER environment variables
Length at which to wrap log file lines (0 for no wrap): 80
Authentication timestamp timeout: 5 minutes
Password prompt timeout: 5 minutes
Number of tries to enter a password: 3
Umask to use or 0777 to use user's: 022
Path to mail program: /usr/sbin/sendmail
Flags for mail program: -t
Address to send mail to: root
Subject line for mail messages: *** SECURITY information for %h ***
Incorrect password message: Sorry, try again.
Path to authentication timestamp dir: /var/run/sudo
Default password prompt: Password:
Default user to run commands as: root
Path to the editor for use by visudo: /bin/vi
When to require a password for 'list' pseudocommand: any
```

Listing 24-9 Example sudo -V output executing with root authority

```
When to require a password for 'verify' pseudocommand: all
File containing dummy exec functions: /usr/local/libexec/sudo_noexec.so
Reset the environment to a default set of variables
Environment variables to check for sanity:
        TERM
        LINGUAS
        LC_*
        LANGUAGE
        LANG
        COLORTERM
Environment variables to remove:
        RUBYOPT
        RUBYLIB
        PYTHONINSPECT
        PYTHONPATH
        PYTHONHOME
        TMPPREFIX
        ZDOTDIR
        READNULLCMD
        NULLCMD
        FPATH
        PERL5DB
        PERL5OPT
        PERL5LIB
        PERLLIB
        PERLIO_DEBUG
        JAVA_TOOL_OPTIONS
        SHELLOPTS
        GLOBIGNORE
        PS4
        BASH_ENV
        ENV
        TERMCAP
        TERMPATH
        TERMINFO_DIRS
        TERMINFO
        _RLD*
        LD_*
        PATH_LOCALE
        NLSPATH
        HOSTALIASES
        RES_OPTIONS
        LOCALDOMAIN
        CDPATH
        IFS
Environment variables to preserve:
        XAUTHORIZATION
        XAUTHORITY
```

Listing 24-9 (*continued*)

```
        TZ
        PS2
        PS1
        PATH
        MAIL
        LS_COLORS
        KRB5CCNAME
        HOSTNAME
        DISPLAY
        COLORS
Local IP address and netmask pairs:
        192.168.100.38 / 255.255.255.0
        fe80::299:25aa:fe7a:818c / ffff:ffff:ffff:ffff::
```

Listing 24-9 (*continued*)

There is a lot information here, but the only lines we are interested in are the `syslog` facility and priorities that `sudo` is configured to use:

```
Syslog facility if syslog is being used for logging: local2
Syslog priority to use when user authenticates successfully: notice
Syslog priority to use when user authenticates unsuccessfully: alert
```

To quickly get this data, run the following command:

```
[root@yogi ~]# sudo -V | grep Syslog
Syslog facility if syslog is being used for logging: local2
Syslog priority to use when user authenticates successfully: notice
Syslog priority to use when user authenticates unsuccessfully: alert
```

With the `syslog` facility for `sudo` known, we can add an entry to the `/etc/syslog.conf` to set up `sudo` logging. We can log to both a local log file and to a remote `syslog` server. If you have had any SOX or PCI audits, you already know the requirement for having a log history, and a central `syslog` repository is an excellent way to meet these logging requirements. The file shown in Listing 24-10 is called `sample.syslog.conf` and comes with the source code of the `sudo` distribution.

```
# This is a sample syslog.conf fragment for use with Sudo.
#
# Sudo logs to local2 by default, but this is changeable via the
# --with-logfac configure option.  To see what syslog facility
# a sudo binary uses, run `sudo -V' as *root*.  You may have
# to check /usr/include/syslog.h to map the facility number to
# a name.
#
# NOTES:
#     The whitespace in the following line is made up of <TAB>
```

Listing 24-10 Sample syslog configuration file — sample.syslog.conf

```
#     characters, *not* spaces.  You cannot just cut and paste!
#     If you edit syslog.conf you need to send syslogd a HUP signal.
#     Ie: kill -HUP process_id
#
#     Syslogd will not create new log files for you, you must first
#     create the file before syslogd will log to it.  Eg.
#     'touch /var/log/sudo'

# This logs successful and failed sudo attempts to the file /var/log/sudo
local2.debug            /var/log/sudo

# To log to a remote machine, use something like the following,
# where "loghost" is the name of the remote machine.
local2.debug        @loghost
```

Listing 24-10 (*continued*)

In this `syslog.conf` file example, we define both a local log file as well as a remote log host. Notice that we set the logging priority to `debug` so that both successful and failed `sudo` attempts are logged to the same file, `/var/log/sudo`.

After modifying the `/etc/syslog.conf` file, we need to have `syslogd` reread the configuration file. To do this, we need the process ID (PID) of the `syslogd` process so that we can send a `HUP` signal to `syslogd`, as shown in Listing 24-11.

```
[root@yogi ~]# ps aux | grep syslogd
root      1765  0.0  0.0   1652   600 ?       Ss   Dec03   0:00 syslogd -m 0
root     32349  0.0  0.0   3916   656 pts/1    R+   13:15   0:00 grep
syslogd
[root@yogi ~]# kill -HUP 1765
```

Listing 24-11 Telling syslogd to reread the /etc/syslog.conf file

Listing 24-11 queries the system for the process named `syslogd` using the `ps aux` command. From this output, we find that the `syslogd` process ID is 1765. Then we use the `kill -HUP 1765` command to tell `syslogd` to reread `/etc/syslog.conf`.

NOTE Understand that adding `sudo` logging to `syslogd` does not remove the logging we configured in the `/etc/sudoers` file, as shown here:

```
# Override Defaults

# Change the default location of the SUDO log file
Defaults      logfile=/var/adm/sudo.log
```

Just be aware where you want the logs to go. It is entirely up to you.

The sudo Log File

Before we end this chapter I want to show you what the `sudo` log file looks like. Each time `sudo` is executed, an entry is made in the specified log. Logging can be to a file or to the system `syslog`. I specify a log file in the `/etc/sudoers`, but you may prefer the `syslog`. A short version of my `sudo` log file is shown in Listing 24-12.

```
Nov  9 10:07:44 : d7742 : TTY=pts/2 ; PWD=/usr/local ; USER=root ;
    COMMAND=/usr/bin/ftp bambam
Nov  9 10:09:13 : d7742 : TTY=pts/2 ; PWD=/usr/local ; USER=root ;
    COMMAND=/usr/bin/ftp dino
Nov 13 10:10:48 : d7742 : TTY=pts/0 ; PWD=/home/guest ; USER=root ;
    COMMAND=/usr/bin/whoami
Jul 23 17:35:47 : d7996 : TTY=pts/3 ; PWD=/home/guest ; USER=root ;
    COMMAND=/usr/sbin/mount /usr/local/common
Oct  2 09:29:33 : d7742 : TTY=pts/1 ; PWD=/home/d7742 ; USER=root ;
    COMMAND=/usr/bin/su -
Nov 14 16:01:31 : d7742 : TTY=pts/0 ; PWD=/home/d7742 ; USER=root ;
    COMMAND=/usr/bin/su - root
Nov 14 16:03:58 : rmichael : TTY=pts/0 ; PWD=/home/rmichael ; USER=root ;
    COMMAND=/usr/bin/su - root
Nov 15 11:31:32 : d7742 : TTY=pts/0 ; PWD=/scripts ; USER=root ;
    COMMAND=/usr/bin/pwdadm -f NOCHECK rmichael
Nov 15 11:31:32 : d7742 : TTY=pts/0 ; PWD=/scripts ; USER=root ;
    COMMAND=/usr/bin/pwdadm rmichael
Nov 15 11:31:32 : d7742 : TTY=pts/0 ; PWD=/scripts ; USER=root ;
    COMMAND=/usr/bin/pwdadm -f ADMCHG rmichael
Nov 15 14:58:49 : root : TTY=pts/0 ; PWD=/usr/local/sudo-1.6.3p7 ;
    USER=root ; COMMAND=/usr/bin/errpt
Nov 15 14:59:50 : d7742 : 3 incorrect password attempts ; TTY=pts/0 ;
    PWD=/home/d7742 ; USER=root ; COMMAND=/usr/bin/errpt
```

Listing 24-12 Sample sudo log file

In Listing 24-12 notice the last line of output. This line shows three incorrect password attempts. You can set up `sudo` to send an email on each password failure if you want immediate notification of misuse. The shell script in Listing 24-8 produced three log entries on each password change. I have highlighted several other entries for `ftp` and `su` to root to show you how the log entries look.

Summary

Through this chapter we have shown how to compile, install, configure, and use the `sudo` program. We all know that protecting the `root` password is one of our main tasks as a Systems Administrator, and `sudo` makes the job a little less difficult. When you use `sudo` in a shell script, it is important that each user is familiar with `sudo`

and has used it at least once from the command line. Remember that on the first use the lecture message is displayed, and you do not want a lecture in the middle of a menu! In the `sudo` distribution there are several files that you should review. The readme file has valuable information on installation and a lot of OS-specific problems and workarounds. The FAQ file answers the most frequently asked questions. The *Sudoer's Manual* is a must-read! This manual describes the many options in configuring your `sudoers` file. Finally, we have the *Visudo Manual* that explains how to use the `visudo` editor and lists the command options and possible error conditions. Again, I want to thank Todd Miller at `http://sudo.ws` for allowing me to use his material in this chapter.

In the next chapter, we are going to cover print-queue hell. If the printers are not printing, the queue may be down. We will look at techniques to keep the printers printing with a shell script.

Lab Assignments

1. Write a shell script that will uncompress and untar the `sudo` distribution files, and then run the `configure`, `make`, and `make install` commands to automatically install `sudo` for you.
2. Modify the shell script that you created in Lab Assignment 1 so that the script will NFS mount a remote directory containing the uncompressed and untarred `sudo` source code, and then run the `configure`, `make`, and `make install` commands to install `sudo` remotely.
3. Configure the `/etc/sudoers` file to allow the user ID `e112233` to execute the `/usr/bin/whoami`, `/usr/bin/mount`, and `/usr/bin/umount` commands with `root` authority without the requirement to enter a password. Additionally, allow this same `e112233` user to execute `/usr/sbin/ifconfig` with `root` authority with a valid password.

CHAPTER 25

Print-Queue Hell: Keeping the Printers Printing

If you have worked in a large systems environment for very long, you already know how frustrating it can be to keep the printer farm happy. In my contracting days I worked in several shops that consistently had problems with the printers. In most cases, the print queues went down because of network timeouts and extended device waits. In this kind of environment you have two choices: keep answering the calls from the help desk or write a shell script to monitor the printer queues and re-enable the queues as they drop offline.

I prefer the second method. Like every other Systems Administrator, I like to be proactive in my approach to solving the little problems as well as the big ones. The shop I remember the best is a hospital. This hospital has more than 30 satellite clinics around town and only one 100 MB/Sec pipe coming in to the hospital from the outside world. Most of the clinics have between three and five printers, with at least one printer active most of the day. When I came on board, the first problem I encountered was the huge volume of calls to the help desk about printer problems. What caught my eye was the fact that all of the calls came from the clinics, not from inside the hospital. I knew immediately that a shell script was in order! In this chapter we are going to look at two methods of bringing up the print queues, enabling individual queues and bringing up the whole lot. Because UNIX flavors vary on handling printers and queues, we first will look at the differences between the UNIX flavors.

System V versus BSD versus CUPS Printer Systems

Depending on the UNIX flavor, the commands vary to control the printers and queues, because some use the System V subsystem and others use BSD, also known as *Line Printer Protocol* (`lpd`), and then we have the option of the *Common UNIX Printer System* (CUPS). With AIX you have an ever more confusing situation beginning with AIX 5L, version 5.1. Starting with this release, AIX began supporting both the ''classic'' AIX

printer subsystem *and* the System V printer service. Another problem is that some commands do not provide the full print-queue name if the queue name exceeds seven characters. I have come up with some ways to get around the long queue names, and on most systems you do not have to worry about long queue names too much if you want to control *all* of the printers at once.

In this book we are covering AIX, HP-UX, Linux, OpenBSD, and Solaris operating systems, as well as the Common UNIX Printer System (CUPS). For no other reason that I can think of, let's cover the printer systems in alphabetical order.

AIX Print-Control Commands

AIX is the most interesting of the bunch with its new support for the System V printer service starting with AIX 5L. Although the AIX classic printer subsystem will still be supported for many years, the move seems to be going to System V for printing service.

Classic AIX Printer Subsystem

Most AIX Systems Administrators still prefer to use the classic AIX printer subsystem. This is the primary printing that I have supported for years. With the AIX printer subsystem you do not have the detailed control that either CUPS or the System V service offers. For example, you do not control forms and user priorities at a granular level, and you cannot manage the printers independently of the print queues easily. With this printer subsystem anyone can print on any printer, and the print queue is either `UP`, allowing you to print, or `DOWN`, disabling all printing. The shell scripts we are going to write for the classic AIX printer subsystem work at the print-queue level.

The two commands we are going to use are **lpstat** and **enq -A**. Both commands produce the same output, but some administrators seem to like one over the other. As I stated earlier, we need to be aware that sometimes print queues are created with queue names longer than seven characters, which is the default that can be displayed with both of these commands. I guess IBM noticed this little problem and added the **-W** switch to give a wide character output. Look at Listings 25-1 and 25-2 to see the different outputs.

```
# lpstat

Queue   Dev   Status    Job Files       User        PP  %   Blks  Cp Rnk
------- ----- --------- --- ----------- ---------- ---- -- ----- --- ---
hp4     lp0   READY
hp4-ps  lp0   READY
hp4-gl  lp0   READY
yogi_hp lp0   DOWN
yogi_hp lp0   DOWN
```

Listing 25-1 Output using lpstat or enq -A

```
# lpstat -W
Queue             Dev    Status  Job  Files    User   PP  %  Blks Cp  Rnk
----------------- ----- -------- ---- -------- ------ --- -- ---- --- ---
hp4               lp0   READY
hp4-ps            lp0   READY
hp4-gl            lp0   READY
yogi_hp4_1        lp0   DOWN
yogi_hp4_1ps      lp0   DOWN
```

Listing 25-2 Output using lpstat -W or enq -AW

As you can see in Listing 25-1, the long queue names are cut off at the seventh character when using the `lpstat` or `enq -A` commands. By adding the `-W` switch to these commands we see the entire long queue name. This is important because you cannot control a print queue if you do not have the exact, and full, queue name.

There are two methods to script using either `lpstat -W` or `enq -AW`. One method is to loop through each queue that is reported `DOWN`; the other is to use one long compound command. We are first going to look at the looping method.

A little `for` loop can be used to extract the queue names out of the printers list in a `DOWN` state. The list used for the `for` loop comes from either of the following command statements:

```
lpstat -W | tail +3 | grep DOWN | awk '{print $1}'
```

or

```
enq -AW | tail +3 | grep DOWN | awk '{print $1}'
```

Both of these statements produce the same output. Notice that **tail +3** is the second command in the pipe, just after the `lpstat` and `enq` commands. We use `tail +3` in this statement to remove the two lines of header information. This method is much cleaner than trying to `grep` out some unique character in both of the header lines.

Notice that the number of lines, specified by `+3`, is one larger than the actual number of lines that we want to remove. Using the `tail` command this way, we are telling `tail` to start listing at the third line, so two lines are removed at the top of the output.

The third command in the pipe is where we `grep` for `DOWN`, looking for disabled printers, as shown in Listing 25-2. The output from this stage of the command is only the lines of the `enq` and `lpstat` output that contain the word `DOWN`. Using these lines as input for the next command in the pipe, we are ready to extract the actual queue name(s) of the disabled printers, as shown in the output here:

```
yogi_hp4_1        lp0      DOWN
yogi_hp4_1ps      lp0      DOWN
```

The **awk** command, as we use it, is used to extract the field that we want to work with, which is the first field, the queue name. Using the preceding output as input to our `awk` statement we extract out the first field using the following syntax:

```
command | awk '{print $1}'
```

You can extract any valid field using `awk` as well as different fields at the same time. For example, if we want to extract fields 1 and 3, specified by `$1` and `$3`, the following `awk` statement will take care of the task:

```
command | awk '{print $1, $3}'
```

Notice that I added a comma between `$1` and `$3`. If the comma is omitted, there will *not* be a space between the two strings. Instead the output will be two strings appended together without a space.

For our `for` loop we can first send the `lpstat` and `enq` command output to a file and process the file in a loop, or we can use command substitution to add the statement directly into the `for` loop to create the list of objects to loop through. Let's look at our `for` loop structure:

```
for Q in $( enq -AW | tail +3 | grep DOWN | awk '{print $1}' )
do
     # Do something here.
done
```

Using this loop command statement, the `for` loop will loop through `yogi_hp4_1` and `yogi_hp4_1ps` print-queue names, which is equivalent to the following `for` loop structure:

```
for Q in yogi_hp4_1 yogi_hp4_1ps
do
     # Do something here.
done
```

Because we never know which queues may be down, we need to parse through the output of the actual queue names of the printers in a disabled state. The shell script in its entirety is shown in Listing 25-3.

```
#!/bin/ksh
#
# SCRIPT: enable_AIX_classic.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
# PLATFORM: AIX Only
#
# PURPOSE: This script is used to enable print queues on AIX systems.
#
# REV LIST:
#
```

Listing 25-3 for loop to enable "classic" AIX print queues

```
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#

for Q in $( enq -AW | tail +3 | grep DOWN | awk '{print $1}')
do
     enable $Q
     (( $? == 0 )) || echo "\n$Q print queue FAILED to enable.\n"
done
```

Listing 25-3 (*continued*)

Inside the `for` loop we attempt to enable each print queue individually. If the return code of the **enable** command is not zero we `echo` an error message indicating that the queue could not be enabled. Notice the highlighted lines in Listing 25-3. We use the mathematical test, specified by the double parentheses, `(( math test ))`. Using this math test you normally do not add a dollar sign, `$`, in front of a numeric variable. When the variable is produced by the system, such as `$?`, the dollar sign is required. Testing for equality also requires using the double equal signs, `==`, because the single equal sign, `=`, is meant as an assignment, not a test.

After the test to check for a zero return code, we use a logical OR, specified by the double pipes, `||`. This logical OR will execute the next command only if the return code of the `enable $Q` command is nonzero, which means that the command failed. There is also a logical AND that is used by placing double ampersands, `&&`, in a command statement. A logical AND does just the opposite; it would execute the succeeding command if the test is true, instead of false. Both the logical OR and logical AND are used as replacements for `if..then..else..` statements.

We can also accomplish this task by using a single compound command statement. Just as we used command substitution in the `for` loop, we can use command substitution to produce command parameters. For example, we can use our `for` loop command to create command parameters to the `enable` command. To see this more clearly, look at the following two commands:

```
enable $(enq -AW | tail +3 | grep DOWN | awk '{print $1}') 2>/dev/null
```

or

```
enable $(lpstat -W | tail +3 | grep DOWN | awk '{print $1}') 2>/dev/null
```

Both of these compound command statements produce the same result, enabling all of the print queues on the system. The only problem with using this technique is that if you execute this command and all of the printers are already enabled, you will get the following output from standard error:

```
usage: enable PrinterName ...
               Enables or activates printers.
```

As you can see, I sent this output to the bit bucket by adding `2>/dev/null` to the end of the statement, but the return code is still nonzero if all of the printers are already enabled. This should not be a problem unless you want to create some notification that a printer failed to enable. In our `for` loop in Listing 25-3 we used the return code from the `enable` command to produce notification. I will leave the technique that you use up to you. If you do not want to see any output, you could add the single compound statement as a cron table entry; or use the `for` loop technique in a shell script to redirect the failure notification to a log file. If you use a log file you may want to add a date stamp.

System V Printing on AIX

Beginning with AIX 5L, IBM supports System V printing. I find that Solaris has the closest command usage and output. With only a few differences between AIX and Solaris System V printing in the output produced, you could use the shell scripts interchangeably. Because people tend to read only the parts of a technical book that they need to, I will devote this entire section to AIX System V printing.

To switch your AIX system from the ''classic'' AIX printer subsystem to System V printing, refer to your AIX reference manual. This section expects that you are already running System V printing.

Like Solaris, AIX uses the System V **lpc** (line printer control) command to control the printers and print queues. The nice thing about this print service is that you can control the queues and the printers independently. The main commands that we are interested in for AIX queuing and printing include the following options and parameters to the `lpc` command, as shown in Table 25-1.

As you can see in Table 25-1, the granularity of printer control is excellent, which gives us several options when creating shell scripts. To control *all* of the printing and queuing at one time you really do not need a shell script. The following two commands can start and stop *all* printing and queuing on *all* print queues at the same time:

```
lpc down all      # Disable all printing and queuing

lpc up all        # Enable all printing and queuing
```

Table 25-1 AIX lpc Command Options

LPC COMMAND	COMMAND RESULT
`disable (printer[@host] | all)`	Disables queuing
`stop (printer[@host] | all)`	Disables printing
`down (printer[@host] | all)`	Disables printing and queuing
`enable (printer[@host] | all)`	Enables queuing
`start (printer[@host] | all)`	Enables printing
`up (printer[@host] | all)`	Enables printing and queuing

To keep all of the printers printing and queuing you only need the `lpc up all` command entered into a cron table. I placed an entry in my `root` cron table to execute this `lpc` command every 10 minutes, as shown here:

```
5,15,25,35,45,55 * * * * /usr/sbin/lpc up all >/dev/null 2>&1
```

This cron table entry enables all printing and queuing on all printers on the 5s, 24 hours a day, 7 days a week. With AIX System V printing, the data we are interested in is separated on three lines of output when we use the `lpc status all` command to monitor the printer service. The same BSD originating command executed on AIX, Linux, OpenBSD, and Solaris is shown here.

AIX System V output:

```
# lpc status all

hp4V:
        queueing is enabled
        printing is disabled
        5 entries in spool area
```

Linux System V output:

```
# lpc status
 Printer           Printing Spooling Jobs  Server Subserver
Redirect Status/(Debug)
hp4@localhost      enabled  disabled    0    none    none
```

OpenBSD output:

```
# lpc status all

hp4V:
        queueing is enabled
        printing is disabled
        5 entries in spool area
```

Solaris System V output:

```
# lpc status all

bambam_hp4:
        queueing is enabled
        printing is enabled
        no entries
```

Of these four outputs Linux is the one that differs. With the data we are interested in for AIX residing on three separate lines for each print queue, we need a different strategy to get the exact data that we want. First notice that at the beginning of each stanza a queue name has a colon, `:`, appended to the name of the queue. Because this

character occurs only in the queue name, we can use the colon character as a tag for a `grep` statement. Following the queue-name entry, the next two lines contain the data that we are interested in pertaining to the status of the queuing and printing.

Because we have some unique tag for each entry, it is easy to extract the lines of data that we are interested in by using an *extended* **grep**, or **egrep**, statement, as shown here:

```
lpc status all | egrep ':|printing|queueing' | while read LINE
```

The `egrep` command works the same way as the `grep` command, except that you can specify multiple patterns to match. Each pattern is separated by a pipe *without any spaces*! If you add spaces on either side of the search pattern, the `egrep` statement will fail to make a match. The entire list of patterns is then enclosed within single forward tic marks, `'pattern1|pattern2|pattern3'`. The output produced has the queue name on the first line, the printing status on the second line, and the queuing status on the third line.

The last part of the preceding command is where the output is piped to a `while` loop. On each `read` the entire line of data is loaded into the variable `LINE`. Inside of the `while` loop we use the following `case` statement to assign the data to the appropriate variable:

```
case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
esac
```

Notice that if `$LINE` begins with `*:` we load the `Q` variable. If `$LINE` begins with `printing*` we load the `PSTATUS` variable with the third field, which should be either enabled or disabled. We do the same thing in loading the `QSTATUS` variable with the third field of the value that the `$LINE` variable points to.

The trick in this script is how to load and process three lines of data and then load and process three more lines of data, and so on. The most intuitive approach is to have a loop counter. Each time the loop counter reaches three we process the data and reset the loop counter back to zero. Take a look at the entire script in Listing 25-4 to see how this loop count works. Pay close attention to the bold type.

```
#!/bin/ksh
#
# SCRIPT: print_UP_SYSV_AIX.ksh
#
```

Listing 25-4 print_UP_AIX.ksh shell script

```
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
# PLATFORM: AIX System V Printing
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue on AIX and Solaris systems.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################

LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queueing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
     if ((LOOP == 3))  # Do we have all three lines of data?
     then
          # Check printing status
          case $PSTATUS in
          disabled) lpc start $Q >/dev/null
                    (($? == 0)) && echo "\n$Q printing re-started\n"
                    ;;
          enabled|*) :  # No-Op - Do Nothing
                    ;;
          esac

          # Check queuing status
          case $QSTATUS in
          disabled) lpc enable $Q >/dev/null
```

Listing 25-4 (*continued*)

```
                    (($? == 0)) && echo "\n$Q queueing re-enabled\n"
                    ;;
            enabled|*) :  # No-Op - Do Nothing
                    ;;
            esac
            LOOP=0  # Reset the loop counter to zero
        fi
    done
```

Listing 25-4 (*continued*)

Notice that we grab three lines at a time. The reason that I say that we are grabbing three lines at a time is because I use the `case` statement to specify unique tags for each line of data. I know that the queue name will have a colon, `:`, as a suffix. I know that the printing-status line will begin with `printing*`, and I know that the queuing line will begin with `queueing*`. We load only one variable on each loop iteration. So, to get three pieces of data (queue name, printing status, and queuing status), we need to go through the `while` loop three times for each printer queue. Once we pass the initial `case` statement, we increment the `LOOP` counter by one. If the `$LOOP` variable is equal to `3` we have all of the data that we need to process a single printer queue. After processing the data for this printer queue, we reset the `LOOP` variable to zero, `0`, and start gathering data for the next printer queue.

Sound simple enough? This same technique works for any fixed set of lines of data in command output or in a file. The only changes that are needed to use this method include creating unique tags for the data you are interested in and setting the `$LOOP` equality statement to reflect the number of lines in each set of data.

More System V Printer Commands

We have been looking at only the `lpc` command thus far. We also need to look at two command parameters to the `lpstat` command in this section. The `-a` parameter lists the status of queuing, and the `-p` command parameter lists the status of printing. The nice thing about these two command options is that the output for each queue is on a single line, which makes the data easier to parse through. See Table 25-2.

Table 25-2 System V lpstat Command Options

COMMAND	DESCRIPTION
`lpstat -a`	Show status of queuing on all printers
`lpstat -p`	Show status of printing on all printers

Other than having to query the printer service twice, having to use separate commands for monitoring printing and queuing is not so bad. The separation is built in because the `-a` and `-p` command parameters are mutually exclusive, which means that you cannot use `-a` and `-p` at the same time. Output from each command option is shown in Listing 25-5.

```
# lpstat -a

hp4 accepting requests since May 07 07:02 2007
yogi_hp4_1ps accepting requests since May 07 07:02 2007
long_queue not accepting requests since Tue May  7 07:02:23 EDT 2007 -

s_q_nam not accepting requests since Tue May  7 07:02:23 EDT 2007 -

# lpstat -p

printer long_queue disabled since Tue May  7 07:02:01 EDT 2007.
available.
        stopped by user
printer s_q_nam disabled since Tue May  7 07:02:01 EDT 2007. available.
        stopped by user
printer hp4 unknown state. enabled since May 07 07:30 2007. available.
printer yogi_hp4_1ps unknown state. enabled since May 07 07:30 2007.
available.
```

Listing 25-5 lpstat -a and lpstat -p command output

Notice in Listing 25-5 that the output from each command option has a unique set of status information for each printer on each line of output. We want to use the uniqueness of the status information as tags in a `grep` statement. The terms make sense, too. A queue is either *accepting* new requests or is *not accepting* new requests, and a printer is either *enabled* for printing or is *disabled* from printing. Because we are interested only in the disabled and not-accepting states, we can create a simple script or a one-liner.

We need to know two things to enable printing and to bring up a print queue to accept new requests: the printer/queue name and the state of the queue or printer. The first step is to `grep` out the lines of output that contain our tag. The second step is to extract the printer/queue name from each line of output. Let's first look at using a `while` loop to bring everything up, as shown in Listing 25-6.

```
lpstat -a | grep 'not accepting' | while read LINE
do
     Q=$(echo $LINE | awk '{print $1}')
     lpc enable $Q
done

lpstat -p | grep disabled | while LINE
do
     P=$(echo $LINE | awk '{print $2}')
     lpc start $P
done
```

Listing 25-6 Scripting the lpstat command using -a and -p

Notice in Listing 25-6 that we have to work on the print queues and printers separately, by using two separate loops. In the first `while` loop all of the queuing is started. In the second loop we enable printing for each of the printers. The down side to this method occurs when you have hundreds of printers, and scanning through all of the printers twice can take quite a while. Of course, if you have hundreds of printers you should use `lpc up all` to bring everything up at once.

As I said before, we can also make a one-liner out of the two loops in Listing 25-6. We can combine the `grep` and `awk` commands on the same line and use command substitution to execute the `lpc` command. The following two commands replace the two `while` loops:

```
lpc enable $(lpstat -a | grep 'not accepting' | awk '{print $1}')

lpc start $(lpstat -p | grep disabled | awk '{print $2}')
```

The first command enables queuing, and the second command starts printing. The command substitution, specified by the `$(command)` notation, executes the appropriate `lpstat` command, then `grep`s on the tag and extracts the printer/queue name. The resulting output is used as the parameter to the `lpc` commands.

CUPS – Common UNIX Printing System

The following statement comes from `www.cups.org`:

> *''CUPS provides a portable printing layer for UNIX-based operating systems. It was developed by Easy Software Products and is now owned and maintained by Apple Inc. to promote a standard printing solution. It is the standard printing system in Mac OS X and most Linux distributions.*
>
> *CUPS uses the Internet Printing Protocol (''IPP'') as the basis for managing print jobs and queues and adds network printer browsing and PostScript Printer Description (''PPD'') based printing options to support real-world printing.''*

I use CUPS on my Fedora 7×64 system, `booboo`. If you are not familiar with CUPS printing, it would be a good idea to look at the manual at the URL shown here:

```
http://www.cups.org/doc-1.1/sum.html
```

The amount of control you have in printing a document in CUPS is amazing. The details of print options are beyond the scope of this book, so let's look at controlling printing and queuing.

Speaking of ''queuing,'' we must be careful scripting our solutions on different OS and printing systems because some spell the word ''queuing'' and AIX spells it ''queueing.''

CUPS uses the BSD command `lpc` to look at the queues' status, but controlling printing and queuing is done with the commands shown in Table 25-3.

We are interested in bringing the queues and printing up, so `accept` and `cupsenable` are the commands we use to start printing queued jobs, and to accept new print jobs for queuing. Now we just need to check the queue status and re-enable anything that is down.

Table 25-3 CUPS Commands Table

CUPS COMMANDS	COMMAND RESULT
`accept`	Starts printing jobs in the queue
`reject`	Stops printing jobs in the queue
`cupsenable`	Allows new print jobs to be queued
`cupsdisable`	Rejects new print-queue requests

A view of the print-queue status is shown in Listing 25-7.

```
[root@booboo scripts]# lpc status all
Cups-PDF:
        printer is on device 'cups-pdf' speed -1
        queuing is enabled
        printing is enabled
        no entries
        daemon present
hp4:
        printer is on device 'lpd' speed -1
        queuing is enabled
        printing is enabled
        no entries
        daemon present
```

Listing 25-7 Command output checking CUPS printing and queuing

The `lpc` BSD command implementation of CUPS does not allow for controlling either printing or queuing. Check out the script in Listing 25-8 to see how we re-enable CUPs printing and queuing.

```
#!/bin/ksh
#
# SCRIPT: print_UP_CUPS.ksh
#
# AUTHOR: Randy Michael
# DATE: 08/27/2007
# REV: 2.1.P
#
# PLATFORM: ANY RUNNING CUPS DAEMON
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue for CUPS printing.
```

Listing 25-8 print_UP_CUPS.ksh shell script

```
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################

LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queuing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queuing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
     if ((LOOP == 3))  # Do we have all three lines of data?
     then

          # Check printing status
          case $PSTATUS in
          disabled) cupsenable $Q >/dev/null
                    (($? == 0)) && echo -e "\n$Q printing re-started\n"
                    sleep 1
                    ;;
          enabled|*) :  # No-Op - Do Nothing
                    ;;
          esac

          # Check queuing status
          case $QSTATUS in
          disabled) accept $Q # >/dev/null
                    (($? == 0)) && echo -e "\n$Q queueing re-enabled\n"
                    ;;
          enabled|*) :  # No-Op - Do Nothing
                    ;;
          esac
```

Listing 25-8 (*continued*)

```
            LOOP=0  # Reset the loop counter to zero
        fi
    done
```

Listing 25-8 (*continued*)

This shell script is almost identical to the shell script in Listing 25-4. The only differences we have in Listing 25-8 are the commands that CUPS uses to control UNIX printing and queuing. We still use a `case` statement to select the desired action, or non-action when everything is already enabled.

The trick to using this technique is how we are processing only the first three lines of the output of the `lpc status all` command. We use the `egrep` statement on only select lines containing, as a group, a `:` (colon), or the words `printing*` and `queuing*`. If we find a printer or queue disabled, the script will run the `accept` and/or `cupsenable` commands.

HP-UX Print-Control Commands

Of the UNIX operating systems, HP-UX has a unique **lpstat** command output. We do not have to do anything special to see the full print-queue names, and if queuing is disabled or printing is stopped, we get a *Warning:* message. With a warning message for each printer on a single line we can use `grep` and `awk` to find the printer/queue name and the status in a `case` statement. Let's first look at the `lpstat` output when both printing and queuing is up, as shown here:

```
# lpstat

printer queue for hp4_yogi_1


printer queue for yogi_hp4_1ps
```

If print requests were queued up they would be listed below the queue name. Now let's `disable` printing on the `hp4_yogi_1` print queue:

```
# disable hp4_yogi_1

printer "hp4_yogi_1" now disabled
```

Now look at the output of the `lpstat` command:

```
# lpstat

printer queue for hp4_yogi_1
dino: Warning: hp4_yogi_1 is down


printer queue for yogi_hp4_1ps
```

The warning message tells us that the printer is down; however, notice that the queue status is not listed here. Now let's bring down the `hp4_yogi_1` print queue and see what this does:

```
# reject hp4_yogi_1

destination "hp4_yogi_1" will no longer accept requests
```

To see only queuing status we use the `lpstat -a` command, as shown here:

```
# lpstat -a

hp4_yogi_1 not accepting requests since Oct  1 05:45 -
        reason unknown
yogi_hp4_1ps accepting requests since Sep 26 04:23
```

Because `hp4_yogi_1` now has printing disabled and queuing stopped, I would expect that we should see some queue status output in the `lpstat` command output for the first time:

```
# lpstat

printer queue for hp4_yogi_1
dino: Warning: hp4_yogi_1 queue is turned off
dino: Warning: hp4_yogi_1 is down


printer queue for yogi_hp4_1ps
```

Just what we expected. From this little exercise we have determined that queuing is reported only when the queuing is stopped on the queue using the `lpstat` command alone. For our scripting effort let's stick to the `lpstat` output. We want to use the word `Warning` as a tag for our `grep` statement. Then we can further `grep` this extracted line to check printing and queuing status. If the string `'queue is turned off'` is present we know that queuing is turned off, and if the string `'is down'` appears on the line we know that printing is disabled. The only thing left to extract is the printer/queue name, which is always located in the third field.

To script this we can use the code in Listing 25-9. Pay attention to the bold type, and we will cover the script at the end.

```
#!/bin/ksh
#
# SCRIPT: print_UP_HP-UX.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
```

Listing 25-9 print_UP_HP-UX.ksh shell script

```
# PLATFORM: HP-UX Only
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue on an HP-UX system.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution

lpstat | grep Warning: | while read LINE
do
      if (echo $LINE | grep 'is down') > /dev/null
      then
           enable $(echo $LINE | awk '{print $3}')
      fi

      if (echo $LINE | grep 'queue is turned off') >/dev/null
      then
           accept $(echo $LINE | awk '{print $3}')
      fi
done
```

Listing 25-9 (*continued*)

I want to point out a nice little trick in the shell script in Listing 25-9. In both of the `if...then...fi` statements, notice that we execute a command inside parentheses. What this technique allows us to do is execute a command in a *sub-shell* and use the command's resulting return code directly in the `if...then...fi` structure. We really could not care less about seeing the line that we are grepping on; however, if the return code from the command is zero, the pattern is present.

In the first half of the script in Listing 25-9, we check the status of printing. If a printer is found to be disabled, we use command substitution to produce the printer name for the `enable` command. Likewise, we check for the status of queuing in the second half of the script. Again, using command substitution we have the queue name to provide as a parameter to the `accept` command. Notice that I added the redirection to the bit bucket, specified by `>/dev/null`, after the command in the `if` statement. I add this redirection to `/dev/null` to suppress the output of the `grep` statement.

That is it for HP-UX printing. HP did a good job of keeping everything pretty straightforward in the printing arena.

Linux Print-Control Commands

Linux uses either the System V **lpc** (line printer control) command to control the printers and print queues, or the Common UNIX Printer System (CUPS). For our scripts it does not matter which underlying printer subsystem is used because the Linux `lpc` command works the same as other System V UNIX printer subsystems do. The nice thing about this print service is that you can control the queues and

the printers independently. The main commands that we are interested in for Linux queuing and printing include the options to the `lpc` command listed in Table 25-4.

As you can see in Table 25-4, the granularity of printer control is excellent, which gives us several options when creating shell scripts. To control *all* of the printing and queuing at one time you really do not need a shell script. The following two commands can start and stop all printing and queuing on all print queues at the same time:

```
lpc down all      # Disable all printing and queuing

lpc up all        # Enable all printing and queuing
```

To keep all of the printers printing and queuing you need just the `lpc up all` command entered into a cron table. I placed an entry in my `root` cron table to execute this command every 10 minutes. My cron table entry is shown here:

```
5,15,25,35,45,55 * * * * /usr/sbin/lpc up all >/dev/null 2>&1
```

This cron table entry enables all printing and queuing on all printers on the 5s, 24 hours a day, 7 days a week.

If we do want a little more control and if we keep a log of what is going on on a per queue/printer basis, we have to do a little scripting. The script that follows searches all of the queues and reports on the individual status of printing and queuing and then enables each one independently.

For this script we are going to use *arrays* to load the variables on each loop iteration. Array can be created and elements assigned values in two ways. The first technique is to use **set -A** to define the array and all of its elements. For example, if we want an array called `QUEUE` to contain the values for printing and queuing for a specified queue, we can set it up this way:

```
PQueue=yogi_hp4
Print_val=enabled
Queue_val=disabled

set -A QUEUE $PQueue $Print_val $Queue_val
```

Table 25-4 Linux lpc Command Options

LPC COMMAND	COMMAND RESULT
`disable (printer[@host] | all)`	Disables queuing
`stop (printer[@host] | all)`	Disables printing
`down (printer[@host] | all)`	Disables printing and queuing
`enable (printer[@host] | all)`	Enables queuing
`start (printer[@host] | all)`	Enables printing
`up (printer[@host] | all)`	Enables printing and queuing

We could have assigned the values directly in the `set -A` statement, but this time we used variables for the assignments. This statement defines an array named `QUEUE` that contains three array elements. The elements loaded into the array are the values that the variables `$PQueue`, `$Print_val`, and `$Queue_val` point to. For example, `PQueue` is assigned the value `yogi_hp4`, `Print_val` is assigned the value `enabled`, and `Queue_val` is assigned the value `disabled`. The result is that the first array element, 0 (zero), contains the value `yogi_hp4`, the second array element, 1 (one), has the value `enabled`, and the third array element, 2 (two), contains the value `disabled`, which is what the `$Queue_val` variable points to. Using this technique requires that we access the array elements starting with 0, zero.

To address the array elements we use the following syntax:

```
${QUEUE[0]} # Points to value assigned to the first array element,
              yogi_hp4
${QUEUE[1]} # Points to value assigned to the second array element,
              enabled
${QUEUE[2]} # Points to the value assigned to the third array element,
              disabled
```

To address all of the array's elements at the same time we use the following syntax:

```
# print "${QUEUE[*]}"
     ----OR----
# print "${QUEUE[@]}"

yogi_hp4 enabled disabled
```

Now, before I lose you, let's take a look at a more intuitive way of working with arrays and array elements. Instead of using the `set -A` command to define and load an array, we can define an array and load its elements at the same time using the following syntax:

```
QUEUE[1]=yogi_hp4
QUEUE[2]=enabled
QUEUE[3]=disabled
```

Notice that the first array element is now referenced by 1, one. These commands create an array named `QUEUE` and load the first three array elements, referenced by 1, 2, and 3, into array `QUEUE`. Now we can use the array directly in a command statement by pointing to the array element that we want to use. For example, if we want to print the *printing* status of the `yogi_hp4` print queue, we use the following syntax:

```
echo "\nPrinter ${QUEUE[1]} has print status ${QUEUE[2]}\n"
```

This command produces the following output:

```
Printer yogi_hp4 has print status enabled
```

Now that we have seen the basics of working with arrays, let's look at a shell script to handle keeping the printing and queuing enabled on all of the printers individually. The first step is to load an array in a `while` loop. This is a little different from what we did before with arrays. In this case I want to use the `lpc status all` command to find printers that have either printing or queuing disabled. The output of the `lpc status all` command is shown here:

```
# lpc status all
 Printer           Printing Spooling Jobs  Server Subserver Redirect
Status/(Debug)
hp4@localhost      enabled  disabled    0    none    none
```

This is an easy output to deal with, because all of the data for each queue is on a single line. The output that we are interested in is the printer name, the printing status, and the spooling status — the first three fields on the second line. We are not interested in the first line at all so we can get rid of it with a pipe to the **tail** command. When we add to our command we get the following output:

```
# lpc status all | tail +2
yogi_hp4@localhost  enabled  disabled    0    none    none
```

I currently have only one printer defined on this system, so the output is the status of a single printer. Now we want to load the first three fields into an array using a `while` loop. Look at the next command line to see how we are directly loading an array called `pqstat` with array elements of the first three fields on each line:

```
lpc status all | tail +2 | while read pqstat[1] pqstat[2] pqstat[3] junk
```

Because we want just the first three fields in the output, notice that the fourth variable in the `read` part of the `while` statement is `junk`. The `junk` variable is a catchall variable to capture any remaining strings on the line of output in a single variable. It is a *requirement* that you take care of this remaining text because if you neglect adding a variable to catch any remaining characters on the line, you will `read` the characters in as strings on the next loop iteration! This type of error produces some strange output that is hard to find and troubleshoot.

Notice that in the output of the `lpc status all` command the printer has queuing disabled, which is the third field. The easiest way to handle the two status fields is to use two `case` statements, with each tagging on a separate field. Look at the full script code in Listing 25-10, and we will cover the technique at the end.

```
#!/bin/ksh
#
# SCRIPT: print_UP_Linux.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
```

Listing 25-10 print_UP_Linux.ksh shell script

```
# PLATFORM: Linux Only
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue on a Linux system. Logging can be
#          enabled.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################
# Initial Variables Here
################################################

LOGILE=/usr/local/log/PQlog.log
[ -f $LOGFILE ] || echo /dev/null > $LOGFILE

################################################

lpc status | tail +2 | while read pqstat[1] pqstat[2] pqstat[3] junk
do
     # First check the status of printing for each printer
     case ${pqstat[2]} in
     disabled)
             # Printing is disabled - print status and restart printing
             echo "${pqstat[1]} Printing is ${pqstat[2]}" \
                  | tee -a$LOGFILE
             lpc start ${pqstat[1]} | tee -a $LOGFILE
             (($? == 0)) && echo "${pqstat[1]} Printing Restarted" \
                             | tee -a $LOGFILE
             ;;
     enabled|*) : # No-Op - Do Nothing
             ;;
     esac
     # Next check the status of queueing for each printer
     case ${pqstat[3]} in
     disabled)
               echo "${pqstat[1]} Queueing is ${pqstat[3]}" \
                    | tee -a $LOGFILE
               lpc enable ${pqstat[1]} | tee -a $LOGFILE
               (($? == 0)) && echo "${pqstat[1]} Printing Restarted" \
                             | tee -a $LOGFILE
              ;;
     enabled|*) :   # No-Op - Do Nothing
             ;;
     esac
done
```

Listing 25-10 (*continued*)

We start off this script in Listing 25-10 by defining the `$LOGFILE`. Notice that the following command, after the log file definition, checks to see if the log file exists. If the `$LOGFILE` does not exist, the result of the test is a nonzero return code. We use a logical OR, specified by the double pipes, `||`, to execute the succeeding command to create a zero-length `$LOGFILE` because it does not exist if the return code of the test is nonzero.

Next, we start our `while` loop to load the `pqstat` array on each loop iteration, which in our case is a single loop iteration for a single printer. This means that we load a one-dimensional array with new data on each loop iteration (one-dimensional arrays are all that the shells support). Again, notice the `junk` variable that is added as the last variable in the `while` loop statement. This extra variable is required to catch the remaining text in a single variable.

With the array loaded we proceed with two `case` statements to test for the status of printing and queuing on each print queue. Notice that we use the array element directly in the `case` statement, as shown here:

```
case ${pqstat[2]} in
```

We use the same technique with the print-queuing array element in a separate `case` statement. We have only two possible results for the array elements: `enabled` and `disabled`. The only result we are concerned about is any `disabled` value. If we receive any `disabled` values we attempt to re-enable the printing or queuing on the printer. Notice that the second option in both `case` statements includes `enabled` and anything else, specified by the wildcard, `*`, as shown here:

```
enabled|*)
```

We could have just used the wildcard to cover everything, but it is clearer to the reader of the script to see actual expected results in a `case` statement than just a catchall asterisk.

When a re-enabling task is completed successfully, notice the use of the logical AND to test the return code and give notification on a zero return code value, as shown here:

```
(($? == 0)) && echo "${pqstat[1]} Printing Restarted"
```

The second part of the command will execute only if the test for a zero return code is true. Otherwise, the system will report an error, so there is no need for us to add any failure notification.

To see everything that is happening on the screen and to log everything at the same time we use the **tee -a** command. This command works with a pipe and prints all of the output to the screen; at the same time it sends the exact same output to the file specified after `tee -a`. An example is shown here:

```
lpc start ${pqstat[1]} | tee -a $LOGFILE
```

This command attempts to restart printing on the print queue specified by the array element `pqstat[1]` and sends any resulting output to the screen and to the `$LOGFILE` simultaneously.

Controlling Queuing and Printing Individually

Depending on the situation, you may not always want to enable printing and queuing at the same time. We can break up the shell script in Listing 25-10 and pull out the individual `case` statements to start either printing or queuing. Because printing is controlled by array element `2` we can extract the first `case` statement to create a new shell script. Let's call this shell script `printing_only_UP_Linux.ksh`. You can see the modifications in Listing 25-11.

```
#!/bin/ksh
#
# SCRIPT: printing_only_UP_Linux.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
# PLATFORM: Linux Only
#
# PURPOSE: This script is used to enable printing on each printer
#          on a Linux system. Logging is enabled.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################
# Initial Variables Here
################################################

LOGILE=/usr/local/log/PQlog.log
[ -f $LOGFILE ] || echo /dev/null > $LOGFILE

################################################

lpc status | tail +2 | while read pqstat[1] pqstat[2] pqstat[3] junk
do
     # Check the status of printing for each printer
     case ${pqstat[2]} in
     disabled)
               # Printing is disabled - print status and restart printing
               echo "${pqstat[1]} Printing is ${pqstat[2]}" \
                    | tee -a$LOGFILE
               lpc start ${pqstat[1]} | tee -a $LOGFILE
               (($? == 0)) && echo "${pqstat[1]} Printing Restarted" \
                              | tee -a $LOGFILE
```

Listing 25-11 printing_only_UP_Linux.ksh shell script

```
                ;;
        enabled|*) : # No-Op - Do Nothing
                ;;
        esac
done
```

Listing 25-11 (*continued*)

Notice that the only thing that was changed is that the second `case` statement structure was removed from the script and the name was changed. We can do the same thing to create a shell script that only enables queuing, as shown in Listing 25-12.

```
#!/bin/ksh
#
# SCRIPT: queuing_only_UP_Linux.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
# PLATFORM: Linux Only
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue on a Linux system. Logging can be
#          enabled.
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################
# Initial Variables Here
################################################

LOGILE=/usr/local/log/PQlog.log
[ -f $LOGFILE ] || echo /dev/null > $LOGFILE

################################################

lpc status | tail +2 | while read pqstat[1] pqstat[2] pqstat[3] junk
do
     # check the status of queueing for each printer
     case ${pqstat[3]} in
     disabled)
```

Listing 25-12 queuing_only_UP_Linux.ksh shell script

```
                echo "${pqstat[1]} Queueing is ${pqstat[3]}" \
                     | tee -a $LOGFILE
                lpc enable ${pqstat[1]} | tee -a $LOGFILE
                (($? == 0)) && echo "${pqstat[1]} Printing Restarted" \
                               | tee -a $LOGFILE
               ;;
     enabled|*) :   # No-Op - Do Nothing
               ;;
     esac
done
```

Listing 25-12 (*continued*)

Notice that the only thing that was changed this time is that the first `case` statement structure was removed from the script and the name of the shell script was changed. You could also modify the shell script in Listing 25-10 to add a command-line parameter to let you control queuing and printing individually from the same shell script. I am going to leave this as an exercise for you to complete.

NOTE **A hint for this exercise: expect only zero or one command-line parameters. If `$#` is equal to zero, then enable both queuing and printing. If there is one parameter and the value of `$1` is "all," then enable both printing and queuing. If the `$1` parameter is equal to "printing," then enable only printing. If `$1` is equal to "queuing," then enable only queuing. You need to add a `usage` function to show how to use the shell script if the given value does not match what you are expecting.**

Arrays are good to use in a lot of situations where you want to address certain output fields directly and randomly. All shell arrays are one-dimensional arrays, but using the array in a loop gives the *appearance* of a two-dimensional array.

Solaris Print-Control Commands

Solaris uses the System V **lpc** (line printer control) command to control the printers and print queues, as most System V UNIX systems do. The nice thing about this print service is that you can control the queues and the printers independently. The main commands that we are interested in for Solaris queuing and printing include the following options and parameters to the `lpc` command, as shown in Table 25-5.

As you can see in Table 25-5, the granularity of printer control is excellent, which gives several options when creating shell scripts. To control *all* of the printing and queuing at one time you really do not need a shell script. The following two commands can start and stop all printing and queuing on all print queues at the same time:

```
lpc down all      # Disable all printing and queuing

lpc up all        # Enable all printing and queuing
```

Table 25-5 Solaris lpc Command Options

LPC COMMAND	COMMAND RESULT
`disable (printer[@host] | all)`	Disables queuing
`stop (printer[@host] | all)`	Disables printing
`down (printer[@host] | all)`	Disables printing and queuing
`enable (printer[@host] | all)`	Enables queuing
`start (printer[@host] | all)`	Enables printing
`up (printer[@host] | all)`	Enables printing and queuing

To keep all of the printers printing and queuing you need only the `lpc up all` command entered into a cron table. I placed an entry in my `root` cron table to execute this command every 10 minutes. My cron table entry is shown here:

```
5,15,25,35,45,55 * * * * /usr/sbin/lpc up all >/dev/null 2>&1
```

This cron table entry enables all printing and queuing on all printers on the 5s, 24 hours a day, 7 days a week.

We have a nice situation here because we can use the same shell script that we used for the AIX System V printing on Solaris. Unlike Linux, where all of the data that we want is on a single line of output, with Solaris and AIX System V printing, the data we are interested in is separated on three lines of output. You can see the difference in the output here.

AIX System V output:

```
# lpc status all
hp4V:
        queueing is enabled
        printing is disabled
        5 entries in spool area
```

Linux System V output:

```
# lpc status
 Printer           Printing Spooling Jobs  Server Subserver Redirect
Status/(Debug)
hp4@localhost      enabled  disabled    0    none    none
```

Solaris System V output:

```
# lpc status all

bambam_hp4:
        queueing is enabled
```

```
        printing is enabled
        no entries
```

Of these three outputs, Linux is the one that differs. With the data we are interested in for Solaris residing on three separate lines for each print queue, we need a different strategy to get the exact data that we want. First notice that at the beginning of the stanza for the queue name there is a colon, `:`, appended to the name of the queue. Because this character occurs only in the queue name, we can use the colon character as a tag for a `grep` statement. Following the queue-name entry the next two lines contain the data pertaining to the status of the queuing and printing.

Because we have some unique tag for each entry, it is easy to extract the lines of data that we are interested in by using an *extended* **grep**, or **egrep**, statement, as shown here:

```
lpc status all | egrep ':|printing|queueing' | while read LINE
```

The `egrep` command works the same way as the `grep` command, except that you can specify multiple patterns to match. Each pattern is separated by a pipe *without any spaces*! If you add spaces on either side of the search pattern the `egrep` statement will fail to make a match. The entire list of patterns is then enclosed within single forward tic marks, `'pattern1|pattern2|pattern3'`. The output produced has the queue name on the first line, the printing status on the second line, and the queuing status on the third line.

The last part of the preceding command is where the output is piped to a `while` loop. On each `read`, the entire line of data is loaded into the variable `LINE`. Inside of the `while` loop we use the following `case` statement to assign the data to the appropriate variable:

```
case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
esac
```

Notice that if `$LINE` begins with `*:` we load the `Q` variable. If `$LINE` begins with `printing*` we load the `PSTATUS` variable with the third field, which should be either `enabled` or `disabled`. We do the same thing in loading the `QSTATUS` variable with the third field of the value that the `$LINE` variable points to.

The trick in this script is how to load and process three lines of data and then load and process three more lines of data, and so on. The most intuitive approach is to have a loop counter. Each time the loop counter reaches three we process the data and reset the loop counter back to zero. Take a look at the entire script in Listing 25-13 to see how this loop count works. Pay close attention to the bold type.

```
#!/bin/ksh
#
# SCRIPT: print_UP_Solaris.ksh
#
# AUTHOR: Randy Michael
# DATE: 03/14/2007
# REV: 1.1.P
#
# PLATFORM: Solaris Only
#
# PURPOSE: This script is used to enable printing and queuing separately
#          on each print queue on Solaris systems.
#
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
################################################

LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queueing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
     if ((LOOP == 3))  # Do we have all three lines of data?
     then
          # Check printing status
          case $PSTATUS in
          disabled) lpc start $Q >/dev/null
                    (($? == 0)) && echo "\n$Q printing re-started\n"
                    ;;
          enabled|*) :  # No-Op - Do Nothing
```

Listing 25-13 print_UP_SUN.ksh shell script

```
                ;;
        esac

        # Check queuing status
        case $QSTATUS in
        disabled) lpc enable $Q >/dev/null
                ((? == 0)) && echo "\n$Q queueing re-enabled\n"
                ;;
        enabled|*) :  # No-Op - Do Nothing
                ;;
        esac
        LOOP=0  # Reset the loop counter to zero
    fi
done
```

Listing 25-13 (*continued*)

Within this `while` loop we are grabbing three lines of data at a time to process. I say that we are grabbing three lines at a time in Listing 25-13 because I use the `case` statement to specify unique tags for each line of data. I know that the queue name will have a colon, `:`, as a suffix. I know that the printing status line will begin with `printing*`, and I know that the queuing line will begin with `queueing*`. We load only one variable on each loop iteration, though. To get three pieces of data (queue name, printing status, and queuing status), we need to go through the `while` loop three times for each printer queue. Once we pass the initial `case` statement, we increment the `LOOP` counter by one. If the `$LOOP` variable is equal to `3`, we have all the data that we need to process a single printer queue. After processing the data for this printer queue we reset the `LOOP` variable to zero, `0`, and start gathering data for the next printer queue.

Sound simple enough? This same technique works for any fixed set of lines of data in command output or in a file. The only changes that are needed to use this method include creating unique tags for the data you are interested in and setting the `$LOOP` equality statement to reflect the number of lines that are in each set of data.

More System V Printer Commands

We have been looking only at the `lpc` command thus far. We also need to look at two command parameters to the `lpstat` command in this section. The `-a` parameter lists the status of queuing, and the `-p` command parameter lists the status of printing. The nice thing about these two command options is that the output for each queue is on a single line, which makes the data easier to parse through. The `lpstat` command options are shown in Table 25-6.

Other than having to query the printer subsystem twice, having to use separate commands for monitoring printing and queuing is not so bad. The separation is built in because the `-a` and `-p` command parameters are mutually exclusive, which means that you cannot use `-a` and `-p` at the same time. Listing 25-14 shows the output from each command option.

Table 25-6 System V lpstat Command Options

COMMAND	DESCRIPTION
`lpstat -a`	Show status of queuing on all printers
`lpstat -p`	Show status of printing on all printers

```
# lpstat -a

hp4 accepting requests since May 07 07:02 2007
yogi_hp4_1ps accepting requests since May 07 07:02 2007
long_queue not accepting requests since Tue May  7 07:02:23 EDT 2007 -

s_q_nam not accepting requests since Tue May  7 07:02:23 EDT 2007 -

# lpstat -p

printer long_queue disabled since Tue May  7 07:02:01 EDT 2007.
available.
        stopped by user
printer s_q_nam disabled since Tue May  7 07:02:01 EDT 2007. available.
        stopped by user
printer hp4 unknown state. enabled since May 07 07:30 2007. available.
printer yogi_hp4_1ps unknown state. enabled since May 07 07:30 2007.
available.
```

Listing 25-14 lpstat -a and lpstat -p command output

Notice in Listing 25-14 that the output from each command option has a unique set of status information for each printer on each line of output. We want to use the uniqueness of the status information as tags in a `grep` statement. The terms make sense, too. A queue is either *accepting* new requests or *not accepting* new requests, and a printer is either *enabled* for printing or *disabled* from printing. Because we are interested in only the disabled and not-accepting states, we can create a simple script or a one-liner.

We need to know two things to enable printing and to bring up a print queue to accept new requests: the printer/queue name and the state of the queue or printer. The first step is to `grep` out the lines of output that contain our tag. The second step is to extract the printer/queue name from each line of output. Let's first look at using a `while` loop to bring everything up, as shown in Listing 25-15.

```
lpstat -a | grep 'not accepting' | while read LINE
do
     Q=$(echo $LINE | awk '{print $1}')
     lpc enable $Q
done
```

Listing 25-15 Scripting the lpstat command using -a and -p

```
lpstat -p | grep disabled | while LINE
do
     P=$(echo $LINE | awk '{print $2}')
     lpc start $P
done
```

Listing 25-15 (*continued*)

Notice in Listing 25-15 that we have to work on the print queues and printers separately, by using two separate loops. In the first `while` loop all of the queuing is started. In the second loop we enable printing for each of the printers. The down side to this method is where you have hundreds of printers. The time it takes to scan through all of the printers once and then rescan the printer service can be quite long. Of course, if you have hundreds of printers, you should use `lpc up all` to bring everything up at once.

As I said before, we can also make a one-liner out of the two loops in Listing 25-15. We can combine the `grep` and `awk` commands on the same line and use command substitution to execute the `lpc` command. The following two commands replace the two `while` loops:

```
lpc enable $(lpstat -a | grep 'not accepting' | awk '{print $1}')

lpc start $( lpstat -p | grep disabled | awk '{print $2}')
```

The first command enables queuing, and the second command starts printing. The command substitution, specified by the `$(command)` notation, executes the appropriate `lpstat` command, then `grep`s on the tag and extracts the printer/queue name. The resulting output is used as the parameter to the `lpc` commands.

Putting It All Together

Now we need to combine the shell scripts for each of the different UNIX flavors so that one script does it all. Please do not think that taking several shell scripts, making functions out of them, and combining the new functions into a new script are difficult tasks. To make one script out of this chapter we are going to take the best of our scripts and extract the code. For each shell script we make a new function, which requires only the word `function`, a function name, and the code block surrounded by curly braces, `function function_name { code stuff here }`. Let's take a look at the entire combined shell script in Listing 25-16 and cover the functions at the end.

```
#!/bin/ksh
#
# SCRIPT: PQ_UP_manager.ksh
#
# AUTHOR: Randy Michael
```

Listing 25-16 PQ_UP_manager.ksh shell script

```
# DATE: 08/14/2007
# REV: 2.1.P
#
# PLATFORM/SYSTEMS: AIX, CUPS, HP-UX, Linux, OpenBSD, and Solaris
#
# PURPOSE: This script is used to enable printing and queuing on
#          AIX, CUPS, HP-UX, Linux, OpenBDS, and Solaris
#
# REV LIST:
#
# set -x # Uncomment to debug this script
# set -n # Uncomment to check syntax without any execution
#
#####################################################
# DEFINE FUNCTIONS HERE
#####################################################

function AIX_classic_printing
{
for Q in $( enq -AW | tail +3 | grep DOWN | awk '{print $1}')
do
     enable $Q
     (( $? == 0 )) || echo "\n$Q print queue FAILED to enable.\n"
done
}

#########################################################

function AIX_SYSV_printing
{
LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queueing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
```

Listing 25-16 (*continued*)

```
      if ((LOOP == 3))  # Do we have all three lines of data?
      then
           # Check printing status
           case $PSTATUS in
           disabled) lpc start $Q  # >/dev/null
                     (($? == 0)) && echo "\n$Q printing re-started\n"
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac

           # Check queuing status
           case $QSTATUS in
           disabled) lpc enable $Q # >/dev/null
                     (($? == 0)) && echo "\n$Q queueing re-enabled\n"
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac
           LOOP=0  # Reset the loop counter to zero
     fi
done

}

#########################################################

function CUPS_printing
{
LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queuing' | while read LINE
do
      # Load three unique lines at a time
      case $LINE in
      *:) Q=$(echo $LINE | cut -d ':' -f1)
          ;;
      printing*)
          PSTATUS=$(echo $LINE | awk '{print $3}')
          ;;
      queuing*)
          QSTATUS=$(echo $LINE | awk '{print $3}')
          ;;
      esac

      # Increment the LOOP counter
      (( LOOP = LOOP + 1 ))
      if ((LOOP == 3))  # Do we have all three lines of data?
```

Listing 25-16 (*continued*)

```
      then

           # Check printing status
           case $PSTATUS in
           disabled) cupsenable $Q >/dev/null
                     (($? == 0)) && echo -e "\n$Q printing re-started\n"
                     sleep 1
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac

           # Check queuing status
           case $QSTATUS in
           disabled) accept $Q # >/dev/null
                     (($? == 0)) && echo -e "\n$Q queueing re-enabled\n"
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac

           LOOP=0  # Reset the loop counter to zero
     fi
done
}

#########################################################

function HP_UX_printing
{
lpstat | grep Warning: | while read LINE
do
      if (echo $LINE | grep 'is down') > /dev/null
      then
           enable $(echo $LINE | awk '{print $3}')
      fi

      if (echo $LINE | grep 'queue is turned off') >/dev/null
      then
           accept $(echo $LINE | awk '{print $3}')
      fi
done
}

#########################################################

function Linux_printing
{
```

Listing 25-16 (*continued*)

```
lpc status | tail -n +2 | while read pqstat[1] pqstat[2] pqstat[3] junk
do
     # First check the status of printing for each printer
     case ${pqstat[2]} in
     disabled)
               # Printing is disabled - print status and restart printing
                echo "${pqstat[1]} Printing is ${pqstat[2]}"
                lpc start ${pqstat[1]}
                (($? == 0)) && echo "${pqstat[1]} Printing Restarted"
              ;;
     enabled|*) : # No-Op - Do Nothing
              ;;
     esac
     # Next check the status of queueing for each printer
     case ${pqstat[3]} in
     disabled)
                echo "${pqstat[1]} Queueing is ${pqstat[3]}"
                lpc enable ${pqstat[1]}
                (($? == 0)) && echo "${pqstat[1]} Printing Restarted"
               ;;
     enabled|*) :   # No-Op - Do Nothing
              ;;
     esac
done
}

#########################################################

function OpenBSD_printing
{
LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queuing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queuing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
```

Listing 25-16 (*continued*)

```
      if ((LOOP == 3))  # Do we have all three lines of data?
      then
           # Check queuing status
           case $QSTATUS in
           disabled) lpc enable $Q >/dev/null
                     (($? == 0)) && echo "\n$Q queueing re-enabled\n"
                     sleep 1
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac

           # Check printing status
           case $PSTATUS in
           disabled) lpc up $Q >/dev/null
                     (($? == 0)) && echo "\n$Q printing re-started\n"
                     ;;
           enabled|*) :  # No-Op - Do Nothing
                     ;;
           esac
           LOOP=0  # Reset the loop counter to zero
     fi
done
}

#########################################################

function Solaris_printing
{
LOOP=0     # Loop Counter - To grab three lines at a time

lpc status all | egrep ':|printing|queueing' | while read LINE
do
     # Load three unique lines at a time
     case $LINE in
     *:) Q=$(echo $LINE | cut -d ':' -f1)
         ;;
     printing*)
         PSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     queueing*)
         QSTATUS=$(echo $LINE | awk '{print $3}')
         ;;
     esac

     # Increment the LOOP counter
     (( LOOP = LOOP + 1 ))
     if ((LOOP == 3))  # Do we have all three lines of data?
```

Listing 25-16 (*continued*)

```
     then
          # Check printing status
          case $PSTATUS in
          disabled) lpc start $Q >/dev/null
                    (($? == 0)) && echo "\n$Q printing re-started\n"
                    ;;
          enabled|*) :  # No-Op - Do Nothing
                    ;;
          esac

          # Check queuing status
          case $QSTATUS in
          disabled) lpc enable $Q >/dev/null
                    (($? == 0)) && echo "\n$Q queueing re-enabled\n"
                    ;;
          enabled|*) :  # No-Op - Do Nothing
                    ;;
          esac
          LOOP=0  # Reset the loop counter to zero
    fi
done
}

#########################################################
############### BEGINNING OF MAIN #######################
#########################################################

# Is CUPS Running?  If CUPS is running we can just
# run the CUPS standard commands.

ps auxw | grep -q [c]upsd
if (( $? == 0 ))
then
    CUPS_printing
    exit $?
fi

# What OS are we running?

# To start with we need to know the UNIX flavor.
# This case statement runs the uname command to
# determine the OS name. Different functions are
# used for each OS to restart printing and queuing.

case $(uname) in

AIX) # AIX okay...Which printer subsystem?
     # Starting with AIX 5L we support System V printing also!
```

Listing 25-16 (*continued*)

```
      # Check for an active qdaemon using the SRC lssrc command

      if (ps -ef | grep '/usr/sbin/qdaemon' | grep -v grep) \
          >/dev/null 2>&1
      then
            # Standard AIX printer subsystem found
            AIX_PSS=CLASSIC
      elif (ps -ef | grep '/usr/lib/lp/lpsched' | grep -v grep) \
            >/dev/null 2>&1
      then
            # AIX System V printer service is running
            AIX_PSS=SYSTEMV
      fi

      # Call the correct function for Classic AIX or SysV printing

      case $AIX_PSS in
      CLASSIC)  # Call the classic AIX printing function
                AIX_classic_printing
               ;;
      SYSTEMV)  # Call the AIX SysV printing function
                AIX_SYSV_printing
               ;;
      esac

       ;;
HP-UX)  # Call the HP-UX printing function
        HP_UX_printing

       ;;
Linux)  # Call the Linux printing function
        Linux_printing

       ;;
OpenBSD) # Call the OpenBSD printing function
         OpenBSD_printing

       ;;
SunOS)  # Call the Solaris printing function
        Solaris_printing

       ;;
*)      # Anything else is unsupported.
        echo "\nERROR: Unsupported Operating System: $(uname)\n"
        echo "\n\t\t...EXITING...\n"
       ;;
esac
```

Listing 25-16 (*continued*)

For each of the operating systems and, in the case of AIX, each printer service, we took the previously created shell scripts, extracted the code, and placed it between `function function_name {` and the function-ending character `}`. We now have the following functions:

```
AIX_classic_printing
AIX_SYSV_printing
CUPS_printing
HP_UX_printing
Linux_printing
OpenBSD_printing
Solaris_printing
```

To execute the correct function for a specific operating system, we need to know the UNIX flavor. The **uname** command returns the following output for each of our target operating systems:

OS	uname Output
AIX	AIX
HP-UX	HP-UX
Linux	Linux
OpenBSD	OpenBSD
Solaris	SunOS

With the exception of AIX, this information is all that is needed to execute the correct function. But with AIX we have to determine which printer service is running on the server. Both types of print services have a process controlling them, so we can `grep` for each of the processes using the `ps -ef` command to find the currently running printer service. When the classic AIX printer subsystem is running, there is a `/usr/sbin/qdaemon` process running. When the System V printer service is running, there is a `/usr/lib/lp/lpsched` process running. With this information we have everything needed to make a decision on the correct function to run.

We added at the end of the script all of the function execution control in the `case` statement that is shown in Listing 25-17.

```
case $(uname) in

AIX) # AIX okay...Which printer subsystem?
     # Starting with AIX 5L we support System V printing also!

     # Check for an active qdaemon using the SRC lssrc command

     if (ps -ef | grep '/usr/sbin/qdaemon' | grep -v grep) \
         >/dev/null 2>&1
     then
           # Standard AIX printer subsystem found
           AIX_PSS=CLASSIC
```

Listing 25-17 Controlling case statement listing to pick the OS

```
      elif (ps -ef | grep '/usr/lib/lp/lpsched' | grep -v grep) \
            >/dev/null 2>&1
      then
            # AIX System V printer service is running
            AIX_PSS=SYSTEMV
      fi

      # Call the correct function for Classic AIX or SysV printing

      case $AIX_PSS in
      CLASSIC)  # Call the classic AIX printing function
                AIX_classic_printing
               ;;
      SYSTEMV)  # Call the AIX SysV printing function
                AIX_SYSV_printing
               ;;
      esac

       ;;
HP-UX)  # Call the HP-UX printing function
        HP_UX_printing

       ;;
Linux)  # Call the Linux printing function
        Linux_printing

       ;;
OpenBSD) # Call the OpenBSD printing function
         OpenBSD_printing

       ;;
SunOS)  # Call the Solaris printing function
        Solaris_printing

       ;;
*)      # Anything else is unsupported.
        echo "\nERROR: Unsupported Operating System: $(uname)\n"
        echo "\n\t\t...EXITING...\n"
       ;;
esac
```

Listing 25-17 (*continued*)

I hope by now that the code in the `case` statement is intuitively obvious to read and understand. If not, the first line of the `case` block of code is the `uname` command. At this point we know what the OS flavor is. For HP-UX, Linux, OpenBSD, and Solaris we execute the target OS printing function. For AIX we make an additional test to figure out which one of the supported printing services is running. The two options are System V and the Classic AIX printer subsystem.

Notice that I removed all of the logging functionality from the functions. With this type of setup, where you have the functions doing the work, you can move the logging out to the main body of the shell script. This means that you can capture all of the output data of the function to save to a log file, use the **tee** command to view the data while logging at the same time, or just point it to the bit bucket by redirection to `/dev/null`.

Other Options to Consider

As usual, we can always improve on a shell script, and these shell scripts are no exception. Some options that you may want to consider are listed next.

Logging

You may want to add logging with date/time stamps. If you are having a lot of trouble keeping certain print queues up, studying the log may give you a trend that can help you find the cause of the problem. Some queues may drop in a particular location more than others. This can indicate network problems to the site. Any time you start logging do not forget to keep an eye on the log files! I often see that a script is added to a production machine, and the next thing you know, the log file has grown so large that it has filled up the filesystem. Don't forget to prune the log files. Trimming the log files is another little shell script for you to write. *Hint: tail command*.

Exceptions Capability

In a lot of shops you do not want to enable every single printer and print queue. In this case you can create an *exceptions* file, which contains the queue/printer names that you want to exclude from enabling. You also may have special considerations if your shop uses specific forms at different times on some of the *floating* printers. Some shops are just print-queue hell! Having the capability to keep the majority of the printers active all of the time and exclude a few is a nice thing to have.

Maintenance

During maintenance windows and other times when you want to stop all printing, you may want to comment out any cron table entries that are executing the enabling scripts. You usually find this out after the fact.

Scheduling

I keep a script running 24×7 to keep all of the printers available. You may want to tailor the monitoring scheduling to fit business hours (my requirement is 24×7). Users' loading up on print jobs during the middle of the day is always a problem, so we try to hold big jobs for times of low activity. Low-activity times are the times when you want to be at home, so make sure you are keeping the printers printing during these hours, or the next morning you will have the same problem.

Summary

In this chapter we covered some unique techniques to handle the data from command output. In many scripts we used arrays to hold the data as array elements. In other cases we read in a line at a time and used tags to grab the data we needed. We learned how to process a specific number of lines of data in groups by using a loop counter within a `while` loop.

The techniques in this chapter are varied, but the solutions are readable and can be easily maintained. Someone will follow in your footsteps and try to figure out what you did when you wrote the shell script. Do not play the ''job security'' game because you are you own worst enemy when it comes to documenting your shell scripts. If you comment when you write the script and make a note in the `REV` section when you edit it, you will have a long, happy life using your shell script.

In the next chapter we are going to move into the world of the government-induced audits you will have to endure if you are working at a ''public'' company, SOX! What's SOX, you ask? Keep reading to find out about your worst nightmare coming to a cubicle near you.

Lab Assignments

1. Using the techniques from Chapter 17, ''Filesystem Monitoring,'' modify the `PQ_UP_manager.ksh` script to allow *exceptions*. Sometimes we do not want to enable all of the printers or queues when we do printer maintenance and when a printer is not working. Hint: see Listing 17-14 and Listing 17-15.
2. Rewrite the `PQ_UP_manager.ksh` shell script in Listing 25-16 to log all printer and print queue ''down'' events with a date/time stamp. The new log file should reside in the `/usr/local/log/` directory.
3. Write a new Bash shell script that will ''prune'' the log file to the last 3000 lines of data. Name this new script `prune_printer_log.bash`. Schedule the `prune_printer_log.bash` shell script to execute every day at 12:00 midnight using a cron table entry.

CHAPTER 26

Those Pesky Sarbanes-Oxley (SOX) Audits

If you work for any publicly traded company registered with the United States Securities and Exchange Commission (SEC), you have either already had an IT audit, or you are preparing for an upcoming IT audit. You can thank the Sarbanes-Oxley (SOX) act of 2002 for this extra headache. The SOX act was a result of the corporate financial scandals of Enron and the like. The purpose of SOX is to require the chief executive officer (CEO) and the chief financial officer (CFO) of all publicly traded companies to personally validate the accuracy of its financial records, and to ensure there are internal controls in place to protect all financial data. That last part is where all the IT staff entered the picture. You have probably noticed that the system change-request process has become burdensome with all the detailed plans for any system change and the back-out plans if something goes wrong. This is a good thing to do, but some organizations have gone overboard with the amount of detail required. As Systems Administrators, it falls on us to try to make sense of the new rules and to comply with the auditors. I am not going to cover the law, but rather tactics for UNIX Administrators to be prepared for an audit. Just remember that we are not the only department that will have to pass the audits. The Mainframe Team, the DBA Team, the Win-Tel Team, and the Network Team also have to pass the audits. So, be prepared to work with all these teams as the audit date approaches.

In this chapter, I am going to walk you through a typical audit of the UNIX machines in your landscape and give you some hints on making the process easy. Most people who have to work with the auditors hate spending time answering the same questions over and over again. Well, think about it; the auditors have their ''script'' to go by. This is not a shell script, but a set of criteria that they want to verify for a select set of UNIX machines. They want to look at the `/etc/passwd` and `/etc/shadow` files. Here they want to make sure that everyone has a password. They want to ensure that all non-essential network services are turned off. They want `telnet`, `ftp`, `rsh`, `rcp`, and all other non-encrypted communications disabled and their Open Secure Shell counterparts used instead. So, as you can see, because the questions they ask are pretty

limited in scope, you get asked the same questions by all of the different auditors. This makes the audit process a bit more predictable.

What to Expect

You will either be in a staff meeting or get an email one day talking about the upcoming audit. This will make every manager turn into a yes-man/yes-woman to any request upper management makes to get ready for this audit. It is upper management's butt that is on the line and everything runs downhill from there. There will be a lot of pressure and this audit will be granted emergency status, and you may even open up the ''war room.'' You may be thinking that I'm making this up, but I'm not! This is serious stuff and they do not want to fail an audit; ''Failure is Not an Option!''

The first audit is an internal audit. A different auditing firm will perform the internal audit that the ''real'' audit uses. Oh yes, there is more than one auditor to deal with. Internal auditors are on your side, so to speak. They will scan some systems and want to sit down with a Systems Administrator and query a representative set of machines. They will want printouts of the query outputs and other data. Just expect it. The auditors will analyze the data and let you know where the systems are not compliant. You go back and fix the issues raised in the first round of audits, and then they scan the machines again to ensure the issues are corrected.

After you go through all that, the real auditors arrive on site. They will want to run some system scans and sit down with a Systems Administrator to query a representative set of machines to ensure they are compliant. Sound familiar? They ask the same questions that the first set of auditors asked. You just repeat the same process again, and you should pass the audit with flying colors.

How to Work with the Auditors

If you are the lucky soul who ''gets to'' work with the auditors, I have a simple way to start the automation process for the audits. You and the auditors sit at your terminal. Ask the auditors which machine they want to see first. Log in to that server and get `root` access. You will need `root` access to complete an audit. When you get logged in, create a directory somewhere called ''`auditstuff`''. I sometimes use `/tmp/auditstuff`. Then we just create a script session, so we log and save every step as we audit this first machine:

```
script  /tmp/auditstuff/audit-hostname.log
```

Once you start the `script` session, ask the auditors what they want to see. Then just show them anything they want to look at. When finished with that machine, press Ctrl+D to exit the `script` session, which saves the `/tmp/auditstuff/audit-hostname.log` file. Now that we know what they want to see, we can just make a copy of the script file and edit it to extract all the commands we used to answer the audit questions, and now we have a shell script to do the system queries for us. Now you can just copy this new script, maybe named `/tmp/auditstuff/sys-audit.sh`, to the other machines and execute it, saving the data in a log file for the auditors to review.

It may not be as quick as that, because when you find out what the auditors want to look at, you need to make your queries more precise. Then you can make the output in more of a report form by parsing through the data. You definitely need to brush up on the **find** command, because you're going to have to search the system for different sets of files. Files include those with the sticky bit set, world-writable files, and many others. You're also going to need to parse out the data of interest from some queries, so also brush up on `awk`, `sed`, `cut`, and the various looping-control structures.

What the Auditors Want to See

The full scope of a SOX audit encompasses the entire network infrastructure, but we are limiting our discussion to the UNIX environment and auditing specific UNIX machines. To pass a SOX audit, there is a basic set of criteria that must be met at the machine level. Some of these include file and directory permissions to system-critical and system-configuration files, world-writable files, all non-encrypted communications must be disabled, and all user accounts have a password and that password expires on a periodic basis. The following is a broader list of system-specific tasks to harden a system to pass a SOX audit:

- Disable remote login for all service or application accounts, such as `root`, `oracle`, and `dbadm`. Users must log in with their personal account and then switch-user (`su`) to the service account.
- All user accounts must have a password.
- All users' passwords must expire on a regular basis (although there are always exceptions for service and application system accounts).
- Ensure that passwords are of a minimum length, and are a mix of alphanumeric and special characters.
- Disable all accounts that have not been accessed in 30 days.
- Remove or disable all unused default system and application accounts, such as `uucp`.
- Review all user accounts that are a member of any administrative group (`system`, `root`, and so on). Each user assigned to a service group will need to be verified and documented.
- Disable `telnet`, `ftp`, `rsh`, `remsh`, `rlogin`, `rstatd`, `tftpd`, `talkd`, `bootps`, `fingerd`, `uucp` and any other non-encrypted communications.
- Install the latest version of Secure Shell and use `ssh` in place of `telnet` and `rsh`, use `scp` in place of `rcp`, and use `sftp` in place of `ftp`. You can download OpenSSH at `www.openssh.org`.
- Ensure that the file permissions to all system-critical and system-configuration files and directories are set correctly. Files and directories include `/etc/passed`, `/etc/shadow`, `/etc/security/passwd` (AIX), `/etc/hosts`, `/etc/services`, `/etc`, `/usr/sbin`, `/opt`, `/etc/security`, and `/usr/lib`. There are many more, and every UNIX flavor has a different set of files and directories.

- Ensure that all UNIX servers have the latest operating system patches and release, if possible. This is always a hard one, and you really have to work with the business unit that owns the applications to work in a maintenance window for patches and upgrades. You really need the latest patches because most likely the auditors will also probe network ports looking for vulnerabilities.
- You should have a documented plan for scheduled upgrades and patches for both the operating system and applications.
- You may have a requirement to install Tripwire to send alerts when critical system files are modified.
- You may have a requirement to set up a central audit server to hold all of the UNIX system's `syslog` files.
- Search the system for all files that have the sticky bit set, allowing users extended privileges.

This list should give you a pretty good idea about the topics the auditors will look at.

Some Handy Commands

You need to get familiar with a set of commands that will make your life easier when dealing with auditor questions. Most commands you use weekly, but you might not see some of the extra command switches to limit data output.

Using the id Command

Because we started with user access to the system, let's start with the **id** command. The `id` command can tell us about various aspects of a user-account definition. We can list the group memberships, both real and effective, GID, group name, and UID. The little script in Listing 26-1 queries the `/etc/passwd` file and lists the group membership of each user account.

```
#!/bin/Bash
#
# SCRIPT: search_group_id.Bash
# AUTHOR: Randy Michael
# DATE: 14/4/2007
# REV: 1.0
# PURPOSE: This script is used to list the group(s) associated
#      with each user defined in the /etc/passwd file.
#
#
##########################################
# DECLARE FILES AND VARIABLES HERE
##########################################
```

Listing 26-1 search_group_id.Bash shell script

```
case $(uname) in
SunOS) alias awk=nawk
             ;;
esac

########################################
# BEGINNING OF MAIN
########################################

cat /etc/passwd | awk -F : '{print $1}' | while read ID
do
   echo -e "${ID}: \c"
   id -gn $ID
done
```

Listing 26-1 (*continued*)

NOTE **Solaris does not support `awk -F :`. For Solaris we must use `nawk` (new `awk`). This `case` statement will alias `awk` to `nawk` if the UNIX flavor is SunOS:**

```
case $(uname) in
SunOS) alias awk=nawk
             ;;
esac
```

Notice in Listing 26-1 that we specify the `:` (colon) character as a field separator with the syntax `awk -F :`. This allows us to use `'{print $1}'` to extract the username as the first field of every line in the `/etc/passwd` file. With this output listing the usernames, we pipe this data to a `while read ID` loop. Then for each `$ID`, we `echo` the username to the screen, continuing on the same line specified by `echo -e ''${ID}\c''`. The `-e` switch on the `echo` command enables the backslash operator `\c` in Bash shell. Then we use the `id` command with the `-g` and `-n` switches. This syntax tells the `id` command to limit output to the group *name*, as opposed to the group ID (GID) number.

Using the find Command

Next let's look at the `find` command, one of the most powerful commands on any UNIX system. You can search a system for any type of file, including files, directories, links, sockets, block special files, character special files, and many others. You can search the system for files that are world-readable, world-writable, files with the sticky bit set, as well as perform an action on each file found. For example, you might want to find all the files modified in the past seven days to back up to tape:

```
find . -mtime -7 | xargs tar -cvf /dev/rmt0
```

This `find` command will search for files modified within the past seven days, starting in the current directory and then searching all subdirectories. This output is piped to `xargs`, which adds the previous output as arguments to the `tar` command.

The `find` command can also search for files that have the sticky bit set by using the `-perm -1000 -type f` command switches:

```
find / -perm -1000 -type f
```

This `find` command searches the entire system, starting in the root directory, for files of type file that have minimum permissions of the sticky bit set.

To `find` all files on the system that are world-writable, use the following `find` command syntax:

```
find / -perm -2 -exec ls -l {} \;
```

This `find` command searches the entire system, beginning in the root directory, for any type of file (including directories) that is world-writable. For each file found, the `-exec` switch specifies to perform a long listing. Notice that we ended the `-exec` switch option with a blank space followed by a backslash-semicolon, `\;`. This is a requirement to terminate the `-exec` switch option.

To `find` all the `.rhosts` files on the system and show the contents of each file, use the following syntax:

```
find / -name .rhosts -print -exec cat {} \;
```

This `find` command searches the entire system, beginning in the root directory, for any file named `.rhosts`. For each file found, the `-exec` switch lists the filename followed by the contents of each file. Again, notice that we ended the `-exec` switch option with a blank space followed by a backslash-semicolon, `\;`. This is a requirement to terminate the `-exec` switch option.

Using the awk and cut Commands

We can parse fields out of data by using the `awk` and `cut` commands. Both of these commands work on rows, or lines of data. The `cut` command can also cut out specific characters in a line of data by specifying the specific character placement range in the string.

To extract the first field of data from an entire file using the `awk` command, we use the following syntax:

```
awk '{print $1}'  filename
```

or

```
cat filename | awk '{print $1}'
```

Both of these commands will display the entire file while limiting the output to the first field of each line in the file, using a space for the field delimiter. As an example, we want to extract all the IP addresses from the `/etc/hosts` file. Because the IP address is the first field in the `/etc/hosts` file, the following command will work:

```
awk '{print $1}' /etc/hosts
```

The original `/etc/hosts` file is shown in Listing 26-2.

```
# Do not remove the following line, or various programs
# that require network functionality will fail.
127.0.0.1     localhost.localdomain localhost
::1           localhost6.localdomain6 localhost6
192.168.1.100 yogi   # AIX
192.168.1.102 booboo # Linux
192.168.1.103 fred   # OpenBSD
```

Listing 26-2 /etc/hosts file

If we run the previous `awk` statement, we get the following output:

```
# awk '{print $1}' /etc/hosts
#
#
127.0.0.1
::1
192.168.1.100
192.168.1.102
192.168.1.103
```

If we want to extract more than one field of data, we add the desired positional parameter, separating each field with a comma (`,`) and a space, if we want the field separated. If we want both strings concatenated together, we leave out the space, as shown here:

```
awk '{print $1,$2}' /etc/hosts
```

To extract the IP address and hostname fields, `$1`, and `$2`, respectively, while leaving white space between the values, we can use either of the following commands:

```
awk '{print $1, $2}' /etc/hosts
```

or

```
cat /etc/hosts | awk '{print $1, $2}'
```

The resulting output of this `awk` statement is shown here:

```
# awk '{print $1, $2}' /etc/hosts
# Do
# that
127.0.0.1 localhost.localdomain
::1 localhost6.localdomain6
192.168.1.100 yogi
```

```
192.168.1.102 booboo
192.168.1.103 fred
```

We still have a little extra output we are not interested in. We can omit the comment lines, those beginning with a hash mark (#), by adding a pipe `grep -v '^#'` to the end of the previous command statement. The caret (^) specifies *begins with*, so this `grep` statement matches any line of data that begins with a hash mark (#). The `-v` switch tells `grep` to show everything *except* what `grep` pattern matched on, thus deleting the unwanted comment lines. The result of this command is shown here:

```
# awk '{print $1, $2}' /etc/hosts | grep -v '^#'
127.0.0.1 localhost.localdomain
::1 localhost6.localdomain6
192.168.1.100 yogi
192.168.1.102 booboo
192.168.1.103 fred
```

This is better, but we still have the loopback address, 127.0.0.1, and an entry for IPv6 protocol (::1) that we are not interested in. To remove these, we add a second pipe to `egrep -v '127.0.0.1|::1'` (extended `grep`) to the statement to match multiple patterns. The result of this addition is shown here:

```
# awk '{print $1, $2}' /etc/hosts | grep -v '^#' | egrep -v '127.0.0.1|::1'


192.168.1.100 yogi
192.168.1.102 booboo
192.168.1.103 fred
```

Now we have only the IP addresses and hostnames listed without the unwanted data.

The `cut` command can also be used to extract one or more fields of data. For example, to cut the IP address from the `/etc/hosts` file, we use either of the following commands:

```
# cut -f1 /etc/hosts
#
#
127.0.0.1
::1
192.168.1.100
192.168.1.102
192.168.1.103
```

or

```
# cat /etc/hosts | cut -f1
#
#
127.0.0.1
::1
192.168.1.100
```

```
192.168.1.102
192.168.1.103
```

However, some Linux distributions require us to specify the field separator for the `cut` command even if it is white space. To specify the field delimiter, we add `-d` followed by the field delimiter character, as follows:

```
# cut -d ' ' -f1 /etc/hosts
#
#
127.0.0.1
::1
192.168.1.100
192.168.1.102
192.168.1.103
```

The previous example specifies a blank space as the field delimiter. We can also extract multiple fields with the `cut` command by adding the additional field numbers separated by a comma (`,`), but *no space*. The following `cut` command extracts the first and second fields from the `/etc/hosts` file:

```
[root@booboo scripts]# cut -d ' ' -f1,2 /etc/hosts
# Do
# that
127.0.0.1       localhost.localdomain localhost
::1             localhost6.localdomain6 localhost6
192.168.1.100 yogi
192.168.1.102 booboo
192.168.1.103 fred
```

We can again strip out the unwanted lines of data with a single `egrep` statement, `egrep -v '^#|127.0.0.1|::1'`, as shown here:

```
# cut -d ' ' -f1,2 /etc/hosts | egrep -v '^#|127.0.0.1|::1'
192.168.1.100 yogi
192.168.1.102 booboo
192.168.1.103 fred
```

Now let's look at parsing through the `/etc/passwd` file. The `/etc/passwd` file is a field-delimited file with the colon (`:`) character being the field delimiter, as shown here:

```
root:x:0:0:root:/root:/bin/Bash
bin:x:1:1:bin:/bin:/sbin/nologin
daemon:x:2:2:daemon:/sbin:/sbin/nologin
adm:x:3:4:adm:/var/adm:/sbin/nologin
lp:x:4:7:lp:/var/spool/lpd:/sbin/nologin
oracle:x:205:205::/home/oracle:/bin/Bash
sterling:x:513:514::/usr2/sterling:/bin/Bash
kingjon:x:0:0::/home/knudsepe:/bin/Bash
```

This is part of a Linux `/etc/passwd` file. Let's look at an example of looking for all users in the `/etc/passwd` file who are members of the system, or root, group. The group ID (GID) is located in the third field on each line of the file, and the system/root groups are specified by the number 0. The example shown here uses an `awk` statement to extract the first and third fields, and then we check to see if the GID is equal to 0. If so, we display a warning to the user. This time we need to tell `awk` what to use for a field delimiter by specifying `awk -F :` to declare a colon (`:`) as a field delimiter, overriding the `awk` command default of white space.

NOTE The Solaris implementation of `awk` does not support declaring a field separator with `awk -F :`. For Solaris, use `nawk` (new `awk`) instead. You can add the following `case` statement in the variable declaration of the section to correct this problem:

```
case $(uname) in
SunOS) alias awk=nawk
             ;;
esac
```

This `case` statement will `alias awk` to `nawk` if the UNIX flavor is Solaris, specified by `SunOS`.

Take a look at the `chk_passwd_gid_0.Bash` script shown in Listing 26-3, and we will look at the details at the end.

```
#!/bin/Bash
#
# SCRIPT: chk_passwd_gid_0.Bash
#
# PURPOSE: This script searches the /etc/passwd
#     for all non-root users who are a member of
#     the system/root group, GID=0
#
##########################################
# DECLARE FILES AND VARIABLES HERE
##########################################

case $(uname) in
SunOS) alias awk=nawk
             ;;
esac

##########################################
# BEGINNING OF MAIN
##########################################

awk -F ':' '{print $1, $3}' /etc/passwd | while read U G
```

Listing 26-3 chk_passwd_gid_0.Bash shell script

```
do
   # If the user is root skip the test
   if [ $U != 'root' ]
   then
       # Test for GID=0
       if (( G == 0 ))
       then
           echo "WARNING: $U is a member of the root/system group"
       fi
   fi
done
```

Listing 26-3 (*continued*)

This `chk_passwd_gid_0.Bash` shell script in Listing 26-3 begins with an `awk` statement to extract data fields `$1` and `$3`, and then sends this output to a `while read U G` loop. Next we test to see if the user ID for each line of data read in is the `root` user. If `root`, we skip the test because `root` is supposed to be part of the system/root group. Otherwise, we test to see if the GID captured from the data field is 0. If so, we display a warning message to the user and continue looping. The result of running this script with one user being a member of the system/root group is shown here:

```
# ./passwd_file_test.Bash
WARNING: kingjon is a member of the root/system group
```

If we tried to use the `cut` command for this task, it would not work as well because the `cut` command displays the field separator along with the data if more than one field of data is extracted, as shown here:

```
cut -d ':' -f1,3 /etc/passwd
root:0
bin:1
daemon:2
adm:3
lp:4
oracle:205
sterling:513
kingjon:0
```

If we had piped this `cut` command output to a `while read U G` loop, as we did with the `awk` statement, it would fail. To make it work, we would have to pipe it to a `sed` command and substitute a blank space for each colon (`:`). Extracting a single field using `cut` will result in only the data, without an additional field separator, being displayed, but multi-field extractions using the `cut` command will include the field separator in the output.

So, depending on what we are doing, sometimes we want to use `awk` and sometimes `cut` is better. Just be aware that each has its limitations.

Using the sed Command

Now let's look at `sed`. The `sed` program is a stream editor that we use for character substitution in a file, or other output data string. Use the following syntax to substitute data with `sed`:

```
sed s/'current_string'/'new_string'/g filename
```

or

```
cat filename | sed s/'current_string'/'new_string'/g
```

Both commands will display the entire file with every occurrence of `current_string` replaced with `new_string`. In the `sed` part of the statement, the `s` specifies substitute, and the `g` tells `sed` to do a global substitution.

As an example, suppose we have a file named `fruit.txt` that contains the following data:

```
apple
orange
peach
banana
pineapple
grape
bluebarry
blackbarry
```

Notice that the last two entries are spelled incorrectly. We can use a `sed` statement to substitute the correct spelling for "`berry`", which is misspelled "`barry`", as shown here:

```
# sed s/barry/berry/g fruit
apple
orange
peach
banana
pineapple
grape
blueberry
blackberry
```

That fixed the problem. We can also `cat` the file and pipe the output to `sed`, as shown here:

```
# cat fruit | sed s/barry/berry/g
apple
orange
peach
banana
pineapple
grape
```

```
blueberry
blackberry
```

We can also use `sed` to delete all the blank lines in a file using the following syntax:

```
sed /^$/d filename
```

or

```
cat filename | sed /^$/d
```

This should be intuitively obvious. If the caret (^) means *begins with*, and a dollar sign ($) means *ends with*, we are saying *if it begins with the end of line, delete it*. The trailing `/d` in the `sed` statement means delete.

We can do the same thing with a command using the following syntax:

```
some_command | sed /^$/d
```

If you want to save the output, redirect it to a file with either > to create a new file or overwrite an existing file, or >> to create a new file or append text to the end of an existing file. We can also pipe the output to `tee -a outputfile` to both display the output to the screen and append the output to the *outputfile* at the same time, as shown here:

```
some_command | sed /^$/d | tee -a outputfile
```

This command will create the *outputfile* if it does not already exist, and will append it to an already existing file.

Using the dirname and basename Commands

When we need to separate a fully qualified filename into the directory path and the filename, we can use the **dirname** and **basename** commands, respectively. Both commands require a single command-line argument.

The `dirname` command will return the directory part of a full-path filename, as follows:

```
# dirname /usr/local/bin/somescript.Bash
/usr/local/bin
```

The `basename` command will return the filename part of a full-path filename, as shown here:

```
# basename /usr/local/bin/somescript.Bash
somescript.Bash
```

These are handy tools for a lot of scripts. We have seen throughout this book a technique to capture the name of an executing shell script, or function, using the following command:

```
basename $0
```

This `basename` command will return the name of the shell script, if executed in the main body of the shell script, or the name of the function, if executed inside a function from within a shell script. In many shell scripts we capture the name of the shell script in the variable declaration section of the shell script using the following variable assignment in association with command substitution, as shown here:

```
THIS_SCRIPT=$(basename $0)
```

The `$( )` specifies command substitution. Enclosing a command in back tics, `` `command` ``, is also a method of command substitution. The result of the `basename $0` command is assigned to the variable `THIS_SCRIPT`. We can do the same thing with a function with this variable assignment in association with command substitution:

```
THIS_FUNCTION=$(basename $0)
```

Same command, but the scope is different depending on where the variable assignment is made. These are also handy tools when writing scripts to create reports.

Other Things to Consider

As you get into the audit process, you will have a better idea of what your particular auditor wants to see. The `find` command will quickly become your friend, so study the `find` manual page, **man find.** There are so many options to the `find` command that it may take you several days to play with them all.

For everything an auditor wants to see you can write a shell script to query the system to extract the desired data. The trick is to limit and parse the output to get the desired data in a usable format. This is where `awk`, `sed`, and `cut` help you out. Once you have the scripts set up, you can have anybody, well just about anybody, run the scripts for you. Then you can get back to some real work.

Summary

I added this chapter at the request of several Systems Administrators I have worked with over the past few years. I was always the lucky soul who ''got to'' work with the auditors. I found that if you automate the process, you can respond to auditor requests very quickly. And believe me, management will see this!

The most important thing to remember with any audit, whether SOX or PCI (financial institutions processing more than six million credit cards per year), is that it's upper management's butt on the line, and everything goes downhill from there.

In the next chapter we are going to study using `rsync` with Dirvish to perform snapshot-type backups. I hope your audits go well. See you in the next chapter.

Lab Assignments

1. Write a shell script that will list all user accounts that have membership in the `root`, `system`, `sys`, `adm`, `admin`, `printq`, `dba`, or `nobody` groups.
2. Write a shell script that will query the entire system for all directories that have the sticky bit set. Limit the query to not search `/opt` and `/proc`.
3. Write a shell script that will search the system for all regular files that are world-writable that have been created in the past 30 days.
4. Write a shell script that will search the system for all directories that have been modified in the past 10 minutes.
5. Write a shell script that will search the system for all regular files that have been accessed between 5 and 10 minutes ago.

CHAPTER 27

Using Dirvish with rsync to Create Snapshot-Type Backups

Six months ago I hadn't heard of Dirvish and I had used **`rsync`** fewer than 10 times. Now when I need to copy files either locally or over the network, I like to use `rsync` for its compression capabilities and, after an initial copy, the ability to replicate only changes *in a file* as opposed to *changed files*. Usually when a file is modified it is only a small percentage of the file that has changed, so sending only the updates greatly reduces the amount of data transmitted over the network. We are able to do this feat because of hard links and inodes. Read on; this is a very beneficial chapter for any shop, and it's free!

Dirvish is a backup program, originally written by J.W. Schultz, that you can download from `www.dirvish.org`. Dirvish uses `rsync` to transfer files over the network, and thus uses the `rsync` *remote-update protocol*, which allows us to do an incremental backup by transmitting only the *changed parts of the changed files*, as opposed to a tape incremental backup that requires transmitting the entire contents of *all changed files*. We studied `rsync` in detail in Chapter 7, ''Using `rsync` to Efficiently Replicate Data.''

The Dirvish backup program uses one or more backup servers with the image data stored on disk. Ideally, this backup server should be located in another building, or location, and then we have offsite backup storage. You may still want to make periodic backup tapes for legal purposes on a monthly and yearly basis.

In this chapter I want to accomplish two things:

- Familiarize you with the details of Dirvish configuration and how Dirvish works on the command line.
- Write a shell script to do all the hard work for us. This is a menu-driven user interface that will allow us to interact with Dirvish to configure a new server to back up, delete a server backup, restore files, and all the other things we need to do with backup images.

How Does Dirvish Work?

Dirvish is a backup program that produces *snapshot-style* backups to disk storage by utilizing the `rsync` remote-update protocol. Traditionally, backups have always been stored on tapes, and more recently CD-ROM and DVD optical storage. Dirvish is different in that it stores the *image filesystem trees on disk* on the backup server.

Typical backups consist of a periodic full system backup, followed by a set of incremental backups to archive only the files that have changed since the last backup. This process continues until the next full system backup, when the process repeats. Then when we have to restore a system we have to first extract the file(s) from the full backup, and then extract data from each incremental backup until we have the data current for that date. With Dirvish, after we perform the initial backup, all backups are incremental. Additionally, only the *changes* in the files, *not the entire files*, are transferred over the network. This magic is performed with the help of `rsync` under the covers using hard links associated with inodes. The idea is that after we make an initial backup as a set of reference files, we only need to transfer the changes to a file over the network with the remaining data replicated with pointers to the reference image files. Even though each backup is ''incremental,'' each backup image is completely intact. To restore, we just copy the files to wherever we need them. We will write a shell script that will take care of these details for us.

How Much Disk Storage Will I Need?

So, how does this ''incremental backup'' work and how much disk space do we need? To understand the guts of Dirvish, we need to get down to the filesystem level and understand the concept of an *inode*. Each separate file and directory in a filesystem has a unique number associated with it, called an inode. The operating system references files on the system by an inode number. As we know, directories are just special files in UNIX. A directory is a special file with a list of inodes that map to each of the files that reside in the directory. So, as with any pointer, you can have a directory that has in its list more than one filename pointing to the same inode. Using this technique, Dirvish is able to represent multiple files by pointing to the same inode, just as we create soft and hard links to point to files or directories to save disk space and to set links for application files and directories. This is nothing more than a hard link! Therefore, the disk space requirements for Dirvish will be much less than you first realize. Depending on the data you are backing up and time of retention before the data expires, you can start with 1.5–3 times the source data. This is just an estimate to get you started. Ideally, we expire the oldest backup just prior to performing the new backup to help conserve space. Separate filesystems should be created on the Dirvish backup server(s) to store the backup image data.

Configuring Dirvish

There is a great guide to using Dirvish, *Configuring and Using Dirvish for Snapshot Backups* written by Jason Boxman, at `http://edseek.com/~jasonb/articles/dirvish_backup/index.html`. You should reference this study guide for more advanced

details on Dirvish. I have referenced this document to write this chapter because it is the best document I have found. You can find another source of good information on Dirvish in the wiki at `http://www.dirvish.org/wiki?VaultBranch` (be sure the *V* and *B* are capped as shown here), and, of course, the official Dirvish web site, `http://www.dirvish.org`. As we go through this chapter, I will also point out specific manual pages you can look at for more detail.

We need to start with the Dirvish lingo and structure. Dirvish uses the analogy of a big banking firm. We use terms like *bank*, *branch*, and *vault* to describe locations where backup images are stored. It is always a good idea to create a separate filesystem for Dirvish backup images, such as `/prod_backups` or `/backup_bank1`. A *bank* is a directory (such as `/backup_bank1`) that contains *vaults* (subdirectories of server names to back up specifying a top-level directory tree) only. Do not store anything else in a bank directory. A bank is defined in the master configuration file (`master.conf`), allowing us to configure more than one bank if we desire. A vault is where the backup image is stored for a particular filesystem. There is one vault for every *filesystem* we back up with Dirvish. The best way to use Dirvish is to specify the root directory (`/`) as the backup tree to archive, and create a list of root subdirectories and files to exclude from the backup. An *image* is the entire directory tree structure that resulted from a Dirvish backup operation. We also have the concept of a branch. A *branch* is a way to archive multiple clients having very similar data by sharing the same vault. For example, if the `yogi` and `booboo` servers contain almost the same data, then when we perform a backup, two directory tree structures are created in the *shared* vault with the file and date format `yogi-YYMMDDHHMMSS` and `booboo-YYMMDDHHMMSS`.

Installing Dirvish

On my Linux machine, I installed Dirvish using `yum`, although `apt` works, too. Using `yum` takes care of installing the Dirvish dependencies. For details on setting up `yum` or `apt` refer the respective manual pages, **man yum** and **map apt**. Dirvish requires two Perl modules: `Time::ParseDate` and `Time::Period`. Installing Dirvish with `yum` is the simplest method, as shown in Listing 27-1.

```
[root@booboo scripts]# yum install dirvish
Loading "installonlyn" plugin
Setting up Install Process
Parsing package install arguments
updates                 100% |=========================| 1.9 kB  00:00
primary.sqlite.bz2      100% |=========================| 1.5 MB  00:02
freshrpms               100% |=========================| 1.9 kB  00:00
primary.sqlite.bz2      100% |=========================|  89 kB  00:00
fedora                  100% |=========================| 2.1 kB  00:00
primary.sqlite.bz2      100% |=========================| 4.7 MB  00:05
Resolving Dependencies
--> Running transaction check
---> Package dirvish.noarch 0:1.2.1-2.fc6 set to be updated
```

Listing 27-1 Installing Dirvish on Linux with yum

```
--> Processing Dependency: perl(Time::ParseDate) for package: dirvish
--> Processing Dependency: perl(Time::Period) for package: dirvish
--> Restarting Dependency Resolution with new changes.
--> Running transaction check
---> Package perl-Time-Period.noarch 0:1.20-1.fc6 set to be updated
---> Package perl-Time-modules.noarch 0:2003.1126-4.fc6 set to be
updated
---> Package dirvish.noarch 0:1.2.1-2.fc6 set to be updated

Dependencies Resolved

================================================================================
 Package                 Arch       Version           Repository    Size
================================================================================
Installing:
 dirvish                 noarch     1.2.1-2.fc6       fedora        51 k
Installing for dependencies:
 perl-Time-Period        noarch     1.20-1.fc6        fedora        14 k
 perl-Time-modules       noarch     2003.1126-4.fc6   fedora        36 k

Transaction Summary
================================================================================
Install      3 Package(s)
Update       0 Package(s)
Remove       0 Package(s)

Total download size: 101 k
Is this ok [y/N]: y
Downloading Packages:
(1/3): dirvish-1.2.1-2.fc 100% |=========================| 51 kB
00:00
(2/3): perl-Time-modules- 100% |=========================| 36 kB
00:00
(3/3): perl-Time-Period-1 100% |=========================| 14 kB
00:00
Running Transaction Test
Finished Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing: perl-Time-modules         ########################## [1/3]
  Installing: perl-Time-Period          ########################## [2/3]
  Installing: dirvish                   ########################## [3/3]

Installed: dirvish.noarch 0:1.2.1-2.fc6
Dependency Installed: perl-Time-Period.noarch 0:1.20-1.fc6
perl-Time-modules.noarch 0:2003.1126-4.fc6
Complete!
```

Listing 27-1 (*continued*)

```
[root@booboo scripts]# dirvish
vault undefined

[root@booboo scripts]#
```

Listing 27-1 (*continued*)

You can also download the latest version of Dirvish from `http://www.dirvish.org`. Then extract the tarball files to a directory somewhere. Make sure to read the INSTALL document. Now we just execute the `install.sh` script and answer a few questions, as shown in Listing 27-2.

```
[root@booboo Dirvish-1.2]# sh install.sh
perl to use (/usr/bin/perl)
What installation prefix should be used? () /usr/local
Directory to install executables? (/usr/local/bin)
Directory to install MANPAGES? (/usr/local/man)
Configuration directory (/etc/dirvish) /usr/local/etc

Perl executable to use is /usr/bin/perl
Dirvish executables to be installed in /usr/local/bin
Dirvish manpages to be installed in /usr/local/man
Dirvish will expect its configuration files in /usr/local/dirvish


Is this correct? (no/yes/quit) yes
Executables created.

Install executables and manpages? (no/yes) yes

installing /usr/local/bin/dirvish
installing /usr/local/bin/dirvish-runall
installing /usr/local/bin/dirvish-expire
installing /usr/local/bin/dirvish-locate
installing /usr/local/man/man8/dirvish.8
installing /usr/local/man/man8/dirvish-runall.8
installing /usr/local/man/man8/dirvish-expire.8
installing /usr/local/man/man8/dirvish-locate.8
installing /usr/local/man/man5/dirvish.conf.5

Installation complete
Clean installation directory? (no/yes) yes
Install directory cleaned.
```

Listing 27-2 Installing Dirvish with install.sh

With Dirvish installed, we are now ready to do a little configuration.

Modifying the master.conf Dirvish Configuration File

On startup Dirvish expects to find its master configuration file in `/etc/dirvish.conf` or `/etc/dirvish/master.conf`. This is not a typo! Let's just call it `master.conf` to not get confused. The `master.conf` file contains all the configuration information and default definitions and values for Dirvish. This `master.conf` file uses the *stanza* file format. Using the stanza format we can specify single values or lists of values. Single values have the form `option:value`. Lists of options must be specified on multiple lines, as shown here:

```
option:
          value1
          value1
          value3
          .
          .
          .
          valuen
```

Every value must reside on a different line and must be indented by any type of white space (spaces or tabs); one space is sufficient to define a value. If you need to add a comment to the `master.conf` file, a hash mark (#) specifies a comment to the end of the line. The initial `master.conf` from a fresh install is shown in Listing 27-3.

```
bank:

  exclude:
                  lost+found/
                  *~
                  .nfs*
  Runall:
                  yogi      22:00
                  booboo    22:00
                  dino      22:00
                  wilma     22:00
                  fred      22:00

  expire-default: +15 days
  expire-rule:
  #        MIN HR    DOM MON        DOW  STRFTIME_FMT
           *   *      *   *          1    +3 months
           *   *     1-7  *          1    +1 year
         *   *     1-7 1,4,7,10  1
```

Listing 27-3 Initial installation master.conf file

The first thing we need to define in the `master.conf` file is one or more banks. Within a bank we have one or more vaults. A vault contains the image trees of

individual filesystems, and we must create a vault for each filesystem we want to back up. I will show you how to back up the entire system by just excluding the subdirectories you do not wish to back up, and thus using only one vault per system.

To define two banks, `/backup_bank1` and `/prod_backups`, in the `master.conf` file, we use the following stanza format:

```
bank:
        /backup_bank1
        /prod_backups
```

To define a vault, we need only create a subdirectory in one of the banks. Dirvish knows a subdirectory of a bank is a vault if the vault contains a subdirectory named `dirvish`. This `dirvish` subdirectory contains a file named `default.conf`. If a subdirectory in a bank does not meet these criteria, it is just a subdirectory and Dirvish ignores it. We will cover creating `default.conf` files later in this chapter.

Let's assume we want to create a vault to store backup images of the `yogi` server in the `/backup_bank1` bank. The directory path to define this vault is shown here with the required `default.conf` file:

```
/backup_bank1/yogi/dirvish/default.conf
```

Just the presence of this directory path and `default.conf` file makes this a Dirvish vault; there is not any configuration other than creating the `default.conf` file.

Creating the default.conf File for Each Filesystem Backup

Each filesystem we back up has its own `default.conf` file that defines that particular backup. The `default.conf` file specifies the name of the client to back up, the bank to use for the backup, the vault to store the images, the image name, the backup server name, days before the backup expires, and any files and directories we want to exclude from the backup image. A simple `default.conf` file is shown in Listing 27-4.

```
client: booboo
bank: /backup_bank1
vault: booboo
server: yogi
expire: 15 day
index: gzip
image: booboo-%y%m%d%H%M%S
tree: /scripts

exclude:
        test/
        tmp/
```

Listing 27-4 Simple default.conf file

The `default.conf` file is straightforward. It specifies that we back up the `/scripts` filesystem on the `booboo` server. The Dirvish backup server is `yogi`; the bank assigned for this backup is `/backup_bank1` and the vault is `booboo`, with an image directory having the Base name `booboo` with a filename/time stamp format `booboo-%y%m%d%H%M%S`. So, a Dirvish server backup image directory may be `/backup_bank1/booboo/booboo-071210143304`, using the definition from our `default.conf` file. Notice that we did exclude all files and subdirectories in `/scripts/test/` and `/scripts/tmp/` from the backup. If you look closely at the `exclude:` stanza, you will see that we are specifying *relative pathnames*. Because we start in the root directory, `/`, all pathnames are *relative to the root directory*. Also, when defining a subdirectory to exclude, we need to add a trailing forward slash — for example, `subdirectory/`.

Performing a Full System Backup

In the example in Listing 27-4, we configured the `default.conf` file to back up the `/scripts` directory and all subdirectories, with the exception of `/scripts/test/` and `/scripts/tmp/`. We can expand on this idea to back up the entire system, but exclude any temporary and other data that is not really needed for a backup. Additionally, because we are doing a full system backup, we can use a branch to save space on the backup server. Using a branch allows us to back up entire systems using a fraction of the space normally required. Of course, when you set up a branch, you need to set one up for each flavor of UNIX in your landscape. For more information on using a branch, see the manual page for the `dirvish` command, **man dirvish**.

The `default.conf` file shown in Listing 27-5 uses the branch root and excludes filesystems like `/tmp`, `/proc`, and `/cdrom` from the backup image.

```
client: booboo
expire: 5 day
index: gzip
server: yogi
tree: /
vault: booboo
branch: root
image: root-%y%m%d%H%M%S
exclude:
        proc/
        sys/
        tmp/
        dev/shm
        dev/.SRC-unix/
        dev/SRC
        usr/HTTPServer/logs/siddport
        usr/IBMIHS/logs/cgisock
        usr/IBMIHS/logs/siddport
        var/ct/
```

Listing 27-5 default.conf defining a full system backup

```
        install/
        dev/log
        opt/ISS/
        usr/HTTPServer/logs/tmp.sock
        cdrom
```

Listing 27-5 (*continued*)

A `default.conf` file must be created for each system or filesystem, depending on how you define the `tree:`, `exclude:`, and `branch:` stanza directives. Now let's look at using Dirvish on the command line.

Using Dirvish on the Command Line

Dirvish has many commands to perform specific tasks for executing backups. We can back up a single server/filesystem or run all the backups at once. We can list backup images to find the correct file and image date for the data we want to restore, and we can delete expired backup images.

The first step after creating a new `default.conf` file is to do the initial backup reference image. We do this with the following syntax:

```
/usr/local/sbin/dirvish --vault vaultname [--branch branch] --init
```

The `--init` switch tells Dirvish to perform an initial backup. Once this initial backup is done, we execute all future backups without the `--init` switch. To perform the initial backup of the `booboo` vault, use the following syntax:

```
/usr/local/sbin/dirvish --vault booboo --init
```

For all new backups after the initial backup, we use the following syntax:

```
/usr/local/sbin/dirvish --vault vaultname [--branch branch]
```

To run a Dirvish backup of `booboo` after the initial Dirvish backup, use the following syntax:

```
/usr/local/sbin/dirvish -vault booboo
```

We can also do the backup using the `dirvish-runall` command. This command runs all the jobs specified in the `Runall:` stanza of the Dirvish master configuration file, `master.conf`. In this example, we specify `yogi`, `booboo`, `dino`, `wilma`, and `fred` as servers to back up when the `dirvish-runall` command is executed. For more information on the `dirvish-runall` command, see **man dirvish-runall**.

```
Runall:
            yogi     22:00
            booboo   22:00
            dino     22:00
            wilma    22:00
            fred     22:00
```

To search a particular vault for a file or directory, we use the `dirvish-locate` command. The basic syntax is shown here:

```
/usr/local/sbin/dirvish-locate vault[:branch] patternfile
```

The `patternfile` is the file or directory we are searching for. To search for the file `/scripts/dirvish_ctrl` in the `yogi` vault, we use the syntax shown in Listing 27-6.

```
dirvish-locate yogi  /scripts/dirvish_ctrl
2 matches in 16 images
/scripts/dirvish_ctrl
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815
    Dec 11 10:04 yogi-071211115107, yogi-071211115013
    Dec 10 12:31 yogi-071210123131, yogi-071210123128
    Dec 10 12:30 yogi-071210123049
    Dec 10 12:28 yogi-071210122858
    Dec 10 12:19 yogi-071210122226, yogi-071210122214,
                 yogi-071210122030
    May 25 09:28 yogi-070719153227, yogi-070627130342,
                 yogi-070626093920
                 yogi-070529152028
    May 21 14:30 scripts-070521144312

/scripts/dirvish_ctrl.log
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815
```

Listing 27-6 Using the dirvish-locate command

This search returns a list of all the matching files and directories, along with the date/time stamp of each backup image. The backup archives are shown as the `yogi-071211140359` files in this example. For more information on using the `dirvish-locate` command, see **man dirvish-locate**.

Now that we have all the commands, we can build a shell script to do all the hard work for us.

A Menu-Interface Shell Script to Control Dirvish

In this section we are going to build a shell script that is a simple menu-driven interface for Dirvish. In any menu-type shell script, we have to do a lot of cursor control to manipulate the data on the screen. For this script we are going to use a lot of `sed` and `awk`, parse through stanza format files, edit files using `sed`, restore files to a *restore area* on the Dirvish backup server, and a whole boatload of other things. The goal is to have a shell script that we can use right after a fresh Dirvish installation to do the initial configuration and then use on a daily basis to maintain the backups.

I call this script `dirvish_ctrl`. I wrote this as a full backup script, in that I define the vaults as the hostname of the server we are backing up. Here we will use the terms *vault*, *server*, and *host* interchangeably. The first step we will cover is creating the main menu. The easiest way to do this is with a function. The function in Listing 27-7 displays the main menu on the screen.

```
display_main_menu ()
{
clear  # Clear the screen
echo -e "\n\n\tWELCOME TO DIRVISH BACKUP COMMAND-CENTER


\t1) Dirvish RunAll Backups

\t2) Dirvish Run Backup

\t3) Dirvish Locate/Restore Image

\t4) Dirvish Expire/Delete Backup(s)

\t5) Dirvish Add a New Backup

\t6) Dirvish Remove a Backup

\t7) Dirvish Manage Backup Banks

\t8) EXIT

"
echo -e "\tSelect an Option: \c"
}
```

Listing 27-7 Main menu function

Now any time we need to display the main menu we just call the `display_main_menu` function. The main menu in action is shown in Listing 27-8.

```
        WELCOME TO DIRVISH BACKUP COMMAND-CENTER


        1) Dirvish Run All Backups

        2) Dirvish Run a Backup

        3) Dirvish Locate/Restore Image
```

Listing 27-8 dervish_ctrl shell script main menu

```
        4) Dirvish Expire/Delete Backup(s)

        5) Dirvish Add a New Backup

        6) Dirvish Remove a Backup

        7) Dirvish Manage Backup Banks

        8) EXIT


        Select an Option:
```

Listing 27-8 (*continued*)

From the main menu shown in Listing 27-8 a user can control the Dirvish backup program without really knowing any of the Dirvish commands we have been studying. Let's go through each of the seven Dirvish options.

NOTE **You can also use the `select` shell command to create a menu. For details, see man select.**

Running All Backups

In this section we are going to use the `dirvish-runall` command. Just understand that this Dirvish command option will run a backup only if the vault has been defined in the `RunAll:` stanza in the `master.conf` file, as shown here:

```
Runall:
            yogi     22:00
            booboo   22:00
            dino     22:00
            wilma    22:00
            fred     22:00
```

Executing the `dirvish-runall` command will only run backups for `yogi`, `booboo`, `dino`, `wilma`, and `fred`. The `run_all` function is shown in Listing 27-9.

```
run_all ()
{
clear
echo -e "\n\n"
/usr/local/sbin/dirvish-runall
if (( $? == 0 ))
then
    echo -e "\n\tBackups Complete...Press Enter to Continue...\c"
```

Listing 27-9 run_all function

```
else
    echo -e "\n\tDirvish Backup ERROR...Press Enter to Continue...\c"
fi
read KEY
}
```

Listing 27-9 (*continued*)

This `run_all` function in Listing 27-9 is pretty simple. We clear the screen, and then run the `dirvish-runall` command and check the return code. We give the end user feedback on the success or failure and wait for him or her to press Enter. Executing the `run_all` function produces the following output:

```
14:03:58 dirvish --vault yogi
14:03:59 dirvish --vault booboo
14:04:04 dirvish --vault dino
14:04:22 dirvish --vault wilma
14:04:51 dirvish --vault fred
14:05:04 done

        Backups Complete...Press Enter to Continue...
```

Running a Particular Backup

The next step is to write a function to ask the user which backup to run, and then run that particular backup. Check out the `run_backup` function in Listing 27-10, and we will cover the details at the end.

```
run_backup ()
{
# set -x
clear  # Clear the screen
echo -e "\n\n\t\tRUN A PARTICULAR BACKUP\n"
echo -e "\tEnter a Hostname to Back up: \c"
read HTBU  # Host to Back up
echo "Searching for default.conf in ${HTBU}'s Vault"

BANK_LIST=$(parse_conf)

for P in $BANK_LIST
do
    # Find the default config file for $HTBU
    CF=$(find ${P}/${HTBU} -type f -name default.conf)
    if [[ ! -z $CF ]]
    then
        echo -e "\nFound Configuration File...Starting Backup..."
        /usr/local/sbin/dirvish --vault $HTBU
```

Listing 27-10 run_backup function

```
        RC=$?
        echo -e "\nDirvish Exit Code: $RC"
        echo -e "\nBackup Complete..."
        echo -e "\nPress Enter to Continue...\c"
        read KEY
        break
    else
        echo -e "\nERROR: Could not Locate the Configuration File for
$HTBU"
        echo -e "\n...You Need to Configure $HTBU for Dirvish Backup
First"
        echo -e "\nPress Enter to Continue...\c"
        read KEY
    fi
done

if [[ -z "$CF" ]]
then
    echo -e "\nERROR: Could not Locate the Configuration File for $HTBU"
    echo -e "\n...You Need to Configure $HTBU for Dirvish Backup First"
    echo -e "\nPress Enter to Continue...\c"
    read KEY
fi
}
```

Listing 27-10 (*continued*)

In the `run_backup` function in Listing 27-10 we begin by clearing the screen and displaying a screen header. Next we ask the user for a server to back up. Remember; we are using the terms *server* and *vault* and *filesystem* interchangeably for this script. With the server name we search for the `default.conf` file to ensure it is an already configured server. If we find the `default.conf` file, we execute the backup of that server using the following command:

```
/usr/local/sbin/dirvish --vault $HTBU
```

We give the user feedback on the success or failure of the backup if we find the `default.conf` file. If the `default.conf` file is not found in any banks, we inform the user that this server is not configured in Dirvish and wait for the user to press Enter.

Locating and Restoring Images

In this section we want to interact with the user by asking for a file or directory to search for in the image archives. With a pattern to search for, we present the query data

and ask the users if they found what they are looking for. If the users found the files, we ask if they want the file or directory restored to a separate restore-area filesystem on the local Dirvish backup server. The `locate_restore_image` function is too long to repeat here. Please check out this function in the `dirvish_ctrl` shell script shown in Listing 27-24.

In the `locate_restore_image` function we first clear the screen and display the screen heading. The first question we ask the users is the host where the file or directory resides. Then we ask the users to enter as much of the file or directory name as they know. We use this information to search the backup images for the desired file or directory:

```
/usr/local/sbin/dirvish-locate $H ${DP} | more
```

This command searches the `$H` vault for the pattern `${DP}` (for data path) and lists the results one page at a time by piping this output to `more`. After the full output is displayed, we ask the users if they found what they are looking for. If they did, we ask whether they want to restore the data. If the answer is yes (y or Y), we ask for the *full pathname* of the file/directory to restore. Using this new value, we do another search using the `dirvish-locate` command. This lists all matching files and directories, along with each of the archive image names, with the date/time stamp.

From this output, we ask the user to enter the exact file or directory name to restore, and then which archive image to extract the file(s) from. We then use the `find` command to search the defined bank, vault, and specified archive image tree, and copy all files found recursively to the local restore area, which is defined as `/dirvish_restores` in this script.

Expiring and Deleting Backup Images

In this section our goal is to write a function to delete expired backup images, and expire backups that are not currently expired. To delete expired backups, we execute the `dirvish-expire` command. To expire a backup image that is not currently expired, we have to edit the `summary` file for that particular backup image to change the expiration date/time stamp.

The `expire_backup` function is too long to repeat here. Please look at the `dirvish_ctrl` shell script in Listing 27-24 for details.

We start the `expire_backup` function by clearing the screen and displaying a new sub-menu. For this shell script option, we need the ability to

1. Delete all expired backups in all vaults/hosts.
2. Delete expired backups for one vault/host.
3. Expire a single non-expired backup for one vault/host.
4. Expire all backups for one vault/host.

Listing 27-11 shows the code to create our expire backups menu.

```
clear
echo -e "
   \n\n\t\tDIRVISH EXPIRE BACKUP(S)\n
   \n\t1) Delete Expired Backups for ALL Hosts
   \n\t2) Delete Expired Backups for One Host
   \n\t3) Expire One Backup for One Host
   \n\t4) Expire All Backups for One Host
   \n\t5) Previous Menu
   \n\n\tSelect an Option: \c"
```

Listing 27-11 Code to display the expire backups menu

The resulting menu is shown in Listing 27-12.

```
               DIRVISH EXPIRE BACKUP(S)


        1) Delete Expired Backups for ALL Hosts

        2) Delete Expired Backups for One Host

        3) Expire One Backup for One Host

        4) Expire All Backups for One Host

        5) Previous Menu


        Select an Option:
```

Listing 27-12 Dirvish expire backup menu

The first two options use the `dirvish-expire` command to delete already-expired backups, but the last two options to expire backups that are not already expired require more work.

The command to *expire all backups in all vaults* is shown here:

```
/usr/local/sbin/dirvish-expire --tree
```

The command to expire *all backups in a single vault* is shown here:

```
/usr/local/sbin/dirvish-expire --tree --vault $H
```

The variable `$H` defines the vault to delete all expired backups in.

Using sed to Modify the summary File

The next part gets kind of involved-with a deep `sed` statement to modify the particular backup image or all backups in the vault. If we have a backup that is current and has not yet expired, the only way to expire the backup is to modify the `summary` file located in the image directory. A sample summary file is shown in Listing 27-13 (the expiration date is highlighted in bold).

```
[root@yogi booboo-071211080741]# cat summary
client: booboo
tree: /scripts
rsh: ssh
Server: yogi
Bank: /prod_backups
vault: booboo
branch: default
Image: booboo-071211080741
Reference: default
Image-now: 2007-12-11 08:07:41
Expire: 180 day == 2008-06-08 08:07:41
exclude:
        lost+found/
        *~
        .nfs*
        tmp/
        test/
SET permissions devices init numeric-ids stats
UNSET checksum sparse whole-file xdev zxfer


ACTION: rsync -vrltH --delete -pgo --stats -D --numeric-ids
--exclude-from=/prod_backups/fred/fred-071211080741/exclude
fred:/scripts/ /prod_backups/fred/fred-071211080741/tree

Backup-begin: 2007-12-11 08:07:41
Backup-complete: 2007-12-11 08:07:42
Status: success
[root@booboo fred-071211080741]#
```

Listing 27-13 Sample image summary file

If you have problems with a backup, you should look in the image directory for the `summary` and `log` files. They can help you troubleshoot a problem. The only thing we are interested in here is the expiration date shown here:

```
Expire: 180 day == 2008-06-08 08:07:41
```

The part of this line of data we are interested in is `2008-06-08 08:07:41`, the actual date/time stamp. We need to create a date/time stamp that has the current date and time. We can to this with the **date** command. If we use the date syntax `date "+%Y-%m-%d %H:%M:%S"` we will produce a similar date and time stamp:

```
[root@booboo /]# date "+%Y-%m-%d %H:%M:%S"
2007-12-11 08:22:07
[root@booboo /]#
```

Now, how do we modify the `summary` file with this new date/time stamp? We can do character substitution with a `sed` statement. Take a look at this `sed` statement in Listing 27-14, and we will cover the details at the end.

```
sed s/"$(grep Expire ${B}/${H}/${IMAGE_NAME}/summary)"/"$(grep Expire
${B}/${H}/${IMAGE_NAME}/summary | cut -f 1-4 -d ' ')
$EXPIRE_STAMP"/g "${B}/${H}/${IMAGE_NAME}/summary" >
"${B}/${H}/${IMAGE_NAME}/summary2"

if (( $? == 0 ))
then
     mv ${B}/${H}/${IMAGE_NAME}/summary2 ${B}/${H}/${IMAGE_NAME}/summary
fi
```

Listing 27-14 Modify the summary file with a sed statement

The `sed` statement is one long statement that continues on four lines. This `sed` statement first greps on `Expire` in the `summary` file and uses this result as the value to substitute. The second part of the `sed` statement extracts the same line out of the `summary` file but uses the `cut` command to extract the first four fields, followed by our new date/time stamp. This resulting substitution is redirected to the new filename `summary2`. If this `sed` statement has a zero return code, we move the `summary2` file to replace the `summary` file. With this change the backup is now expired, but not yet deleted.

Adding a New Backup

To add a new backup, all we need to do is create a new vault in an existing bank and create a `default.conf` file to define the backup. To create this new `default.conf` file, we need to query the user for some information, and some other information we already know. Check out the Dirvish Add a New Backup menu in Listing 27-15.

```
             DIRVISH ADD A NEW BACKUP

         Select Each Option to Add a New Backup

         1) Enter Hostname
```

Listing 27-15 Dirvish Add a New Backup menu

```
        2) Select a Bank for this Backup

        3) Enter Directory Tree to Back up

        4) Enter Files and Directories to Ignore

        5) Enter Days to Retain Each Backup

        6) Add the New Backup to Dirvish

        7) Create the Initial Backup

        8) Main Menu

        Select Each Option to Add a New Backup

        Enter Option:
```

Listing 27-15 (*continued*)

To create a new backup, the user selects each option. Options 1–5 can be selected in any order, but adding the new backup definition and running the initial backup (Options 6 and 7) are to be completed last in the series.

Let's look at these one at a time. In Option 1 we ask the user to enter the hostname of the server we want to add to Dirvish. Remember; I wrote this script to back up a bunch of servers, so the hostname here is the name of the new vault we are creating. We search the bank for the vault/host entered to ensure that it does not already exist. The code for this option is shown in Listing 27-16.

```
echo -e "\n\tEnter the Hostname for this Backup: \c"
read HN
for B in $BANK_LIST
do
    P=$(find $B -type d -name $HN)
    if [ ! -z $P ]
    then
        echo -e "\n\tWARNING: Vault $HN Already Exists in the
Following Bank:"
        echo -e "\n\t$P"
        echo -e "\n\tPress Enter to Continue...\c"
        read KEY
    fi
done
```

Listing 27-16 Code to enter a hostname and ensure it does not exist in a bank

Note that we use the find command to search all the banks for this new vault/hostname. We can have only one vault for each host in this script.

Option 2 displays all the banks defined in the Dirvish master configuration file, `master.conf`. Then we ask the user to enter the bank for this backup. This code is shown in Listing 27-17.

```
FINISH=0
until (( FINISH == 1 ))
do
   clear
   BANK=
   echo -e "\n\n\t\tSELECT A BANK TO STORE THIS BACKUP\n"
   echo -e "\nAvailable Banks:\n"
   for B in $BANK_LIST
   do
        echo -e "\t$B"
   done
   echo -e "\nPlease Enter a Bank: \c:"
   read BANK
   if $(echo $BANK_LIST | grep -q ${BANK})
   then
       echo "$BANK selected for $HN"
       FINISH=1
   else
       echo -e "\nERROR: $BANK is not a Valid Bank"
       sleep 2
       continue
   fi
done
```

Listing 27-17 Code to display all banks and ask for a selection

Notice in Listing 27-17 that we verify the bank entered is a valid bank.

In Option 3 we just ask for a top-level directory tree that we want to back up. In Option 4 we will be able to exclude files and subdirectories we do not want to back up. The code to query the user for a directory tree to back up is shown here:

```
echo -e "\n\tEnter the Directory Tree to Back up: \c"
read TREE
```

If Option 4 is selected, we display all the contents of the tree specified in Option 3 and ask the users if they want to exclude anything from the backups. This is the data for the `exclude:` stanza directive in the `default.conf` file. We read and save each entry the user wants to exclude from the backup using the `read_input` function shown in Listing 27-18.

```
read_input ()
{
LINE=
```

Listing 27-18 read_input function

```
while true
do
    read "ENTRY"
    if [[ $ENTRY = 99 ]]
    then
        echo "$LINE"
        break
    fi
    LINE="$LINE
$ENTRY"
done
}
```

Listing 27-18 (*continued*)

The idea with the `read_input` function in Listing 27-18 is to keep looping and reading input and saving each value until 99 is entered as a value. This signals the loop to exit, specified by the `break` command. The entire code section to enter items to exclude is shown in Listing 27-19.

```
echo -e "\n\n\tDIRECTORY TREE(S) and FILES TO IGNORE\n"
echo -e "\nThe Specified Directory Tree Contains the Following Files/
Directories:\n\n"
if [ $HN = $(hostname) ]
then
    ls $TREE | more
else
    ssh $HN ls $TREE | more
fi
echo -e "\nDo you want to Exclude any Files or Directories from the
Backups? (y/n): \c"
read ANS3
case $ANS3 in
y|Y) echo -e "\n\tEnter Directories and Files to Ignore One per Line\n"
     echo -e "Enter 99 when finished\n"
     IGNORE_LIST=$(read_input)
     continue
     ;;
n|N) IGNORE_LIST=$(echo)
     continue
     ;;
  *) echo -e "\nInvalid Entry..."
     ;;
esac
```

Listing 27-19 Code to read in and save exclude data

After displaying all the files located in the specified tree, we ask the users if they would like to exclude anything. If the answer is yes (y or Y), we use `read_input` to

gather the data. Notice that we call the `read_input` function and assign the resulting list to the `IGNORE_LIST` variable.

Option 5 is where we ask for the number of days to retain the backups. The query code is shown here:

```
echo -e "\n\tDays before each Backup Expires: \c"
read DAYS
```

Simple enough. We just assign the variable to `DAYS` variable.

Option 6, to add a new backup, is where we actually create the new `default.conf` file. Check out the code in Listing 27-20, and we will cover the details at the end.

```
build_default_conf ()
{
# Define files and variables here

HN="$1"      # Hostname of server to add
BANK="$2"    # Bank to use for backup
DAYS="$3"    # Days before backups expire
TREE="$4"    # Directory tree to back up
IGNORE_LIST="$5"  # Files and directories to ignore
OUTFILE=$DEFAULT_CONF # Name of the output file

# All of the following output is used to build the
# new default.conf file for this backup
{
echo "client: $HN"
echo "bank: $BANK"
echo "vault: $HN"
echo "server: $DIRVISH_SERVER"
echo "expire: $DAYS day"
echo "index: gzip"
echo "log: gzip"
echo "image: ${HN}-%y%m%d%H%M%S"
echo "tree: $TREE"
echo -e "\nexclude:"
echo "$IGNORE_LIST" | sed /^$/d | while read Q
do
    echo -e "\t$Q"
done
} >$OUTFILE
}
```

Listing 27-20 build_default_conf function

Notice in the `build_default_conf` function in Listing 27-20 that we are expecting five arguments: the hostname, bank, days before the backup expires, the directory tree to back up, and the list of objects to exclude from the backups. The remaining data we already know, such as the Dirvish backup server (this script assumes it is executing on the Dirvish backup server), image name with the date format defined, and using `gzip`

to compress the index. See how we put all the `echo` statements within curly braces, { }, and then use a single output redirection to create the `$OUTFILE`.

The file that the `build_default_conf` function creates is a temporary file, not the real `default.conf` file we need to create in the new vault. The last step is to create the new vault and copy the newly created `default.conf` file to the newly created vault. The rest of the code is shown in Listing 27-21.

```
echo -e "\n\nCreating default.conf Dirvish Configuration File for $HN"
build_default_conf $HN "$BANK" $DAYS "$TREE" "$IGNORE_LIST"
echo -e "\nCopying file to:  ${BANK}/${HN}/dirvish/default.conf"
cp -f $DEFAULT_CONF "${BANK}/${HN}/dirvish/default.conf"
echo -e "\n...Press ENTER to Continue...\c"
read ANS
```

Listing 27-21 Code to create a new default.conf file

In Listing 27-21 we inform the user that we are creating the new `default.conf` file, and then call the `build_default_conf` function, passing the hostname, bank, days before expiration, the tree to back up, and the list of files and directories to ignore. Notice that `"$BANK"`, `"$TREE"`, and `"$IGNORE_LIST"` are all enclosed in double quotes. These double quotes are required because there may be white space in the data assigned to each of these variables.

The last step is to copy the new `default.conf` file to the new vault to complete the vault configuration.

Removing a Backup

By now you are probably thinking, ''Okay, when is this script going to end?'' Well, one more topic after this. In this section, we want to remove a vault/hostname from the Dirvish backup server. The only way to do this is to remove the vault's directory and all its contents. The work in the `delete_backup` function is done by one command:

```
rm -fr "$VAULT_ID"
```

Before we start deleting directories and all their contents, we need to do a little sanity checking to ensure we do not break something. Check out the `delete_backup` function in Listing 27-22, and we will cover the details at the end.

```
delete_backup ()
{
clear
echo -e "\n\n\tREMOVE A SERVER FROM DIRVISH BACKUPS\n"
echo -e "\n\tEnter the Host to Remove from Dirvish Backups: \c"
read H

BANK_LIST=$(parse_conf)
```

Listing 27-22 delete_backup function

```
for P in $BANK_LIST
do
   VAULT_ID=$(find $P -type d -name "$H")
   if [[ ! -z "$VAULT_ID" ]]
   then
       STOP=0
       until (( STOP == 1 ))
       do
          echo -e "\n\tRemove Backup Vault $H from the Dirvish Backup
Server? (y/n): \c"
          read ANS
          case $ANS in
          y|Y) echo -e "\n\tRemoving Backup Vault for $H from Dirvish
Backups...\c"
               rm -fr "$VAULT_ID"
               echo -e "\n\tBackup Vault Removed...Press Enter to
Continue...\c"
               read KEY
               STOP=1
               ;;
          n|N) echo -e "\n\tVault Removal Canceled...Press Enter to
Continue...\c"
               read KEY
               STOP=1
               continue
               ;;
            *) echo -e "\n\tInvalid Entry..."
               ;;
          esac
       done
  fi
done
}
```

Listing 27-22 (*continued*)

We start the `delete_backup` function in Listing 27-22 by clearing the screen and displaying the screen header. We ask the user for the hostname/vault to delete, then we search all the banks for the specified hostname/vault. If we find the vault, we ask the user to confirm deleting it (''Are you sure…?''). If the user responds with `y` or `Y` we run the `rm -fr "$VAULT_ID"`, which deletes the vault from the Dirvish backup server.

Managing the Dirvish Backup Banks

I wrote this script with the ability to modify the `master.conf` file in much the same way we modified the `summary` files to expire a backup image. The `manage_banks` function is too long to repeat here. For details see the `dirvish_ctrl` shell script in Listing 27-24.

We begin the `manage_banks` function by clearing the screen and displaying the screen header. The next step is to display all the banks defined in the Dirvish master configuration file, `master.conf`. If no banks are currently defined, such as in a fresh Dirvish installation, we inform the user. We then display the menu to manage the Dirvish backup banks. This menu code is shown here:

```
echo -e "\n\n1) Add a New Backup Bank"
echo -e "\n2) Delete a Current Backup Bank"
echo -e "\n3) Return to the Previous Menu"
echo -e "\n\nSelect an Option: \c"
```

Our options are to add a new Dirvish backup bank or to delete a currently defined backup bank. Adding a new Dirvish backup bank is a two-step process. First we define the new bank in the Dirvish master configuration file, `master.conf`. Then we need to create the directory for the new bank on the system.

NOTE **It is always a good idea to create a separate filesystem for each new bank. You can also create a large filesystem and create different banks/directories in the same filesystem. Either way, do *not* just add the new bank's directory to the root filesystem. If you do, you could fill the up root filesystem and disable the system.**

Adding a New Dirvish Backup Bank

To add a new bank, we need to parse through the `master.conf` file to find the last bank defined in the list. As we parse through the file, we assign the values to the `LAST_ENTRY` variable on each loop iteration. When the loop completes executing, we have the last bank defined under the `bank:` stanza directive in the `master.conf` file. This `for` loop finds the last entry and saves the list of banks in a file, as shown here:

```
for B in $BANK_LIST
do
   ((COUNT == COUNT + 1))
   LAST_ENTRY=$B
   echo -e "\t$B" | tee -a $BANK_FILE
done
```

Now we can add a new bank definition to the `master.conf` file with character substitution using a `sed` statement, as follows:

```
     sed "s!$LAST_ENTRY!& \n\t${A_BANK}!g" $M_CONFIG > ${M_CONFIG}.
modified
     if (( $? == 0 ))
     then
        cp ${D_CONFIG} ${D_CONFIG}.$(date +%m%d%Y)
        cp ${D_CONFIG}.modified ${D_CONFIG}
        echo -e "\n$A_BANK Successfully Added to Dirvish Master
Config File"
        chk_create_dir $A_BANK
```

```
    else
       echo -e "\nERROR: Adding $A_BANK Failed...See Administrator..."
    fi
```

This `sed` statement adds the new bank after the last defined bank in the list, or adds it as the first bank in the list if the `bank:` stanza directive has no other banks defined. This step creates the `master.conf.modified` file. If the `sed` statement completes with a return code of `0`, we copy the new file to `master.conf`.

Deleting a Dirvish Backup Bank

Deleting a bank is a two-step process if you want to delete all the backup images that reside in that bank. The code to delete a bank from the `master.conf` file and to remove the directory structure, upon verification, is shown in Listing 27-23.

```
cat $D_CONFIG | grep -v $R_BANK > ${D_CONFIG}.modified
cp -p $D_CONFIG ${D_CONFIG}.bak.$(date +%m%d%y)
cp ${D_CONFIG}.modified $D_CONFIG
echo -e "\n$R_BANK Removed from the Dirvish Configuration File..."
if [ -d $R_BANK ]
then
    echo -e "\nDo You Want to Remove the $R_BANK Directory? (y/n): \c"
    read ANS
    case $ANS in
    y|Y) rm -r $R_BANK
         if (( $? == 0 ))
         then
             echo -e "\n$R_BANK Directory Removed Successfully"
         else
              echo -e "\nERROR: Remove $R_BANK Directory Failed"
         fi
         ;;
    n|N) echo -e "\nSkipping $R_BANK Directory Removal"
         ;;
      *) echo -e "\nInvalid Input..."
         ;;
         esac
fi
```

Listing 27-23 Code to delete a Dirvish bank

The first step is to remove the bank definition from the `master.conf` file. As far as Dirvish is concerned, this bank no longer exists, but the directory structure is still in place. Before we delete the actual directory structure containing the bank and all the archived images, we ask the user. If the user confirms deleting the contents, we proceed with deleting the bank directory and all subdirectories.

To delete a bank from the `master.conf` file, we use `grep` with the `-v pattern` switch. The `-v` switch tells `grep` to list everything *except* the `pattern`. Then we copy

the newly modified file to `master.conf`. Finally, we ask the user before we delete the bank directory structure and all the archived images.

Putting It All Together

The preceding sections described each of the pieces that make up the `dirvish_ctrl` shell script. Now let's put it all together. There are too many individual little details for me to describe everything in minute detail. Study the `dirvish_ctrl` shell script in Listing 27-24 in detail, and you will surely pick a lot of tips and tricks.

```
#!/bin/Bash
#
# SCRIPT: dirvish_ctrl
# AUTHOR: Randy Michael
# DATE: 5/14/2007
# REV: 1.0
# PLATFORM: Most any UNIX platform
#
# PURPOSE: This script is used to interface with the Dirvish
#          backup utilities.
#
# set -x # Uncomment to debug this script
#
# set -n # Uncomment to check the script's syntax
#        # without any execution. Do not forget to
#        # recomment this line!
#
########################################
# REVISION LIST:
########################################
#
# IF YOU MODIFY THIS SCRIPT DOCUMENT THE CHANGE(S)!!!
#
########################################
#
# Revised by:
# Revision Date:
# Revision:
#
#
########################################
#
# Revised by:
# Revision Date:
# Revision:
#
```

Listing 27-24 dirvish_ctrl menu interface shell script

```
########################################
# DEFINE FILES AND VARIABLES HERE
########################################

RESTORE_AREA=/dirvish_restores
DIRVISH_SERVER=$(hostname)
DEFAULT_CONF=/tmp/dirvish_build_conf.out
LOGFILE=$(basename $0).log
echo -e "\n\t\tDirvish Log Created: $(date) \n" >$LOGFILE
DONE=0

########################################
# DEFINE FUNCTIONS HERE
########################################

display_main_menu ()
{
# This function displays the main menu

clear # Clear the screen

# Display the menu header and menu

echo -e "\n\n\tWELCOME TO DIRVISH BACKUP COMMAND-CENTER


\t1) Dirvish Run All Backups

\t2) Dirvish Run a Backup

\t3) Dirvish Locate/Restore Image

\t4) Dirvish Expire/Delete Backup(s)

\t5) Dirvish Add a New Backup

\t6) Dirvish Remove a Backup

\t7) Dirvish Manage Backup Banks

\t8) EXIT

"
echo -e "\tSelect an Option: \c"
}

########################################
```

Listing 27-24 (*continued*)

```
read_input ()
{
# This function is used to save user input

LINE=  # Initialize LINE to NULL

while true
do
    read "ENTRY"
    if [[ $ENTRY = 99 ]]
    then
        echo "$LINE"
        break
    fi
    LINE="$LINE
$ENTRY"
done
}

########################################

parse_conf ()
{
# This function parses through the Dirvish Master
# Configuration File, specified by $M_CONFIG, to
# gather a list of all of the defined Dirvish banks.

# set -x # Uncomment to debug this function

# Initial local variables

BANK_LIST=
START=0

# Loop through the $M_CONFIG file until we find
# the 'bank:' stanza, then add each bank to a list
# until we reach another stanza, 'stanza:'

while read DATA
do
    [[ $DATA = 'bank:' ]] && START=1 && continue
    if (( START == 1 ))
    then
       if $(echo "$DATA" | grep -q ':')
       then
           break
       else
           if [[ -z "$BANK_LIST" ]]
```

Listing 27-24 (*continued*)

```
            then
                BANK_LIST="$DATA"
            else
                BANK_LIST="$BANK_LIST $DATA"
            fi
        fi
    fi
done < $M_CONFIG # Feed the while loop from the bottom

echo "$BANK_LIST" # Return the list
}

########################################

build_default_conf ()
{
# Define files and variables here

HN="$1"      # Hostname of server to add
BANK="$2"    # Bank to use for backup
DAYS="$3"    # Days before backups expire
TREE="$4"    # Directory tree to back up
IGNORE_LIST="$5"  # Files and directories to ignore
OUTFILE=$DEFAULT_CONF # Name of the output file

# All of the following output is used to build the
# new default.conf file for this backup
{
echo "client: $HN"
echo "bank: $BANK"
echo "vault: $HN"
echo "server: $DIRVISH_SERVER"
echo "expire: $DAYS day"
echo "index: gzip"
echo "log: gzip"
echo "image: ${HN}-%y%m%d%H%M%S"
echo "tree: $TREE"
echo -e "\nexclude:"
echo "$IGNORE_LIST" | sed /^$/d | while read Q
do
    echo -e "\t$Q"
done
} >$OUTFILE
}

########################################

run_all ()
```

Listing 27-24 (*continued*)

```
{
# This function runs all of the backups defined in
# the Dirvish master configuration file stanza "Runall:"

clear # Clear the screen
echo -e "\n\n"

# Execute all master.conf defined backups

/usr/local/sbin/dirvish-runall

if (( $? == 0 )) # Check the return code!
then
    echo -e "\n\tBackups Complete...Press Enter to Continue...\c"
else
    echo -e "\n\tDirvish Backup ERROR...Press Enter to Continue...\c"
fi
read KEY
}

########################################

run_backup ()
{
# This function runs one particular backup

# set -x # Uncomment to debug this function

clear # Clear the screen

# Display the screen heading and query the user
echo -e "\n\n\t\tRUN A PARTICULAR BACKUP\n"
echo -e "\tEnter a Hostname to Back Up: \c"
read HTBU  # Host to Back Up

echo -e "\nSearching for default.conf in ${HTBU}'s Vault"

BANK_LIST=$(parse_conf)

for P in $BANK_LIST
do
    # Find the Default Config File (default.conf) for $HTBU

    DCF=$(find ${P}/${HTBU} -type f -name default.conf)

    if [[ ! -z $DCF ]]
    then
        echo -e "\nFound Configuration File...Starting Backup..."
```

Listing 27-24 (*continued*)

```
        /usr/local/sbin/dirvish --vault $HTBU
        RC=$?
        echo -e "\nDirvish Exit Code: $RC"
        echo -e "\nBackup Complete..."
        echo -e "\nPress Enter to Continue...\c"
        read KEY
        break
    else
        echo -e "\nERROR: Could not Locate the Configuration File for
 $HTBU"
        echo -e "\n...You Need to Configure $HTBU for Dirvish Backup
First"
        echo -e "\nPress Enter to Continue...\c"
        read KEY
    fi
done

if [[ -z "$DCF" ]]
then
    echo -e "\nERROR: Could not Locate the Configuration File
 for $HTBU"
    echo -e "\n...You Need to Configure $HTBU for Dirvish
Backup First"
    echo -e "\nPress Enter to Continue...\c"
    read KEY
fi
}

########################################

chk_create_dir ()
{
# This function is used to add a new Dirvish "bank" to
# the Dirvish backup server, which should be this machine

D=$1 # Directory name to add

if [ ! -d $D ] # Check if the directory already exists
then
    echo -e "\n$D Directory Does Not Exist...Create $D Directory?
(y/n): \c"
    read ANS
    case $ANS in
    y|Y) echo -e "\nCreating $D Directory..."
         mkdir $D
         if (( $? == 0 ))
         then
             echo -e "\n$D Directory Created"
```

Listing 27-24 (*continued*)

```
          else
              echo -e "\n$D Directory Creation Failed...See
Administrator..."
          fi
          ;;
     n|N) echo -e "\nSkipping Creating the $D Directory"
          echo -e "\nWARNING: Until the $D Directory is Created
Dirvish Cannot use this Bank\n"
          ;;
       *) echo -e "\nInvalid Input..."
          ;;
     esac
fi
}

########################################

locate_restore_image ()
{
# set -x # Uncomment to debug this function

clear # Clear the screen

# Display the screen heading, query the user, display the
# files matching the search, and ask if the user wants to
# restore the files. If a restore is requested we ensure
# there is a directory for the target server in the $RESTORE_AREA,
# if not create it, and copy the files into this subdirectory in
# the $RESTORE_AREA.

echo -e "\n\n\t\tLOCATE/RESTORE A BACKUP IMAGE\n"
echo -e "Enter the Hostname where the File/Directory Resides: \c"
read H
echo -e "\nEnter as Much of the Directory Path and Filename as
You Know:\n"
read "DP"
if [ "$DP" = '/' ]
then
    echo -e "\nERROR: This Program is Not Intended for Full System
Restores...\n"
    sleep 2
    return
fi
echo -e "\nSearching for Archive Images..."

# Search and display all matching files one page at a time

/usr/local/sbin/dirvish-locate $H ${DP} | more
```

Listing 27-24 (*continued*)

```
QUIT=0
until (( QUIT == 1 ))
do
   echo -e "\nDid You Find What You Want? (y/n): \c"
   read ANS1
   case $ANS1 in
   y|Y) echo -e "\nDo You Want to Perform a Restore? (y/n): \c"
        read ANS2
        while true
        do
           case $ANS2 in
           y|Y) QUIT=1
                break
                ;;
           n|N) echo -e "\nPress Enter to Continue...\c"
                read KEY
                return 0
                ;;
             *) echo -e "\nInvalid Input..."
                ;;
           esac
        done
        ;;
   n|N) return 0
        ;;
     *) echo -e "\nInvalid Input..."
        ;;
   esac
done

echo -e "\nEnter the FULL PATHNAME of the File/Directory You Want to
Restore:\n"
read TARGET

if [ -z "$TARGET" ]
then
    echo -e "\nInvalid Entry..."
    sleep 2
    return
fi

if [[ $(echo "$TARGET" | cut -c1) != '/' ]]
then
    echo -e "\nERROR: $TARGET is Not a Valid Full Pathname...\n"
    sleep 2
    break
fi
```

Listing 27-24 (*continued*)

```
echo -e "\nSearching Images..."

/usr/local/sbin/dirvish-locate "$H" "${TARGET}" | more

echo -e "\nEnter the Image to Restore From: \c"
read IMAGE_NAME
echo

# Check to ensure that the defined $RESTORE_AREA
# directory has been created on the system.

if [[ ! -d $RESTORE_AREA ]]
then
    mkdir $RESTORE_AREA
fi

# Ensure that a subdirectory exists for this host

if [[ ! -d ${RESTORE_AREA}/${H} ]]
then
    mkdir ${RESTORE_AREA}/${H}
fi

BANK_LIST=$(parse_conf)

# This is where we restore the data

for BANK in $BANK_LIST
do
   if [ -d "$TARGET" ]
   then
       # If $TARGET is a directory we only want the last
       # part of the path, not the entire path.

       TARGET=$(basename "$TARGET")

       find ${BANK}/${H}/${IMAGE_NAME}/tree -name "${TARGET}" -print \
            -exec cp -rp {} "${RESTORE_AREA}/${H}" \; 2>/dev/null

       if (( $? ==  0 ))
       then
           echo -e "\nFiles Restored to the Following Restore Area:"
           echo -e "\n${RESTORE_AREA}/${H}/${TARGET}\n"
           break
       else
           echo -e "\nRestore Failed...See Administrator...\n"
           break
```

Listing 27-24 (*continued*)

```
        fi
    else
        # We are working with a file

        D_NAME=$(dirname "$TARGET")
        F_NAME=$(basename "$TARGET")
        echo "DIRNAME is $D_NAME"

        # Find and copy the file(s) to the $RESTORE_AREA

        find ${BANK}/${H}/${IMAGE_NAME}/tree/ -name "${F_NAME}" \
             -exec cp -rp {} "${RESTORE_AREA}/${H}" \; 2>/dev/null

        if (( $? ==  0 ))
        then
            echo -e "\nFiles Restored to the Following Restore Area:"
            echo -e "\n${RESTORE_AREA}/${H}/${F_NAME}\n"
            break
        else
            echo -e "\nRestore Failed...See Administrator...\n"
            break
        fi
  fi
done

echo -e "\nPress Enter to Continue...\c"
read KEY
}

########################################

expire_backup ()
{
# This function is used to expire backups

# set -x # Uncomment to debug this function

clear # Clear the screen

# Display the screen header and menu

echo -e "
   \n\n\t\tDIRVISH EXPIRE BACKUP(S)\n
   \n\t1) Delete Expired Backups for ALL Hosts
   \n\t2) Delete Expired Backups for One Host
   \n\t3) Expire One Backup for One Host
   \n\t4) Expire All Backups for One Host
   \n\t5) Previous Menu
```

Listing 27-24 (*continued*)

```
    \n\n\tSelect an Option: \c"

read ANS
case $ANS in
1) echo -e "\n\tDeleting Expired Backups for ALL Hosts...\n"
   /usr/local/sbin/dirvish-expire --tree
   echo -e "\n\tTasks Complete..."
   echo -e "\n\tPress Enter to Continue...\c"
   read KEY
   ;;
2) echo -e "\n\tEnter the Hostname to Delete Expired Backups: \c"
   read H
   /usr/local/sbin/dirvish-expire --tree --vault $H | more
   echo -e "\n\tTasks Complete..."
   echo -e "\n\tPress Enter to Continue...\c"
   read KEY
   ;;
3) EXPIRE_STAMP="$(date "+%Y-%m-%d %H:%M:%S")"
   echo -e "\n\tEnter the Hostname for the Backup Image: \c"
   read H

   BANK_LIST=$(parse_conf)
   MYPWD=$(pwd)

   # Parse through all of the banks to this host

   for B in $BANK_LIST
   do
      if [ -d ${B}/${H} ]
      then
          cd ${B}/${H}
          IMAGE_LIST=$(find . -type d -name "*-[0-9][0-9]*" |
cut -c3-)
      fi
   done

   echo -e "\nSelect an Image to Expire from the Following List:\n"
   echo -e "\n$IMAGE_LIST" | more
   echo -e "\n\nEnter the Image to Expire: \c"
   read IMAGE_NAME

   cd $MYPWD
   if [[ -r ${B}/${H}/${IMAGE_NAME}/summary ]]
   then
      # This is where we expire a backup that is not currently
      # expired. The 'summary' file contains the expire datestamp

      echo -e "\nExpiring Image: $IMAGE_NAME"
```

Listing 27-24 (*continued*)

```
      sed s/"$(grep Expire ${B}/${H}/${IMAGE_NAME}/summary)"/
"$(grep Expire ${B}/${H}/${IMAGE_NAME}/summary | cut -f 1-4 -d")
$EXPIRE_STAMP"/g "${B}/${H}/${IMAGE_NAME}/summary" >
"${B}/${H}/${IMAGE_NAME}/summary2"

      mv "${B}/${H}/${IMAGE_NAME}/summary2" "${B}/${H}/${IMAGE_NAME}
/summary"
   fi

   # We expired the backups; now we ask the user if we should delete
   # the expired images

   STOP=0
   until (( STOP == 1 ))
   do
     echo -e "\nTasks Complete...Do You Want to Delete This Expired
Image? (y/n): \c"
     read ANS
     case $ANS in
     y|Y) echo -e "\nDeleting Expired Image: $IMAGE_NAME"

          # This next command deletes all expired images for $H
          /usr/local/sbin/dirvish-expire --vault $H

          RC=$?
          echo -e "\n\tDirvish-expire Completed with Return Code: $RC"
          echo -e "\n\tTasks Complete..."
          echo -e "\n\tPress Enter to Continue...\c"
          read KEY
          STOP=1
          ;;
     n|N) STOP=1
          continue
          ;;
       *) echo -e "\n\tInvalid Entry..."
          ;;
     esac
   done
   ;;
4) EXPIRE_STAMP=$(date "+%Y-%m-%d %H:%M:%S")
   clear
   echo -e "\nEnter the Hostname for the Backup Image: \c"
   read H

   BANK_LIST=$(parse_conf)
   MYPWD=$(pwd)

   for P in $BANK_LIST
```

Listing 27-24 (*continued*)

```
   do
      if [ -d ${P}/${H} ]
      then
         cd ${P}/${H}
         IMAGE_LIST=$(find . -type d -name "*-[0-9][0-9]*" |
cut -c3-)
         B=$P
      fi
   done

   echo -e "\nSetting the Following Images to Expire:\n\n"
   echo "$IMAGE_LIST" | more
   cd $MYPWD
   echo -e "\nPress Enter to Continue...\c"

   echo "$IMAGE_LIST" | while read IMAGE_NAME
   do
     if [ -f ${B}/${H}/${IMAGE_NAME}/summary ]
     then
        echo "Expiring $IMAGE_NAME"
        sed s/"$(grep Expire ${B}/${H}/${IMAGE_NAME}/summary)"/
"$(grep Expire ${B}/${H}/${IMAGE_NAME}/summary | cut -f 1-4 -d ' ')
$EXPIRE_STAMP"/g "${B}/${H}/${IMAGE_NAME}/summary" >
"${B}/${H}/${IMAGE_NAME}/summary2"

        if (( $? == 0 ))
        then
           mv ${B}/${H}/${IMAGE_NAME}/summary2 ${B}/${H}/
${IMAGE_NAME}/summary
        fi
     fi
   done

   STOP=0
   until (( STOP == 1 ))
   do
     echo -e "\nTasks Complete...Do You Want to Delete Expired
Images? (y/n): \c"
     read ANS
     case $ANS in
     y|Y) echo -e "\nDeleting Expired Images...\n"
          /usr/local/sbin/dirvish-expire --vault $H
          RC=$?
          echo -e "\nDirvish-expire Completed with Return Code: $RC"
          echo -e "\nTasks Complete..."
          echo -e "\nPress Enter to Continue...\c"
          read KEY
          STOP=1
```

Listing 27-24 (*continued*)

```
            ;;
      n|N) STOP=1
            continue
            ;;
        *) echo -e "\n\tInvalid Entry..."
            ;;
      esac
    done
    ;;
5) :
    ;;
*) echo -e "\nInvalid Entry"
    ;;
esac
}

########################################

add_backup ()
{
# This function is used to define a new backup to Dirvish

# set -x # Uncomment to debug this function

# Get a list of available banks

BANK_LIST=$(parse_conf)

ESCAPE=0
until (( ESCAPE == 1 ))
do
  clear # Clear the screen

  # Display the screen heading and the menu
  echo -e "
  \n\t\t   DIRVISH ADD A BACKUP
  \n\tSelect Each Option to Add a New Backup
  \n\t1) Enter Hostname
  \n\t2) Select a Bank for this Backup
  \n\t3) Enter Directory Tree to Back Up
  \n\t4) Enter Directory Trees to Ignore
  \n\t5) Enter Days to Retain Each Backup
  \n\t6) Add the New Backup to Dirvish
  \n\t7) Create the Initial Backup
  \n\t8) Main Menu
  \n\tSelect Each Option to Add a New Backup
  \n\tEnter Option: \c"
  read OPTION # Read in the user response
```

Listing 27-24 (*continued*)

```
   # Perform the desired operation
   case $OPTION in
   1) echo -e "\n\tEnter the Hostname for this Backup: \c"
      read HN
      for B in $BANK_LIST
      do
          P=$(find $B -type d -name $HN)
          if [ ! -z $P ]
          then
              echo -e "\n\tWARNING: Vault $HN Already Exists in the
Following Bank:"
              echo -e "\n\t$P"
              echo -e "\n\tDo you want to create a new default.conf file
for $HN? (y/n): \c"
              ANS=n  # Set the default answer to 'n', No.
              read ANS
              case $ANS in
              y|Y) continue
                   ;;
              n|N) return
                   ;;
              esac
          fi
      done
      ;;
   2) FINISH=0
      until (( FINISH == 1 ))
      do
        clear
        BANK=
        echo -e "\n\n\t\tSELECT A BANK TO STORE THIS BACKUP\n"
        echo -e "\nAvailable Banks:\n"
        for B in $BANK_LIST
        do
             echo -e "\t$B"
        done
        echo -e "\nPlease Enter a Bank: \c:"
        read BANK
        if $(echo $BANK_LIST | grep -q ${BANK})
        then
            echo "$BANK selected for $HN"
            FINISH=1
        else
            echo -e "\nERROR: $BANK is not a Valid Bank"
            sleep 2
            continue
        fi
      done
```

Listing 27-24 (*continued*)

```
     ;;
  3) echo -e "\n\tEnter the Directory Tree to Back Up: \c"
     read TREE
     continue
     ;;
  4) clear
     echo -e "\n\n\tDIRECTORY TREE(S) and FILES TO IGNORE\n"
     echo -e "\nThe Specified Directory Tree Contains the Following
Files/Directories:\n\n"
     if [ $HN = $(hostname) ]
     then
         ls $TREE | more
     else
         ssh $HN ls $TREE | more
     fi
     echo -e "\nDo you want to Exclude any Files or Directories from
the Backups? (y/n): \c"
     read ANS3
     case $ANS3 in
     y|Y) echo -e "\n\tEnter Directories and Files to Ignore One per
Line\n"
          echo -e "Enter 99 when finished\n"
          IGNORE_LIST=$(read_input)
          continue
          ;;
     n|N) IGNORE_LIST=$(echo)
          continue
          ;;
       *) echo -e "\nInvalid Entry..."
          ;;
     esac
     ;;
  5) echo -e "\n\tDays before each Backup Expires: \c"
     read DAYS
     continue
     ;;
  6) clear
     echo -e "\n\n\tADD NEW BACKUP TO DIRVISH"
     if [[ -r "${BANK}/${HN}/dirvish/default.conf" ]]
     then
        echo -e "\nWARNING: default.conf File Exists...Rebuild default.
conf? (y/n): \c"
        read ANS
        case $ANS in
        y|Y) echo -e "\n\nCreating default.conf Dirvish Configuration
File for $HN"
             build_default_conf $HN "$BANK" $DAYS "$TREE"
"$IGNORE_LIST"
```

Listing 27-24 (*continued*)

```
            echo -e "\nCopying file to:  ${BANK}/${HN}/dirvish
/default.conf"
            cp -f $DEFAULT_CONF "${BANK}/${HN}/dirvish/default.conf"
            echo -e "\n\n...Press ENTER to Continue...\c"
            read ANS
            ;;
         *) break
            ;;
       esac
    else
        echo -e "\n\nCreating default.conf Dirvish Configuration
File for $HN"
        build_default_conf $HN "$BANK" $DAYS "$TREE" "$IGNORE_LIST"
        echo -e "\nCopying file to:  ${BANK}/${HN}/dirvish/default.
conf"
        cp -f $DEFAULT_CONF "${BANK}/${HN}/dirvish/default.conf"
        echo -e "\n...Press ENTER to Continue...\c"
        read ANS
    fi
    ;;
  7) clear
    echo -e "\n\n\tCREATE INITIAL DIRVISH BACKUP"
    echo -e "\n"
    if [[ ! -d "${BANK}/${HN}" ]]
    then
       echo -e "\nCreating Vault $HN for this Backup"
       mkdir "${BANK}/${HN}"
       mkdir "${BANK}/${HN}/dirvish"
    else
       echo -e "\nBackup Vault for $HN Exists...Continuing..."
    fi
    if [[ ! -r "${BANK}/${HN}/dirvish/default.conf" ]]
    then
       Now we have enough information to build the new default.conf
file

       echo -e "Creating default.conf Dirvish Configuration File for
$HN"
       build_default_conf $HN "$BANK" $DAYS "$TREE" "$IGNORE_LIST"

       echo -e "\nCopying file to:  ${BANK}/${HN}/dirvish/default.
conf"
       cp -f $DEFAULT_CONF "${BANK}/${HN}/dirvish/default.conf"

       # Now we need to run an initial backup
       echo -e "\n\tRun an Initial Backup Now? (y/n): \c"
       read BACK_NOW
       case $BACK_NOW in
```

Listing 27-24 (*continued*)

```
        y|Y) echo -e "\nExecuting Initial Dirvish Backup for $HN..."
             /usr/local/sbin/dirvish --vault $HN --init
             RC=$?
             echo -e "\nInitial Backup for $HN Completed with a
Return Code: $RC"
             echo -e "\n...Press Enter to Continue...\c"
             read KEY
             ;;
        n|N) echo -e "\nInitial Backup Skipped..."
             echo -e "\nDo Not Forget to Run an Initial Dirvish
Backup!"
             echo -e "\nTo Manually Run an Initial Backup Enter:\n"
             echo -e "\t/usr/local/sbin/dirvish --vault $HN --init\n"
             echo -e "\n...Press Enter to Continue...\c"
             read KEY
             ;;
         *) echo -e "\nInvalid Input..."
            ;;
        esac
     else
        FINISH=0
        until (( FINISH == 1 ))
        do
           echo -e "\nRun an Initial Backup Now? (y/n): \c"
           read BACK_NOW
           case $BACK_NOW in
           y|Y) echo -e "\nExecuting Initial Dirvish Backup for $HN..."
                /usr/local/sbin/dirvish --vault $HN --init
                RC=$?
                echo -e "\nInitial Backup for $HN Completed with a
Return Code: $RC"
                echo -e "\nPress Enter to Continue...\c"
                read KEY
                FINISH=1
                ;;
           n|N) echo -e "\nInitial Backup Skipped..."
                echo -e "\nDo Not Forget to Run an Initial Dirvish
Backup!"
                echo -e "\nTo Manually Run an Initial Backup Enter:\n"
                echo -e "\t/usr/local/sbin/dirvish --vault $HN
--init\n"
                echo -e "\nPress Enter to Continue...\c"
                read KEY
                FINISH=1
                ;;
            *) echo -e "Invalid Entry..."
               sleep 2
               ;;
```

Listing 27-24 (*continued*)

```
          esac
        done
      fi
      continue
      ;;
  8) break
      ;;
  esac
done
}

########################################

delete_backup ()
{
# This function is used to delete backups from the Dirvish server

clear # Clear the screen
echo -e "\n\n\t\tREMOVE A SERVER FROM DIRVISH BACKUPS\n"
echo -e "\n\tEnter the Host to Remove from Dirvish Backups: \c"
read H

BANK_LIST=$(parse_conf)

for P in $BANK_LIST
do
    VAULT_ID=$(find $P -type d -name "$H")
    if [[ ! -z "$VAULT_ID" ]]
    then
        STOP=0
        until (( STOP == 1 ))
        do
           echo -e "\n\tRemove Backup Vault $H from the Dirvish Backup
Server? (y/n): \c"
           read ANS
           case $ANS in
           y|Y) echo -e "\n\tRemoving Backup Vault for $H from
Dirvish Backups...\c"
                rm -fr "$VAULT_ID"
                echo -e "\n\tBackup Vault Removed...Press Enter
to Continue...\c"
                read KEY
                STOP=1
                ;;
           n|N) echo -e "\n\tVault Removal Canceled...Press Enter to
Continue...\c"
                read KEY
                STOP=1
```

Listing 27-24 (*continued*)

```
                continue
                ;;
             *) echo -e "\n\tInvalid Entry..."
                ;;
          esac
       done
   fi
done
}

########################################

manage_banks ()
{
# This function is used to add and delete Dirvish banks

# set -x # Uncomment to debug this function

clear # Clear the screen

# Get a list of currently defined Dirvish banks
BANK_LIST=$(parse_conf)

# Display the screen header information
echo -e "\n\n\tMANAGE DIRVISH BACKUP BANKS"
echo -e "\n\nCurrently Configured Backup Bank(s):\n"

NO_BANK=0

# If this is an initial installation there will not
# be any Dirvish banks defined.

if [ -z "$BANK_LIST" ]
then
    NO_BANK=1
    echo -e "\nNo Backup Banks Have Been Defined in Dirvish\n"
else
    BANK_FILE=/tmp/banklist.out
    >$BANK_FILE
    COUNT=0

    for B in $BANK_LIST
    do
       ((COUNT == COUNT + 1))
       LAST_ENTRY=$B
       echo -e "\t$B" | tee -a $BANK_FILE
    done
fi
```

Listing 27-24 (*continued*)

```
# Display the menu options

echo -e "\n\n1) Add a New Backup Bank"
echo -e "\n2) Delete a Current Backup Bank"
echo -e "\n3) Return to the Previous Menu"
echo -e "\n\nSelect an Option: \c"

# Read the user input
read OPT
case $OPT in
1) # Add a New Backup Bank
   echo -e "\nEnter the Bank to Add: \c"
   read A_BANK
   echo -e "\nAdding New Backup Bank: $A_BANK"
   if (( NO_BANK == 0 ))
   then
     sed "s!$LAST_ENTRY!& \n\t${A_BANK}!g" $M_CONFIG > ${M_CONFIG}.
modified
     if (( $? == 0 ))
     then
        # Save the old Dirvish master config file with today's
datestamp
        cp ${M_CONFIG} ${M_CONFIG}.$(date +%m%d%Y)
        cp ${M_CONFIG}.modified ${M_CONFIG}

        echo -e "\n$A_BANK Successfully Added to Dirvish Master
Config File"

        # Check to see if the $A_BANK directoey exists, if not
        # ask the user if it is okay to create it.

        chk_create_dir $A_BANK
     else
        echo -e "\nERROR: Adding $A_BANK Failed...See
Administrator..."
     fi
   else
     if $(grep -q "bank:" $M_CONFIG)
     then
        # NOTICE: It is important to note that sed does not "require"
        # us to use / as a field separator. Here we are using ! as a
        # sed field separator because we are working with UNIX
directory
        # paths, sed gets confused using / as a field separator.

        sed "s!bank:!& \n\t${A_BANK}!g" $M_CONFIG > ${M_CONFIG}.
modified
```

Listing 27-24 (*continued*)

```
        if (( $? == 0 ))
        then
            cp ${M_CONFIG} ${M_CONFIG}.$(date +%m%d%Y)
            cp ${M_CONFIG}.modified ${M_CONFIG}
            echo -e "\n$A_BANK Successfully Added to Dirvish Master
Config File"
            chk_create_dir $A_BANK
        else
            echo -e "\nERROR: Adding $A_BANK Failed...See
Administrator..."
        fi
     else
        echo -e "bank:\n\t$A_BANK" >> ${M_CONFIG}.modified
        if (( $? == 0 ))
        then
           cp ${M_CONFIG} ${M_CONFIG}.$(date +%m%d%Y)
           cp ${M_CONFIG}.modified ${M_CONFIG}
           echo -e "\n$A_BANK Successfully Added to Dirvish Master
Config File"
           chk_create_dir $A_BANK
        else
           echo -e "\nERROR: Adding $A_BANK Failed...
See Administrator..."
        fi
     fi
   fi

   rm -f $BANK_FILE

   echo -e "\nPress Enter to Continue...\c"
   read KEY
   ;;
2) echo -e "\nEnter the Backup Bank to Remove: \c"
   read R_BANK
   if [ -d $R_BANK ]
   then
     POPULATED=$(ls $R_BANK | wc -l)
     if (( POPULATED > 0 ))
     then
        echo -e "\nWARNING: The Bank $R_BANK has the Following Backup
Images:\n"
        ls $R_BANK | more
        echo -e "\nAre you Sure you Want to Remove this Bank and
all of the Backup Images? (y/n): \c"
        read ANS
        case $ANS in
```

Listing 27-24 (*continued*)

```
        y|Y) continue
             ;;
        n|N) break
             ;;
          *) echo -e "\nInvalid Input..."
             ;;
        esac
     fi
   fi
   if $(cat "$BANK_FILE" | grep -q "$R_BANK")
   then
       if (( COUNT == 1 ))
       then
           echo -e "\nWARNING: $R_BANK is the Only Backup Bank
Currently Configured!"
           echo -e "\nRemoving this Bank Will Cripple Dirvish..."
       fi
       echo -e "\nAre you Sure You Want to Remove the $R_BANK Bank?
(y/n): \c"
       read ANS4
       case $ANS4 in
       y|Y) cat $M_CONFIG | grep -v $R_BANK > ${M_CONFIG}.modified
            cp -p $M_CONFIG ${M_CONFIG}.bak.$(date +%m%d%y)
            cp ${M_CONFIG}.modified $M_CONFIG
            echo -e "\n$R_BANK Removed from the Dirvish Configuration
File..."
            if [ -d $R_BANK ]
            then
               echo -e "\nDo You Want to Remove the $R_BANK Directory?
(y/n): \c"
               read ANS
               case $ANS in
               y|Y) rm -r $R_BANK
                   if (( $? == 0 ))
                   then
                       echo -e "\n$R_BANK Directory Removed
Successfully"
                   else
                       echo -e "\nERROR: Remove $R_BANK Directory
Failed"
                   fi
                   ;;
               n|N) echo -e "\nSkipping $R_BANK Directory Removal"
                   ;;
                 *) echo -e "\nInvalid Input..."
                   ;;
               esac
```

Listing 27-24 (*continued*)

```
            fi
            ;;
       n|N) echo -e "\nSkipping Bank Removal\n"
            ;;
         *) echo -e "\nInvalid Entry..."
            ;;
       esac
   else
       echo -e "\nERROR: $R_BANK is Not a Valid Bank"
   fi

   echo -e "\nPress Enter to Continue...\c"
   read KEY

   ;;
3) continue
   ;;
*) echo -e "\nInvalid Entry...\n"
   ;;
esac
}

########################################

check_root_user ()
{
# This function ensures the user is "root"

if [[ $(whoami) != root ]]
then
    echo -e "\n\n\tERROR: Only the root User can Execute this
Program..."
    echo -e "\n\n\t...EXITING...\n"
    exit 1
fi
}

########################################

check_config ()
{
# Find the Dirvish Master Configuration File

if [ -r /etc/dirvish.conf ]
then
    M_CONFIG=/etc/dirvish.conf

elif [ -r /etc/dirvish/master.conf ]
```

Listing 27-24 (*continued*)

```
then
    M_CONFIG=/etc/dirvish/master.conf
else
    echo -e "\n\n\tERROR: Dirvish is not installed on this system"
    echo -e "\tTo use this program install rsync and dirvish first."
    echo -e "\n\t...Exiting...\n"
    exit 2
fi
}

########################################
# BEGINNING OF MAIN
########################################

check_root_user

check_config

until (( DONE == 1 ))
do
    display_main_menu
    read OPTION
    case $OPTION in
    1) # Dirvish RunAll
       run_all
       ;;
    2) # Dirvish Run Backup
       run_backup
       ;;
    3) # Dirvish Locate Image
       locate_restore_image
       ;;
    4) # Dirvish Expire Backup(s)
       expire_backup
       ;;
    5) # Dirvish Add Backup
       add_backup
       ;;
    6) # Dirvish Delete Backup
       delete_backup
       ;;
    7) # Manage Backup Banks
       manage_banks
       ;;
    8) clear
       DONE=1
       ;;
    *) echo -e "\n\tERROR: Invalid Entry..."
```

Listing 27-24 (*continued*)

```
        sleep 2
        ;;
    esac
done
```

Listing 27-24 (*continued*)

I know this is a long shell script, but it takes care of a lot of different Dirvish tasks and is a good tool for any shop using Dirvish as a backup solution.

Using the dirvish_ctrl Shell Script

In this section we are going to show examples of using the `dirvish_ctrl` shell script to perform each task. Please follow through this section, and then play around with Dirvish on your own, I'm sure you will be impressed with the capabilities of Dirvish.

The `dirvish_ctrl` main menu is shown in Listing 27-25.

```
        WELCOME TO DIRVISH BACKUP COMMAND-CENTER


        1) Dirvish Run All Backups

        2) Dirvish Run a Particular Backup

        3) Dirvish Locate/Restore a Backup Image

        4) Dirvish Expire/Delete Backup(s)

        5) Dirvish Add a New Backup

        6) Dirvish Remove a Backup

        7) Dirvish Manage Backup Banks

        8) EXIT


        Select an Option:
```

Listing 27-25 dirvish_ctrl shell script main menu

We are going to step through using each option in the following sections.

Running All Backups Defined in the Runall: Stanza

The `dirvish-runall` command is used for this task and has the limitation of requiring each server to be defined in the `Runall:` stanza in the `master.conf` file.

Notice in Listing 27-26 that `yogi`, `booboo`, `dino`, `wilma`, and `fred` are the only backups defined in the `Runall:` stanza in the Dirvish master configuration file, `master.conf`.

```
14:03:58 dirvish --vault yogi
14:03:59 dirvish --vault booboo
14:04:04 dirvish --vault dino
14:04:22 dirvish --vault wilma
14:04:51 dirvish --vault fred
14:05:04 done

        Backups Complete...Press Enter to Continue...
```

Listing 27-26 Using Option 1, Dirvish Run All Backups

Running One Particular Backup

We also have the ability to run individual backups anytime. Listing 27-27 shows a backup of `booboo`.

```
                RUN A PARTICULAR BACKUP

        Enter a Hostname to Back Up: booboo

Searching for default.conf in booboo's Vault

Found Configuration File...Starting Backup...

Dirvish Exit Code: 0

Backup Complete...

Press Enter to Continue...
```

Listing 27-27 Using Option 2, Dirvish Run a Particular Backup

When we run an individual backup, the script first checks to ensure the vault has a `default.conf` file. If the `default.conf` file is found, we execute the backup using the following syntax:

```
/usr/local/sbin/dirvish -vault $HN
```

where `$HN` is the name of the vault to back up.

Locating and Restoring Files

If you make backups, you need a way to restore the files when needed. The nice thing about Dirvish is that each snapshot backup is fully intact in the image `tree`

subdirectory. So, after we find the file we want in the individual image directory, we just copy the files/directories recursively to the local restore area. In this script the restore area is hard-coded to `/dirvish_restores`. If your Dirvish backup server is different, modify the `RESTORE_AREA` variable in the definition section at the top of the `dirvish_ctrl` shell script in Listing 27-24. Listing 27-28 shows the process of locating and restoring a file.

```
                LOCATE/RESTORE A BACKUP IMAGE

Enter the Hostname where the File/Directory Resides: yogi

Enter as Much of the Directory Path and Filename as You Know:

dirvish_ctrl

Searching for Archive Images...
3 matches in 16 images
/scripts/DESTIN_FL/dirvish_ctrl
    May 25  2007 yogi-071211140359, yogi-071211125815
    May 25  2007 yogi-071211115107, yogi-071211115013,
                 yogi-071210123131
                 yogi-071210123128, yogi-071210123049,
                 yogi-071210122858
                 yogi-071210122226, yogi-071210122214,
                 yogi-071210122030

/scripts/dirvish_ctrl
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815
    Dec 11 10:04 yogi-071211115107, yogi-071211115013
    Dec 10 12:31 yogi-071210123131, yogi-071210123128
    Dec 10 12:30 yogi-071210123049
    Dec 10 12:28 yogi-071210122858
    Dec 10 12:19 yogi-071210122226, yogi-071210122214,
                 yogi-071210122030
    May 25 09:28 yogi-070719153227, yogi-070627130342,
                 yogi-070626093920
                 yogi-070529152028
    May 21 14:30 scripts-070521144312

/scripts/dirvish_ctrl.log
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815


Did You Find What You Want? (y/n):

Do You Want to Perform a Restore? (y/n): y
```

Listing 27-28 Using Option 3, Dirvish Locate/Restore a Backup Image

```
Enter the FULL PATHNAME of the File/Directory You Want to Restore:

/scripts/dirvish_ctrl

Searching Images...
2 matches in 16 images
/scripts/dirvish_ctrl
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815
    Dec 11 10:04 yogi-071211115107, yogi-071211115013
    Dec 10 12:31 yogi-071210123131, yogi-071210123128
    Dec 10 12:30 yogi-071210123049
    Dec 10 12:28 yogi-071210122858
    Dec 10 12:19 yogi-071210122226, yogi-071210122214,
                 yogi-071210122030
    May 25 09:28 yogi-070719153227, yogi-070627130342,
                 yogi-070626093920
                 yogi-070529152028
    May 21 14:30 scripts-070521144312

/scripts/dirvish_ctrl.log
    Dec 11 14:03 yogi-071211140359
    Dec 11 12:56 yogi-071211125815


Enter the Image to Restore From:  yogi-071211140359

DIRNAME is /scripts

Files Restored to the Following Restore Area:

/dirvish_restores/yogi/dirvish_ctrl

Press Enter to Continue...
```

Listing 27-28 (*continued*)

Notice in Listing 27-28 that we can search all the images in a specific vault for files and directories without knowing the entire file or directory name. The search does a `grep`-type search for patterns. The result is a list of all the matching files and directories and a list of all the images that contain files that match the search pattern. The user must select a file to restore and the image to retrieve the file from. As stated before, retrieving the file is nothing more than a `cp -fpr` command.

Deleting Expired Backups and Expiring Backups

This option lets us delete expired backups from all vaults, and from individual vaults. We can also expire images that are not currently expired. This is the method to use to delete a backup you no longer need but is not expired. Listing 27-29 shows the sub-menu to delete and expire backups.

```
           DIRVISH EXPIRE BACKUP(S)


        1) Delete Expired Backups for ALL Hosts

        2) Delete Expired Backups for One Host

        3) Expire One Backup for One Host

        4) Expire All Backups for One Host

        5) Previous Menu


        Select an Option:
```

Listing 27-29 Using Option 4, Dirvish Expire/Delete Backup(s) Sub-Menu

Now let's look at each option individually. Listing 27-30 shows how to delete expired backups from all vaults.

```
        Deleting Expired Backups for ALL Hosts...

Expiring images as of 2007-12-11 14:56:19

VAULT:BRANCH    IMAGE           CREATED           EXPIRED
yogi:default    yogi-070521143304 2007-05-21 14:33  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143444 2007-05-21 14:34  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143540 2007-05-21 14:35  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143806 2007-05-21 14:38  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143823 2007-05-21 14:38  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143841 2007-05-21 14:38  15 day == 2007-05-25
09:27
yogi:default    yogi-070521143927 2007-05-21 14:39  15 day == 2007-05-25
09:27
yogi:default    scripts-070521144235 2007-05-21 14:42  15 day
== 2007-05-25 09:28
yogi:default    scripts-070521144312 2007-05-21 14:43  15 day
== 2007-05-25 09:27
```

Listing 27-30 Using Expire Option 1, Delete Expired Backups for ALL Hosts

```
        Tasks Complete...

        Press Enter to Continue...
```

Listing 27-30 (*continued*)

As Dirvish deletes expired backups, it produces a list of activities. Listing 27-31 shows how to delete expired backups for a particular vault.

```
              DIRVISH EXPIRE BACKUP(S)


        1) Delete Expired Backups for ALL Hosts

        2) Delete Expired Backups for One Host

        3) Expire One Backup for One Host

        4) Expire All Backups for One Host

        5) Previous Menu


        Select an Option: 2

        Enter the Hostname to Delete Expired Backups: booboo

        Tasks Complete...

        Press Enter to Continue...
```

Listing 27-31 Using Expire Option 2, Delete Expired Backups for One Host

Notice that we did not go to a sub-menu for this option. Listing 27-32 shows how to expire one particular image in one particular vault.

```
        Enter the Hostname for the Backup Image: yogi

Select an Image to Expire from the Following List:


yogi-071210123128
yogi-071210122858
```

Listing 27-32 Using Expire Option 3, Expire One Backup for One Host

```
yogi-071210123049
yogi-071210122030
yogi-071211125815
yogi-071211115013
yogi-071211115107
yogi-071210123131
yogi-071211140359
yogi-071210122226
yogi-071210122214


        Enter the Image to Expire:  yogi-071211140359

        Tasks Complete...Do You Want to Delete This Expired Image?
(y/n): y

        Deleting Expired Image: yogi-071211140359

        Dirvish-expire Completed with Return Code: 0

        Tasks Complete...

        Press Enter to Continue...
```

Listing 27-32 (*continued*)

This option in Listing 27-32 asks the user for a vault. Then we show a list of current backup images. The script asks the user to enter an image name to expire, and modify the summary file located in the specified vault to change the time stamp to the current date/time. Listing 27-33 shows how to expire all the backup images in a particular vault.

```
Enter the Hostname for the Backup Image: booboo

Setting the Following Images to Expire:


yogi-071211100332
yogi-071211140359
yogi-071211141138
yogi-071211141309
yogi-071211115107
yogi-071211141248

Press Enter to Continue...Expiring yogi-071211100332
Expiring yogi-071211140359
Expiring yogi-071211141138
Expiring yogi-071211141309
```

Listing 27-33 Using Expire Option 4, Expire All Backups for One Host

```
Expiring yogi-071211115107
Expiring yogi-071211141248

Tasks Complete...Do You Want to Delete Expired Images? (y/n): y

Deleting Expired Images...

Expiring images as of 2007-12-11 15:21:07
Restricted to vault yogi

VAULT:BRANCH    IMAGE           CREATED           EXPIRED
yogi:default  yogi-071211115107 2007-12-11 11:51  30 day == 2007-12-11
15:20
yogi:default  yogi-071211140359 2007-12-11 14:03  30 day == 2007-12-11
15:20
yogi:default  yogi-071211141138 2007-12-11 14:11  30 day == 2007-12-11
15:20
yogi:default  yogi-071211141248 2007-12-11 14:12  30 day == 2007-12-11
15:20
yogi:default  yogi-071211141309 2007-12-11 14:13  30 day == 2007-12-11
15:20

Dirvish-expire Completed with Return Code: 0

Tasks Complete...

Press Enter to Continue...
```

Listing 27-33 (*continued*)

For this option we modify the date/time stamp in the summary files in all image subdirectories for that particular vault.

Adding a New Dirvish Backup Vault

To add a new backup vault, we need only to create a new vault directory and create a `default.conf` file for it. To create the new `default.conf` file, we need some information. Listing 27-34 shows the sub-menu to add a new Dirvish vault.

```
            DIRVISH ADD A BACKUP

        Select Each Option to Add a New Backup

        1) Enter Hostname

        2) Select a Bank for this Backup
```

Listing 27-34 Main Menu Option 5, Add a New Backup Sub-Menu

```
        3) Enter Directory Tree to Back Up

        4) Enter Files and Directories to Ignore

        5) Enter Days to Retain Each Backup

        6) Add the New Backup to Dirvish

        7) Create the Initial Backup

        8) Main Menu

        Select Each Option to Add a New Backup

        Enter Option:
```

Listing 27-34 (*continued*)

The process of adding a new backup is to select Options 1–7, one at a time, to configure the new backup in Dirvish, and then to run an initial backup. Let's look at each step individually.

Option 1 is where we get the name of the new vault. Remember that we refer to hostname and vault interchangeably for this shell script. Listing 27-35 shows adding a new hostname.

```
              DIRVISH ADD A BACKUP

        Select Each Option to Add a New Backup

        1) Enter Hostname

        2) Select a Bank for this Backup

        3) Enter Directory Tree to Back Up

        4) Enter Files and Directories to Ignore

        5) Enter Days to Retain Each Backup

        6) Add the New Backup to Dirvish

        7) Create the Initial Backup

        8) Main Menu
```

Listing 27-35 Add a Backup Option 1, Enter Hostname

```
        Select Each Option to Add a New Backup

        Enter Option: 1

        Enter the Hostname for this Backup: booboo
```

Listing 27-35 (*continued*)

Notice that this option did not create a sub-menu. Listing 27-36 shows how to select a bank to store this new backup in.

```
        SELECT A BANK TO STORE THIS BACKUP


Available Banks:

        /backup_bank1
        /prod_backups

Please Enter a Bank: /backup_bank1
```

Listing 27-36 Add a Backup Option 2, Select a Bank for This Backup

Notice that we display all the banks that are currently defined in the `master.conf` file before we ask the user to enter the desired bank for this backup. Listing 27-37 shows how to add the directory tree to back up.

```
            DIRVISH ADD A BACKUP

        Select Each Option to Add a New Backup

        1) Enter Hostname

        2) Select a Bank for this Backup

        3) Enter Directory Tree to Back Up

        4) Enter Files and Directories to Ignore

        5) Enter Days to Retain Each Backup

        6) Add the New Backup to Dirvish
```

Listing 27-37 Add a Backup Option 3, Enter Directory Tree to Back Up

```
        7) Create the Initial Backup

        8) Main Menu

        Select Each Option to Add a New Backup

        Enter Option: 3

        Enter the Directory Tree to Back Up: /scripts
```

Listing 27-37 (*continued*)

This step does not create a sub-menu, either. In Listing 27-38 we list all the files and directories in the tree specified in the last step, and ask the users if they meant to exclude anything. If they do, we keep reading input until 99 is entered.

```
        DIRECTORY TREE(S) and FILES TO IGNORE


The Specified Directory Tree Contains the Following Files/Directories:


mysqlbackup.sh
dsh
get-date.ksh
pluck.sh
tmp/shortlog.out
test/shortlog.out

Do you want to Exclude any Files or Directories from the Backups? (y/n): y


        Enter Directories and Files to Ignore One per Line

Enter 99 when finished

tmp/
test/
99
```

Listing 27-38 Add a Backup Option 4, Enter Files and Directories to Ignore

NOTE **Notice that when we define sub-directories to exclude, we use relative pathnames (path does not start with a `/`) with a trailing forward slash — for example, `tmp/`. This is an important point to note because we must specify the relative pathname in the `exclude:` stanza of the `default.conf` file.**

Listing 27-39 shows the prompt for the number of days before the backup expires.

```
              DIRVISH ADD A BACKUP

         Select Each Option to Add a New Backup

         1) Enter Hostname

         2) Select a Bank for this Backup

         3) Enter Directory Tree to Back Up

         4) Enter Directory Trees to Ignore

         5) Enter Days to Retain Each Backup

         6) Add the New Backup to Dirvish

         7) Create the Initial Backup

         8) Main Menu

         Select Each Option to Add a New Backup

         Enter Option: 5

         Days before each Backup Expires: 30
```

Listing 27-39 Add a Backup Option 5, Enter Days to Retain Each Backup

Notice again that we did not create a sub-menu. Listing 27-40 creates the new vault directory, if it does not already exist, and the new `default.conf` file that described this backup.

```
         ADD NEW BACKUP TO DIRVISH

WARNING: default.conf File Exists...Rebuild default.conf? (y/n): y


Creating default.conf Dirvish Configuration File for booboo

Copying file to:  /backup_bank1/borg/dirvish/default.conf


...Press ENTER to Continue...
```

Listing 27-40 Add a Backup Option 6, Add the New Backup to Dirvish

The internal file we first create is a temporary file. Here we copy the file to the correct vault. Listing 27-41 shows the step where we create the initial Dirvish backup. This initial backup is required because it is the reference set for future backups to reduce the amount of data transmitted over the network. The unchanged data is not transmitted.

```
          CREATE INITIAL DIRVISH BACKUP


Backup Vault for borg Exists...Continuing...

Run an Initial Backup Now? (y/n): y

Executing Initial Dirvish Backup for borg...

Initial Backup for borg Completed with a Return Code: 0

Press Enter to Continue...
```

Listing 27-41 Add a Backup Option 7, Create the Initial Backup

Removing a Dirvish Vault

To remove a Dirvish vault, we need only to remove the vault's subdirectory and all its contents. Listing 27-42 shows the removal of a vault.

```
        REMOVE A SERVER FROM DIRVISH BACKUPS


   Enter the Host to Remove from Dirvish Backups: booboo

   Remove Backup Vault booboo from the Dirvish Backup Server? (y/n): y

   Removing Backup Vault for booboo from Dirvish Backups...

   Backup Vault Removed...Press Enter to Continue...
```

Listing 27-42 Main Menu Option 6, Dirvish Remove a Backup

Here we ask the user for the name of the vault/host to remove. Before removing a vault, we ask the user to confirm the removal.

Managing Dirvish Backup Banks

This task allows us to add and delete Dirvish backup banks. Listing 27-43 shows the sub-menu to manage the Dirvish backup banks.

```
        MANAGE DIRVISH BACKUP BANKS

Currently Configured Backup Bank(s):

        /backup_bank1
        /prod_backups
        /backup_bank2


1) Add a New Backup Bank

2) Delete a Current Backup Bank

3) Return to the Previous Menu

Select an Option:
```

Listing 27-43 Main Menu Option 7, Dirvish Manage Backup Banks Sub-Menu

Adding a New Dirvish Backup Bank

To add a new Dirvish backup bank, we select Option 3. Listing 27-44 shows how to add a new bank to the Dirvish configuration, and ask the user before we create the new directory for the bank.

```
        MANAGE DIRVISH BACKUP BANKS


Currently Configured Backup Bank(s):

        /backup_bank1
        /prod_backups


1) Add a New Backup Bank

2) Delete a Current Backup Bank

3) Return to the Previous Menu


Select an Option: 1

Enter the Bank to Add: /qa_backups
```

Listing 27-44 Example of adding a new Dirvish backup bank

```
Adding New Backup Bank: /qa_backups

/qa_backups Successfully Added to Dirvish Master Config File

/qa_backups Directory Does Not Exist...Create /qa_backups Directory?
(y/n): y

Creating /qa_backups Directory...

/qa_backups Directory Created

Press Enter to Continue...
```

Listing 27-44 (*continued*)

Notice in Listing 27-44 that we ask the user before we create the directory for the new bank. This is to give the users a chance to build a new filesystem for the bank if they have not already done so.

Removing a Dirvish Backup Bank

To remove a Dirvish backup bank, we select Option 2. Listing 27-45 shows how to remove a bank from the Dirvish configuration, and then prompt the user to delete the bank from the system. This will also remove all the backup images stored in that directory tree.

```
Enter the Backup Bank to Remove: /backup_bank2

Are you Sure You Want to Remove the /backup_bank2 Bank? (y/n): y

/backup_bank2 Removed from the Dirvish Configuration File...

Do You Want to Remove the /backup_bank2 Directory? (y/n): y

/backup_bank2 Directory Removed Successfully

Press Enter to Continue...
```

Listing 27-45 Removing a Dirvish backup bank

Notice that before we delete a bank directory, we confirm the removal. Removing the bank directory deletes all the stored images, as well.

Other Things to Consider

I know this is a long chapter and we covered a lot of points in fine detail, but we can always improve. I did not cover using branches very much in this chapter, and you may want to add some functionality to support branches if you use them.

If you are running backups on a daily basis, this menu program is really not what you want. A better bet is to add a cron entry to the root cron table to first delete all expired backups by running the `dirvish-expire` command, then execute the `dirvish-runall` command to kick off the backups. Of course, you need to add each vault to the `Runall:` stanza in the `master.conf` file. A sample cron entry is shown here:

```
0, 23, 0, 0, 0 /usr/local/sbin/dirvish-expire -quiet;
/usr/local/sbin/dirvish-runall --quiet
```

This cron entry will start every night at 11:00 p.m. and first run the `dirvish-expire` command in quiet mode. When the `dirvish-expire` command completes, the `dirvish-runall` command is started in quiet mode.

Summary

I really enjoyed writing this chapter. You should play around with Dirvish on your own and modify the `dirvish_ctrl` shell script to meet the needs of your shop.

In the next chapter we will look at techniques to monitor a user's keystrokes using the `script` command.

Lab Assignments

1. Modify the `dirvish_ctrl` shell script to give the user the option when creating a new backup to add it to the `Runall:` stanza in the `master.conf` file.
2. Rewrite the `dirvish_ctrl` shell script to use the `select` command with a `case` statement to create all the menus. For more details on the `select` command, see the ''Create a Menu with the select Command'' section in Chapter 1, ''Scripting Quick Start and Review,'' and the online manual page, **man select**.
3. Install Dirvish on a server, from scratch, using any method you choose. Using the `dirvish_ctrl` shell script, configure an initial bank, then configure Dirvish to back up a remote server while excluding all `*.log`, `*.a`, `core`, `/proc`, and `/tmp` files and directories. Run an initial backup and time its execution. After this initial backup completes, run a second backup (not another initial backup) and time this second backup. What is the percentage difference in execution times between the two backups?

CHAPTER

28

Monitoring and Auditing User Keystrokes

In most large shops there is a need, at least occasionally, to monitor a user's actions. Thanks to Sarbanes-Oxley requirements on publicly traded United States companies for auditing, we are now required to audit the keystrokes of anyone with `root` access to the system or other administration type accounts, such as `oracle`. Contractors on site can pose a particular security risk. Typically when a new application comes into the environment, one or two contractors are on site for a period of time for installation, troubleshooting, and training personnel on the product. I always set up contractors in **sudo** (see Chapter 23, ''Creating a System-Configuration Snapshot,'' for more details on `sudo`) to access the new application account, after I change the password. `sudo` tracks only the commands that were entered with a date/time stamp. The detail of the command output from `stdout` and `stderr` does not get logged so you do not have a complete audit trail of exactly what happened if a problem arises.

To get around this dilemma you can track a user's keystrokes from the time he or she accesses a user account until the time he or she exits the account, if you have the space for the log file. This little feat is accomplished using the **script** command. The idea is to use `sudo` to kick off a shell script that starts a `script` session. When the `script` session is running, all of the input and output on the terminal is captured in the log file. Of course, if the user goes into some menus or programs the log file gets a little hard to read, but we at least have an idea of what happened. This monitoring is not done surreptitiously because I always want everyone to know that the monitoring is taking place. When a `script` session starts, output from the `script` command informs the user that a session is running and gives the name of the session's log file. We can also set up monitoring to take place from the time a user logs in until the user logs out. For this monitoring we do not need `sudo`, but we do need to edit the `$HOME/.profile` or other login-configuration file for the particular user.

Syntax

Using the `script` command is straightforward, but we want to do a few more things in the shell script. Giving a specific command prompt is one option. If you are auditing `root` access, you need to have a timeout set so that after about five minutes (see the `TMOUT` environment variable discussion after Listing 28-3 later in this chapter) the shell times out and the `root` access ends. On a shell timeout, the session is terminated and the user is either logged out or presented with a command prompt, but we can control this behavior. We have many options for this set of shell scripts. You are going to need to set up `sudo`, *Super User Do*, on your machine. The full details for installing and configuring `sudo` are in Chapter 23. We want `sudo` to be configured with the names of each of the shell scripts that are used for this monitoring effort, as well as the specific users that you will allow to execute them. We will get to these details later.

The `script` command works by making a typescript of everything that appears on the terminal. The `script` command is followed by a filename that will contain the captured typescript. If no filename is given the typescript is saved in the current directory in a file called `typescript`. For our scripting we will specify a filename to use. The `script` session ends when the forked shell is exited, which means that there are two exits required to completely log out of the system. The `script` command has the following syntax:

```
script [filename]
```

As the `script` session starts, notification is shown on the terminal and a time stamp is placed at the top of the file, indicating the start time of the session. Let's look at a short `script` session as used on the command line in Listing 28-1.

```
[root:yogi]@/# more /usr/local/logs/script/script_example.out

Script command is started on Wed May  8 21:35:27 EDT 2002.
[root:yogi]@/# cd /usr/spool/cron/crontabs
[root:yogi]@/usr/spool/cron/crontabs# ls
adm   root  sys   uucp
[root:yogi]@/usr/spool/cron/crontabs# ls -al
total 13
drwxrwx---   2 bin      cron            512 Feb 10 21:36 .
drwxr-xr-x   4 bin      cron            512 Jul 26 2001  ..
-rw-r--r--   1 adm      cron           2027 Feb 10 21:36 adm
-rw-------   1 root     cron           1125 Feb 10 21:35 root
-rw-r--r--   1 sys      cron            864 Jul 26 2001  sys
-rw-r--r--   1 root     cron            703 Jul 26 2001  uucp
[root:yogi]@/usr/spool/cron/crontabs# cd ../..
[root:yogi]@/usr/spool# ls -l
total 12
drwxrwsrwt   2 daemon   staff           512 Sep 17 2000  calendar
drwxr-xr-x   4 bin      cron            512 Jul 26 2001  cron
drwxrwxr-x   7 lp       lp              512 Mar 23 15:21 lp
```

Listing 28-1 Command-line script session

```
drwxrwxr-x   5 bin      printq          512 May 01 20:32 lpd
drwxrwxr-x   2 bin      mail            512 May 06 17:36 mail
drwxrwx---   2 root     system          512 May 06 17:36 mqueue
drwxrwxr-x   2 bin      printq          512 Apr 29 11:52 qdaemon
drwxr-xr-x   2 root     system          512 Jul 26 2001  rwho
drwxrwsrwx   2 bin      staff           512 Jul 26 2001  secretmail
drwxr-xr-x  11 uucp     uucp            512 Mar 13 20:43 uucp
drwxrwxrwx   2 uucp     uucp            512 Sep 08 2000  uucppublic
drwxrwxr-x   2 root     system          512 Apr 16 2001  writesrv
[root:yogi]@/usr/spool# exit

Script command is complete on Wed May  8 21:36:11 EDT 2002.

[root:yogi]@/#
```

Listing 28-1 (*continued*)

Notice that every keystroke is logged as well as all of the command output. At the beginning and end of the log file a `script` command time stamp is produced. These lines of text are also displayed on the screen as the `script` session starts and stops. These are the user notifications given as the monitoring starts and stops.

Scripting the Solution

There are three different situations in which you want to use this type of monitoring/auditing. In this first instance we have users that you want to monitor the entire session. In the next situation you want to monitor activity only when a user wants `root` access to the system. Our systems have only direct `root` login enabled on the console. To gain access to the `root` user remotely, you must log in as yourself and `su` to `root`, or use `sudo` to gain `root` access. So, for our script, we can use `sudo` to switch to `root` using the `broot` script (shown later in this chapter). The third script is a catchall for other administrative user accounts that you want to audit. The first script is covering end-to-end monitoring with the script execution starting at login through the user's `$HOME/.profile`.

Before we actually start the `script` session, there are some options to consider. Because we are executing a shell script from the user's `.profile` we need to ensure that the script is the last entry in the file. If you do not want the users to edit any `.profile` files, you need to set the ownership of the file to `root` and set the user to read-only access.

Logging User Activity

We are keeping log files so it is a good idea to have some kind of standard format for the log filenames. You have a lot of options for filenames, but I like to keep it simple. Our log files use the following naming convention:

```
[hostname].[user $LOGNAME].[Time Stamp]
```

We want the hostname because most likely you are monitoring users on multiple systems and using a central repository to hold all of the log files. When I write a shell script I do not want to execute a command more times than necessary. The `hostname` command is a good example. Assigning the system's hostname to a variable is a good idea because it is not going to change, or it should not change, during the execution of the script. To assign the `hostname` of the system to a variable use the following command-substitution syntax:

```
THISHOST=$(hostname)
```

For the date/time stamp a simple integer representation is best. The following `date` command gives two digits for month, day, year, hour, minute, and second:

```
TS=$(date +%m%d%y%H%M%S)
```

Now we have to reference only the `$TS` variable for the date/time stamp. Because the user may change we can find the active username with either of the following environment variables:

```
echo $LOGNAME

echo $USER

echo $LOGIN
```

As you change user IDs by using the switch user command (`su`), all of these environment variables change accordingly. However, if a user does a switch user using `sudo`, the `$LOGIN` environment variable carries over to the new user while the `$LOGNAME` and `$USER` environment variables gain the new user ID. Now we have everything to build a log filename. A good variable name for a log file is `LOGFILE`, unless this variable is used by your system or another application. On my systems the `LOGFILE` variable is not used. Not only do we need to create the name of the `$LOGFILE`, but we need to create the file and set the permissions on the file. The initial permissions on the file need to be set to read/write by the owner, `chmod 600 $LOGFILE`. The following commands set up the log file:

```
TS=$(date +%m%d%y%H%M%S)           # Create a time stamp
THISHOST=$(hostname)               # Query the system for the hostname
LOGFILE=${THISHOST}.${LOGNAME}.$TS # Name the log file
touch ${LOGDIR}/$LOGFILE           # Create an empty log file
chmod 600 ${LOGDIR}/${LOGFILE}     # Set the file permissions
```

A sample filename is shown here:

```
yogi.randy.05110214519
```

The filename is good, but where do we want to store the file on the system? I like to use a separate variable to hold the directory name. With two separate variables representing the directory and filename, you can move the log directory to another location and have to change just one entry in the script. I set up a log directory on my

system in /usr/local/logs. For these script log files I added a subdirectory called script. Then I set a LOGDIR variable to point to my logging directory, as shown here:

```
LOGDIR=/usr/local/logs/script
```

Starting the Monitoring Session

With the logging set up we are ready to start a script session. We start the session using the following syntax:

```
script ${LOGDIR}/${LOGFILE}
```

When the script session starts, a message is displayed on the screen that informs the user that a script session has started and lists the name of the script log file, as shown here:

```
Script command is started. The file is /usr/local/logs/script/yogi.randy.
051102174519.
```

If the user knows that monitoring is going on and also knows the name of the file, what is to keep the user from editing or deleting the log? Usually directory permissions will take care of this little problem. During the script session the actual log file is an open file — that is, actually a system temporary file that cannot be accessed directly by the user. But if the user is able to delete the $LOGFILE, you have lost the audit trail. This is one problem that we will discuss later.

Where Is the Repository?

So far here is the scenario. A user has logged in to the system. As the user logs in, a monitoring session is started using the script command, which logs all of the terminal output in a log file that we specify. During the time that the session is active the log file is open as a system temporary file. When the session ends, by a user typing exit or Ctrl + D or by an exit signal, the log file is closed and the user is notified of the session ending, and again the name of the log file is displayed.

For security and auditing purposes we need to have a central repository for the logs. The method I like to use is email. When the session ends we want to set the file permissions on the log file to *read only* by the owner. Then we email the log to another machine, ideally, which is where the repository is located. Once the email is sent I compress the local file and exit the script.

With two copies of the user session existing on two different machines, an audit will easily detect any changes. In fact, if a user tries to change the log these commands will also be logged. You may have different ideas on handling the repository, but I set up a user on a remote machine that I use as a log file manager, with a name **logman**. The logman user's email is the repository on the audit/security machine. For simplicity in this shell script we are going to email the logs to the local logman user. Later in this chapter we will cover mutt and metamail to show techniques to send

files as attachments to an email. To send a simple email, I use the `mailx` command, as shown here:

```
mailx -s "$TS - $LOGNAME Audit Report" $LOG_MANAGER < ${LOGDIR}/${LOGFILE}
```

In the `log_keystrokes.ksh` shell script in Listing 28-2, the `$LOG_MANAGER` is defined as `logman`. The nice thing about having a variable hold the mail recipients is that you can add a second repository of other people to receive email notifications. By using the local `logman` account you have other options. You can set up mail aliases; one of my favorites is to use the `logman` account as a *bounce account*. By adding a `.forward` file in the `$HOME` directory for the `logman` user, you can redirect all of the email sent to the `logman` user to other destinations. If a `.forward` file exists in a user's home directory, the mail is not delivered to the user but instead is sent to each email address and alias listed in the `.forward` file. A sample `.forward` file is shown here:

```
yogibear@cave.com
booboo@cave.com
dino@flintstones.org
admin
```

With the preceding entries in the `$HOME/.forward` file for the `logman` user, all mail directed to `logman` is instead sent to the three email addresses and all of the addresses pointed to by the `admin` email alias.

The Scripts

We have covered all of the basics for the shell scripts. We have three different shell scripts that are used in different ways. The first script is intended to be executed at login time by being the last entry in the user's `$HOME/.profile`. The second shell script is used only when you want to gain `root` access, which is done through `sudo`, and the third script is a catchall for any other administration-type accounts that you want to audit, which also use `sudo`. Let's first look at the login script called `log_keystrokes.ksh`, shown in Listing 28-2.

```
#!/bin/ksh
#
# SCRIPT: log_keystrokes.ksh
#
# AUTHOR: Randy Michael
# DATE: 05/08/2002
# REV: 1.0.P
# PLATFORM: Any Unix
#
# PURPOSE: This shell script is used to monitor a login session by
#          capturing all of the terminal data in a log file using
#          the script command. This shell script name should be
#          the last entry in the user's $HOME/.profile. The log file
```

Listing 28-2 log_keystrokes.ksh shell script

```
#          is both kept locally and emailed to a log file
#          administrative user either locally or on a remote machine.
#
# REV LIST:
#
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this shell script
#
############# DEFINE AUDIT LOG MANAGER ###################
#
# This user receives all of the audit logs by email. This
# Log Manager can have a local or remote email address. You
# can add more than one email address if you want by separating
# each address with a space.

LOG_MANAGER="logman"     # List to email audit log

############################################################
################ DEFINE FUNCTIONS HERE ###################
############################################################

cleanup_exit ()
{
# This function is executed on any type of exit except of course
# a kill -9, which cannot be trapped. The script log file is
# emailed either locally or remotely, and the log file is
# compressed. The last "exit" is needed so the user does not
# have the ability to get to the command line without logging.

if [[ -s ${LOGDIR}/${LOGFILE} ]]
then
    mailx -s "$TS - $LOGNAME Audit Report" $LOG_MANAGER < ${LOGDIR}/
${LOGFILE}
    compress ${LOGDIR}/${LOGFILE} 2>/dev/null
fi

exit
}

# Set a trap

trap 'cleanup_exit'1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 26

############################################################
################ DEFINE VARIABLES HERE ###################
############################################################
```

Listing 28-2 (*continued*)

```
TS=$(date +%m%d%y%H%M%S)            # File time stamp
THISHOST=$(hostname|cut -f1-2 -d.) # Host name of this machine
LOGDIR=/usr/local/logs/script       # Directory to hold the logs
LOGFILE=${THISHOST}.${LOGNAME}.$TS # Creates the name of the log file
touch $LOGDIR/$LOGFILE              # Creates the actual file
set -o vi 2>/dev/null               # Previous commands recall
stty erase ^?                       # Set the backspace key

# Set the command prompt
export PS1="[$LOGNAME:$THISHOST]@"'$PWD> '

#################### RUN IT HERE ##########################

chmod 600 ${LOGDIR}/${LOGFILE}   # Change permission to RW for the owner

script ${LOGDIR}/${LOGFILE}      # Start the script monitoring session

chmod 400 ${LOGDIR}/${LOGFILE}   # Set permission to read-only for
                                 # the owner

cleanup_exit                     # Execute the cleanup and exit function
```

Listing 28-2 (*continued*)

The `log_keystrokes.ksh` script in Listing 28-2 is not difficult when you take a close look. At the top we define the `cleanup_exit` function that is used when the script exits to email and compress the log file. In the next section we set a `trap` and define and set some variables. Finally, we start the logging activity with a `script` session.

In the `cleanup_exit` function notice the list of exit codes that the `trap` command will exit on. This signal list ensures that the log file gets emailed and the file gets compressed. The only exit signal we cannot do anything about is a `kill -9` signal because you cannot trap `kill -9`, because this particular kill signal tells the system to remove the process from the process table, *without* any clean-up! There are more exit signals if you want to add to the list in the `trap` statement, but I think the most captured are listed in the `trap` statement.

The last command executed in this shell script is `exit` because in every case the `cleanup_exit` function must execute. If `exit` is not the last command, the user will be placed back to a command prompt without any logging being done. The reason for this behavior is that the `script` session is really a `fork` of the original shell. Therefore, when the `script` command stops executing, one of the shells in the fork terminates, but not the original shell. This last `exit` logs out of the original shell. You may want to replace this last `exit`, located in the `cleanup_exit` function, with `logout`, which will guarantee the user is logged out of the system.

Logging root Activity

In some shops there is a need to log the activity of the `root` user. If you log `root` access activity, you have an audit trail and it is much easier to do root cause analysis

by analyzing the audit logs. You will also be ahead of the game if you are subject to Sarbanes-Oxley (SOX) audits. SOX audits are required only for United States publicly traded companies. We can use the same type of shell that we used in the previous sections, but this time we will use `sudo` instead of a `.profile` entry. I call this script `broot` because it is a short name for "I want to *be* `root`." In this section let's look at the shell script in Listing 28-3 and go through the details at the end.

```
#!/bin/ksh
#
# SCRIPT: broot
#
# AUTHOR: Randy Michael
# DATE: 05/08/2007
# REV: 1.0.P
# PLATFORM: Any Unix
#
# PURPOSE: This shell script is used to monitor all root access by
#          capturing all of the terminal data in a log file using
#          the script command. This shell script is executed from the
#          command line using sudo (Super User Do). The log file
#          is kept locally and emailed to a log file administrative
#          user either locally or on a remote machine. Sudo must be
#          configured for this shell script. Refer to your sudo notes.
#
# USAGE:  sudo  broot
#
# REV LIST:
#
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this shell script
#
############## DEFINE AUDIT LOG MANAGER ####################

# This user receives all of the audit logs by email. This
# Log Manager can have a local or remote email address. You
# can add more than one email address if you want by separating
# each address with a space.

LOG_MANAGER="logman"     # List to email audit log

############################################################
################ DEFINE FUNCTIONS HERE ####################
############################################################

cleanup_exit ()
{
# This function is executed on any type of exit except of course
# a kill -9, which cannot be trapped. The script log file is
```

Listing 28-3 broot shell script listing

```
# emailed either locally or remotely, and the log file is
# compressed. The last "exit" is needed so the user does not
# have the ability to get to the command line without logging.

if [[ -s ${LOGDIR}/${LOGFILE} ]]
then
    mailx -s "$TS - $LOGNAME Audit Report" $LOG_MANAGER < ${LOGDIR}/
${LOGFILE}
    nohup compress ${LOGDIR}/${LOGFILE} 2>/dev/null &
fi

exit
}

# Set a trap

trap 'cleanup_exit'1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 26

############################################################
################ DEFINE VARIABLES HERE ####################
############################################################

TS=$(date +%m%d%y%H%M%S)            # File time stamp
THISHOST=$(hostname)                # Host name of this machine
LOGDIR=/usr/local/logs/script       # Directory to hold the logs
LOGFILE=${THISHOST}.${LOGNAME}.$TS # Creates the name of the log file
touch $LOGDIR/$LOGFILE              # Creates the actual file
TMOUT=300                           # Set the root shell timeout!!!
export TMOUT                        # Export the TMOUT variable
set -o vi                           # To recall previous commands
stty erase _                        # Set the backspace key

# Run root's .profile if one exists

if [[ -f $HOME/.profile ]]
then
     . $HOME/.profile
fi

# set path to include /usr/local/bin
echo $PATH|grep -q ':/usr/local/bin' || PATH=$PATH:/usr/local/bin

# Set the command prompt to override the /.profile default prompt

PS1="$THISHOST:broot> "
export PS1
```

Listing 28-3 (*continued*)

```
#################### RUN IT HERE ##########################


chmod 600 ${LOGDIR}/${LOGFILE}   # Change permission to RW for the owner

script ${LOGDIR}/${LOGFILE}      # Start the script monitoring session

chmod 400 ${LOGDIR}/${LOGFILE}   # Set permission to read-only for the
owner

cleanup_exit                     # Execute the cleanup and exit function
```

Listing 28-3 (*continued*)

There is one extremely important difference between this script and the script in Listing 28-2. In the `broot` script in Listing 28-3 we execute the `.profile` for `root`, if there is a `.profile` for `root`. You may ask why we did not execute the profile last time. The answer involves the recursive nature of running a file onto itself. In the previous case we had the following entry in the `$HOME/.profile` file:

```
. /usr/local/bin/log_keystrokes.ksh
```

We add this entry beginning with a ''dot,'' which means to execute the following file as the last entry in the `$HOME/.profile`. If you add execution of `$HOME/.profile` into the *shell script* you end up executing the `log_keystrokes.ksh` shell script recursively. When you run the script like this you fill up the buffers and you get an error message similar to the following output:

```
ksh: .: 0403-059 There cannot be more than 9 levels of recursion.
```

For monitoring `root` access with the `broot` script we are not executing from the `.profile`, but we use `sudo` to run this `broot` script, so we have no worries about recursion. At the top of the script in Listing 28-3 we define a `LOG_MANAGER`. This list of one or more email addresses is where the log files are going to be emailed. You may even want real-time notification of `root` activity. I like to send the log files off to my audit box for safekeeping using my `logman` user account.

The next step is to set a `trap`. If the script exits on signals `1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 26`, the `cleanup_exit` function is executed. This `trap` ensures that the log file gets emailed and the file gets compressed locally. In the next section we define and set the variables that we use. Notice that we added a shell timeout, specified by the `TMOUT` environment variable. If someone with `root` access is not typing for five minutes, the shell times out. You can set the `TMOUT` variable to anything you want or even comment it out if you do not want a shell timeout. To disable `TMOUT`, assign `0` to the variable, `TMOUT=0`. The measurement is in seconds. The default is 300 seconds, or 5 minutes, for this script.

After the variable definitions we execute the `root .profile`. We run the profile here because we are not running the `broot` script from a login `$HOME/.profile`, as we did

with the `log_keystrokes.ksh` script in Listing 28-2. Next we add `/usr/local/bin` to root's `$PATH`, if it is not already present. And, finally, before we are ready to execute the `script` command we set a command prompt.

The final four things we do are (1) set the permissions on the log file so we can write to it; (2) run the `script` command using the log filename as a parameter; (3) set the file permissions on the log file to read-only; and (4) execute the `cleanup_exit` function to email the log and compress the file locally.

Some sudo Stuff

I have inserted a short `/etc/sudoers` file for Listing 28-4 to show entries that need to be made. The entire task of setting up and using `sudo` is shown in Chapter 14, ''Number Base Conversions.'' Pay attention to the bold type in Listing 28-4.

```
# sudoers file.
#
# This file MUST be edited with the 'visudo' command as root.
#
# See the sudoers man page for the details on how to write a
# sudoers file.
#
#
# Users Identification:
#
# All access:
#
# randy - Randy Michael
# terry - Admin
#
# Restricted Access to: mount umount and exportfs
#
# oracle - Oracle Admin
# operator - operator access
#
# Host alias specification

Host_Alias  LOCAL=yogi

# User alias specification

User_Alias      ROOTADMIN=randy,terry
User_Alias      NORMAL=randy,operator,terry
User_Alias      ADMIN=randy,terry
User_Alias      ORACLE=oracle
User_Alias      DB2=db2adm
User_Alias      OPERATOR=operator
```

Listing 28-4 Example /etc/sudoers file

```
# Runas alias specification

Runas_Alias     ORA=oracle

# Cmnd alias specification

Cmnd_Alias     BROOT=/usr/local/bin/broot
Cmnd_Alias     MNT=/usr/bin/mount
Cmnd_Alias     UMNT=/usr/bin/umount
Cmnd_Alias     EXP_FS=/usr/bin/exportfs
Cmnd_Alias     KILL=/usr/bin/kill
Cmnd_Alias     ORACLE_SU=/usr/bin/su - oracle
Cmnd_Alias     TCPDUMP=/usr/sbin/tcpdump
Cmnd_Alias     ERRPT=/usr/bin/errpt
Cmnd_Alias     SVRMGRL=/oracle/product/8.0.5/bin/svrmgrl

# User privilege specification
root     ALL=(ALL) ALL
ROOTADMIN     LOCAL=BROOT
NORMAL     LOCAL=MNT,UMNT,EXP_FS
ADMIN
     LOCAL=BROOT,MNT,UMNT,KILL,ORACLE_SU,TCPDUMP,ERRPT: \
     LOCAL=EXP_FS
ORACLE     LOCAL=SVRMGRL

# Override Defaults

Defaults   logfile=/var/adm/sudo.log
```

Listing 28-4 (*continued*)

Three entries need to be added to the `/etc/sudoers` file. Do *not* ever edit the `sudoers` file directly with **vi**. There is a special program called **visudo**, in the `/usr/local/sbin` directory, that has a wrapper around the `vi` editor that does a thorough check for mistakes in the file before the file is saved. If you make a mistake the `visudo` program will tell you where the error is located in the `/etc/sudoers` file.

The three entries that need to be added to `/etc/sudoers` are listed next and are highlighted in bold text in Listing 28-4.

Define the `User_Alias`, which is where we give a name to a group of users. For this file let's name the list of users who can get `root` access `ROOTADMIN`, as shown here:

```
User_Alias     ROOTADMIN=randy,terry
```

Next we need to define the `Cmnd_Alias`, which is where we define the full pathname to the command, as shown here:

```
Cmnd_Alias     BROOT=/usr/local/bin/broot
```

The last step is to define the exact commands that the `User_Alias` group of users can execute. In our case we have a separate `User_Alias` group only for the users who can use the `broot` script. Notice that the definition also specifies the machine where the command can be executed. I always let `sudo` execution take place only on a single machine at a time, specified by `LOCAL` here:

```
ROOTADMIN     LOCAL=BROOT
```

Once the `/etc/sudoers` file is set up, you can change the `root` password and allow `root` access only by using the `broot` script. Using this method you have an audit trail of `root` access to the system.

Monitoring Other Administration Users

More often than not, you will want add to the list of auditing that can be done. This next script is rewritten to allow you to quickly set up a `broot` type shell script by changing only the username and the script name. The method that we use to execute the `script` command is what makes this script different — and easy to modify.

For ease of use we can use a lot of variables throughout the script. We have already been doing this to some extent. Now we will call the monitored user the *effective user*, which fits our new variable `$EFF_USER`. For this script, I have set the effective username to `oracle`. You can make it any user that you want to. Take a look at this shell script in Listing 28-5, and pay particular attention to the boldface type.

```
#!/bin/ksh
#
# SCRIPT: "Banybody"   boracle - This time
#
# AUTHOR: Randy Michael
# DATE: 05/08/2007
# REV: 1.0.P
# PLATFORM: Any Unix
#
# PURPOSE: This shell script is used to capture all "$EFF_USER"
#          access by capturing all of the terminal data in a log
#          file using the script command. This shell script is
#          executed from the command line using sudo (Super User Do).
#          The log file is kept locally and emailed to a log file
#          administrative user either locally or on a remote
#          machine. Sudo must be configured for this shell script.
#          Refer to your sudo notes. The effective user, currently
#          oracle, can be changed by setting the "EFF_USER" variable
#          to another user, and changing the name of the script.
#          This is why the original name of the script is called
#          "Banybody".
#
# ORIGINAL USAGE:  sudo  Banybody
```

Listing 28-5 boracle shell script

```
#
# THIS TIME USAGE ==> USAGE: sudo boracle
#
#
# REV LIST:
#          5/10/2007: Modified the script to replace the hard-coded
#                     username with the variable $EFF_USER. This
#                     allows flexibility to add auditing of more
#                     accounts by just changing the EFF_USER variable
#                     and the script name.
#
# set -n # Uncomment to check syntax without any execution
# set -x # Uncomment to debug this shell script
#
#
################## DEFINE EFFECTIVE USER ##################

# This EFF_USER is the username you want to be to execute
# a shell in. An su command is used to switch to this user.

EFF_USER=oracle

############## DEFINE AUDIT LOG MANAGER ###################

# This user receives all of the audit logs by email. This
# Log Manager can have a local or remote email address. You
# can add more than one email address if you want by separating
# each address with a space.

LOG_SERVER=yogi
LOG_MANAGER="logman@$LOG_SERVER"     # List to email audit log

###########################################################
################ DEFINE FUNCTIONS HERE ####################
###########################################################

cleanup_exit ()
{
# This function is executed on any type of exit except of course
# a kill -9, which cannot be trapped. The script log file is
# emailed either locally or remotely, and the log file is
# compressed. The last "exit" is needed so that the user does not
# have the ability to get to the command line without logging.

if [[ -s ${LOGDIR}/${LOGFILE} ]] # Is it greater than zero bytes?
then
    mailx -s "$TS - $LOGNAME Audit Report" $LOG_MANAGER < ${LOGDIR}/
${LOGFILE}
```

Listing 28-5 (*continued*)

```
}

################## SET A TRAP ##############################

trap 'cleanup_exit' 1 2 3 5 15

############################################################
################ DEFINE VARIABLES HERE ####################
############################################################

TS=$(date +%m%d%y%H%M%S)              # File time stamp
THISHOST=$(hostname)                  # Hostname of this machine
LOGDIR=/usr/local/logs/script         # Directory to hold the logs
LOGFILE=${THISHOST}.${EFF_USER}.$TS   # Creates the name of the log file
touch $LOGDIR/$LOGFILE                # Creates the actual file
TMOUT=300                             # Set the root shell timeout!!!
export TMOUT                          # Export the TMOUT variable
set -o vi                             # To recall previous commands
stty erase ^?                         # Set the backspace key

# set path to include /usr/local/bin
echo $PATH|grep -q ':/usr/local/bin' || PATH=$PATH:/usr/local/bin

# Set the command prompt to override the /.profile default prompt

PS1="$THISHOST:b${EFF_USER}> "
export PS1

#################### RUN IT HERE ###########################

chmod 666 ${LOGDIR}/${LOGFILE}     # Set permission to read/write

# To get the script session to work we have to use the switch user (su)
# command with the -c flag, which means execute what follows. Sudo is
# also used just to ensure that root is executing the su command.
# We ARE executing now as root because this script was started with
# sudo. If a nonconfigured sudo user tries to execute this command
# then it will fail unless sudo was used to execute this script as root.
# Notice we are executing the script command as "$EFF_USER". This
# variable is set at the top of the script. A value such as
# "EFF_USER=oracle" is expected.

sudo su - $EFF_USER -c "script ${LOGDIR}/${LOGFILE}"
chmod 400 ${LOGDIR}/${LOGFILE}  # Set permission to read-only for
                                # the owner

cleanup_exit                    # Execute the cleanup and exit function
```

Listing 28-5 (*continued*)

The most important line to study in Listing 28-5 is the third line from the bottom:

```
sudo su - $EFF_USER -c "script ${LOGDIR}/${LOGFILE}"
```

There are several points to make about this command. Notice that we start the command with `sudo`. Because you must use `sudo` to execute the `boracle` script, and you are already executing as `root`, why use `sudo` here? We use `sudo` here to ensure that the `boracle` script was indeed started with `sudo`. If any old user runs the `boracle` command we want it to fail if `sudo` was not used.

The second command in the previous statement is `su - $EFF_USER`. The significance of the hyphen, `-`, is important here. Using the hyphen, `-`, with a space on both sides tells the `su` command to switch to the user pointed to by `$EFF_USER`, `oracle` in our case, and run that user's `.profile`. If the hyphen is omitted or the spaces are not around the hyphen, the user `.profile` is not executed, which is a bad thing in this case.

The last part of this command is where we start our `script` session. When you switch users with `su`, you can specify that you want to run a command as this user by adding the `-c` switch followed by the command enclosed in single or double quotes. Do not forget the quotes around the command.

The only other real change is the use of the `EFF_USER` variable. This variable is set at the top of the script, and changing this variable changes who you want to ''be.'' If you want to create more admin auditing scripts, copy the `boracle` file to a new filename and edit the file to change the name at the top of the script and modify the `EFF_USER` variable. That's it!

Other Options to Consider

Throughout this chapter we have covered some interesting concepts. You may have quite a few things that you want to add to these scripts. I have come up with a few myself.

Emailing the Audit Logs

Depending on the extent of monitoring and auditing you need to do, you may want to send the files to several different machines. I selected using email for the transport, but you may have some other techniques, such as automated FTP. You may also want to compress the files before you email, or whatever, the log files. To email a compressed file, you will need some type of mail tool, such as metamail's `metasend`, written by Nathaniel S. Brenstein (`ftp://ftp.research.telcordia.com/pub/nsb/`), or the open source `mutt` utility, written by Michael Elkins (`http://www.mutt.org`). This is needed sometimes because the mail reader will think that some of the characters in the log file are control characters to mail commands. This can cause some strange things to happen. You can download `metamail` from `ftp://ftp.research.telcordia.com/pub/nsb/mm2.7.tar.Z`.

The syntax to use `metasend` to send a binary file, such as a compressed log file, is shown here:

```
metasend -b -t $LOG_MANAGER -s "Audit log" \
     -m application/postscript -f ${LOGDIR}/${LOGFILE}.Z
```

Metamail requires that you specify the file type, or MIME type, so the mail reader on the recipient side knows what kind of file it is dealing with. MIME types include ''text/plain,'' ''image/gif,'' ''application/postscript,'' and ''audio/wav.''

Mutt is an interactive program but we can supply input to the body of the email the same way we do with the `mail` command. The syntax to use `mutt` to send an attached file is shown here:

```
mutt -a ${LOGDIR}/${LOGFILE}.Z $LOG_MANAGER < /dev/null
```

Notice that we sent the email with a null body, specified by `< /dev/null`. So the only thing the email contains is the attached file. Of course, we need to modify our shell scripts to compress the log file before we email it out.

One last thing: watch the disk space! When you start logging user activity you need to keep a close check on disk space, both on the local server and the `$LOG_SERVER`. Most systems store email in `/var`. If you fill up `/var` for an extended period of time you may crash the box. For my log files I create a large dedicated filesystem called `/usr/local/logs`. With a separate filesystem I do not have to worry about crashing the system if I fill up the filesystem. You can probably think of other methods to move the files around as the emails are received. If you do create a logging filesystem you need to override the `MAIL` variable in the `/etc/profile` for the `logman` user by adding this declaration to the logman's `$HOME/.profile`:

```
MAIL=/usr/local/logs/$LOGNAME
```

NOTE Heiner Steven wrote an excellent tutorial on sending files as email attachments. You can find his discussion at `http://shelldorado.com/articles/mailattachments.html`.

Compression

For all of these scripts we used the `compress` command. This compression algorithm is okay, but we can do better. I find that `gzip` has a much better compression algorithm, and the compression ratio is tunable for your needs. The tuning is done using numbers as a parameter to the `gzip` command, as shown here:

```
# gzip -9 $LOGFILE
```

The valid numbers are 1 to 9, with 9 indicating the highest compression. This extra compression does come at a price — time! The higher the number, the longer it takes to compress the file. By omitting the number you use `gzip` in default mode, which is `-5`. For our needs you will still see a big increase in compression over `compress` in about the same amount of time.

Need Better Security?

Another option for this keystroke auditing is to use Open Secure Shell and keep a real-time encrypted connection to the log server by creating a *named pipe*. This can be done but it, too, has some potential problems. This first major problem is that you introduce a dependency for the logging to work. If the connection is lost, the script session ends. For auditing `root` activities, and especially when all other `root` access has been disabled, you can have a real nightmare. I will leave this idea for you to play around with because it is beyond the scope of this book.

Inform the Users

I did not add this chapter to the book for everyone to start secretly monitoring everyone's keystrokes. Always be up front with the user community, and let them know that an audit is taking place. I know for a fact that Systems Administrators do not like to have the `root` password taken away from them. I know first hand about the reaction.

If you are going to change the user password, please place the `root` password in a safe place where, in case of emergency, you can get to the password without delay. Your group will have to work out how this is accomplished.

Sudoers File

If you start running these scripts and you have a problem, first check your `sudo` configuration by looking at the `/etc/sudoers` file. There are some things to look for that the `visudo` editor will not catch:

- Check the `LOCAL` line. This variable should have the hostname of your machine assigned.
- Check for exact pathnames of the files.
- Ensure that the correct users are assigned to the correct commands.

The `visudo` editor does catch most errors, but there are some things that are not so easy to test for.

Summary

I had a lot of fun writing this chapter and playing with these scripts. I hope you take these auditing scripts and use them in a constructive way. The information gathered can be immense if you do not have a mechanism for pruning the old log files. The following command works pretty well:

```
find /log_directory -mtime +30 -print -exec rm {} \;
```

This command will remove all the files in `/log_directory` that have not been modified in 30 days. You may want to add a `-name` parameter to limit what you delete. As with any type of monitoring activity that creates logs, you need to watch

the filesystem space very closely, especially at first, to see how quickly logs are being created and how large the log files grow.

Another topic that comes up a lot is the shell timeout. The only place I use the `TMOUT` environment variable is in the `broot` script. If you add a shell timeout to your other administrative accounts you may find that a logout happens during a long processing job. With these users I expect them to just lock the terminal when they leave.

Lab Assignments

1. Modify all three shell scripts to utilize `mutt` to email compressed log files as attachments.
2. Modify all three shell scripts to utilize metamail's `metasend` to email compressed log files as attachments.

A Closing Note from the Author

I sure hope that you enjoyed this chapter, and the whole book. The process of writing this book has been a thrill for me. Every time I started a new chapter, I had a firm idea of what I wanted to accomplish, but usually along the way I got these little brainstorms that helped me build on the basic idea that I started with. Some five-page chapters turned into some of the longest chapters in the book. In every case, though, I always tried to hit the scripting techniques from a different angle. Sometimes this resulted in a long script or roundabout way of accomplishing the task. I really did do this on purpose. There is always more than one way to solve a challenge in UNIX, and I always aimed to make each chapter different and interesting. I appreciate that you bought this book, and in return I hope I have given you valuable knowledge, and insight into solving any problem that comes along. Now you can really say that the solution to any challenge is *intuitively obvious*! Thank you for reading, and best regards.

APPENDIX

A

What's on the Web Site

This appendix shows a list of the shell scripts and functions that are included on this book's companion web site, `www.wiley.com/go/michael2e`. Each of the shell scripts and functions has a brief description of the purpose.

Shell Scripts

Chapter 1

`script.stub`

This file has the basic framework to begin writing a shell script.

`keyit.rsa`

This script is used to set up RSA OpenSSH keys for no-password access to a remote machine. This script must be executed by the user who needs the keys set up.

`keyit.dsa`

This script is used to set up DSA OpenSSH keys for no-password access to a remote machine. This script must be executed by the user who needs the keys set up.

`generic_rsync.Bash`

This is a generic shell script to copy files using `rsync`.

`select_system_info_menu.Bash`

This shell script uses a `select` statement to create menu options for general system information.

`test_string.ksh`

This script is used to test and display the composition of a character string based on common criteria.

Chapter 2

`24_ways_to_parse.ksh`

This script shows the different ways of reading a file line-by-line. Again, there is not just one way to read a file line-by-line and some are faster than others and some are more intuitive than others.

`random_file.Bash`

This script is used to create a random-character text file that is the size, in MB, specified on the command line.

Chapter 3

There are no shell scripts to list in Chapter 3.

Chapter 4

`timing_test_function.Bash`

This script is used to test the `elapsed_time` function.

Chapter 5

`parse_record_files.Bash`

This shell script is used to merge and parse fixed- and variable-length record files.

Chapter 6

`tst_ftp.ksh`

Simple FTP automated file-transfer test script.

`get_remote_dir_listing.ksh`

Script to get a remote directory listing using FTP.

`get_ftp_files.ksh`

Shell script to retrieve files from a remote machine using FTP.

`put_ftp_files.ksh`

Shell script to upload files to a remote machine using FTP.

`get_remote_dir_listing_pw_var.ksh`

Script to get a directory listing from a remote machine using FTP. The passwords are stored in an environment file somewhere on the system, defined in the script.

`sftp-scp-getfile.Bash`

This shell script is a simple example of using `scp` and `sftp` without passwords.

`ftp-ls-getfile.exp`

This Expect script is used to do a long listing on a remote machine and FTP a file to the local server.

`get_ftp_files_pw_var.ksh`

Script to retrieve files from a remote machine using FTP. This script gets its password from an environment file somewhere on the system, defined in the script.

`put_ftp_files_pw_var.ksh`

Script to upload files to a remote machine using FTP. This script gets its password from an environment file somewhere on the system, defined in the script.

Chapter 7

`generic_rsync.Bash`

This is a generic shell script used to copy files with `rsync`.

`generic_DIR_rsync_copy.Bash`

This is a generic shell script used to replicate directory structures to one or more remote machines.

`generic_FS_rsync_copy.Bash`

This is a generic shell script used to replicate one or more filesystems to one or more remote machines.

`rsync_daily_copy.ksh`

This shell script is used to replicate an Oracle database to two remote machines.

Chapter 8

`ftp-get-file.exp`

This Expect script is used to transfer a remote file to the local system using FTP.

`ftp-get-file-cmd-line.exp`

This Expect script is used to get files from a remote system by specifying the filenames on the command line.

`etc-hosts-copy.exp`

This Expect script is used to copy a master `/etc/hosts` file to a list of machines.

`showplatform.exp`

This Expect script is used with Sun Blade Servers to execute the Sun Blade Chassis command `showplatform -v`.

`findslot`

This shell script utilizes the `showplatform.exp` Expect script to locate the slot a Sun Blade server is installed in.

`boot-net-install.exp`

This Expect script is used with Sun Blades and Sun's JumpStart to execute the command: `boot net - install` at the ''ok'' prompt.

Chapter 9

`findlarge.ksh`

This shell script is used to find ''large'' files. The file-size limit is supplied on the command line and the search begins in the current directory.

Chapter 10

`proc_mon.ksh`

Process monitor that informs the user when the process ends.

`proc_wait.ksh`

Process monitor that informs the user when the process starts.

`proc_watch.ksh`

Process monitor that monitors a process as it starts and stops.

`proc_watch_timed.ksh`

Process monitor that monitors a process for a user-specified amount of time.

Chapter 11

`random_number_testing.Bash`

This shell script is a test of the `/dev/urandom` character special file used to create random numbers.

`random_number.ksh`

This shell script is used to create pseudo-random numbers.

`mk_unique_filename.ksh`

This shell script creates unique filenames.

`random_file.Bash`

This shell script is used to create a user-defined MB-size file filed with random characters using the `/dev/random` character special file to create the random numbers that point to array elements.

Chapter 12

`mk_passwd.Bash`

This shell script is used to create pseudo-random passwords.

Chapter 13

`float_add.ksh`

Adds a series of floating-point numbers together using the `bc` utility.

`float_subtract.ksh`

Subtracts floating-point numbers using the `bc` utility.

`float_multiply.ksh`

Multiplies a series of floating-point numbers together using the `bc` utility.

`float_divide.ksh`

Divides two floating-point numbers using the `bc` utility.

`float_average.ksh`

Averages a series of floating-point numbers using the `bc` utility.

Chapter 14

`chg_base.ksh`

This shell script converts numbers between bases 2 and 36.

`chg_base_bc.Bash`

This shell script converts numbers between bases 2 and 16 using the `bc` utility.

`mk_swkey.ksh`

Shell script to create a software license key using the hexadecimal representation of the IP address.

`equate_any_base.ksh`

Converts numbers between any base.

`equate_base_2_to_16.ksh`

Converts numbers from base 2 to base 16.

`equate_base_16_to_2.ksh`

Converts numbers from base 16 to base 2.

`equate_base_10_to_16.ksh`

Converts numbers from base 10 to base 16.

`equate_base_16_to_10.ksh`

Converts numbers from base 16 to base 10.

`equate_base_10_to_2.ksh`

Converts numbers from base 10 to base 2.

`equate_base_2_to_10.ksh`

Converts numbers from base 2 to base 10.

`equate_base_10_to_8.ksh`

Converts numbers from base 10 to base 8.

`equate_base_8_to_10.ksh`

Converts numbers from base 8 to base 10.

Chapter 15

`hgrep.ksh`

This shell script works similar to `grep` except that it shows the entire file with the pattern match highlighted in reverse video.

Chapter 16

`keyit`

This shell script is used to set up OpenSSH encryption keys for password-free access.

`proc_mon.ksh`

Process monitor that informs the user when the process ends.

`proc_wait.ksh`

Process monitor that informs the user when the process starts.

`proc_watch.ksh`

Process monitor that monitors a process as it starts and stops.

`proc_watch_timed.ksh`

Process monitor that monitors a process for a user-specified amount of time.

Chapter 17

`fs_mon_AIX.ksh`

This shell script is used to monitor an AIX system for full filesystems using the percentage method.

`fs_mon_AIX_MBFREE.ksh`

This shell script is used to monitor an AIX system for full filesystems using the MB-free method.

`fs_mon_AIX_MBFREE_excep.ksh`

This shell script is used to monitor an AIX system for full filesystems using the MB-free method with exceptions capability.

`fs_mon_AIX_PC_MBFREE.ksh`

This shell script is used to monitor an AIX system for full filesystems using the percentage method with exceptions capability.

`fs_mon_AIX_excep.ksh`

Basic AIX filesystem monitoring using the percent method with exceptions capability.

```
fs_mon_ALL_OS.ksh
```

This shell script autodetects the UNIX flavor and monitors the filesystems using both percent and MB-free techniques with an autodetection to switch between methods.

```
fs_mon_HPUX.ksh
```

This shell script is used to monitor an HP-UX system for full filesystems using the percentage method.

```
fs_mon_HPUX_MBFREE.ksh
```

This shell script is used to monitor an HP-UX system for full filesystems using the MB-free method.

```
fs_mon_HPUX_MBFREE_excep.ksh
```

This shell script is used to monitor an HP-UX system for full filesystems using the percentage method with exceptions capability.

```
fs_mon_HPUX_PC_MBFREE.ksh
```

This shell script is used to monitor an HP-UX system for full filesystems using the percentage method with exceptions capability.

```
fs_mon_HPUX_excep.ksh
```

Basic HP-UX filesystem monitoring using the percent method with exceptions capability.

```
fs_mon_LINUX.ksh
```

This shell script is used to monitor a Linux system for full filesystems using the percentage method.

```
fs_mon_LINUX_MBFREE.ksh
```

This shell script is used to monitor a Linux system for full filesystems using the MB-free method.

```
fs_mon_LINUX_MBFREE_excep.ksh
```

This shell script is used to monitor a Linux system for full filesystems using the percentage method with exceptions capability.

```
fs_mon_LINUX_PC_MBFREE.ksh
```

This shell script is used to monitor a Linux system for full filesystems using the percentage method with exceptions capability.

```
fs_mon_LINUX_excep.ksh
```

Basic Linux filesystem monitoring using the percentage method with exceptions capability.

`fs_mon_SUNOS.ksh`

This shell script is used to monitor a SunOS system for full filesystems using the percentage method.

`fs_mon_SUNOS_MBFREE.ksh`

This shell script is used to monitor a SunOS system for full filesystems using the MB-free method.

`fs_mon_SUNOS_MBFREE_excep.ksh`

This shell script is used to monitor a SunOS system for full filesystems using the percentage method with exceptions capability.

`fs_mon_SUNOS_PC_MBFREE.ksh`

This shell script is used to monitor a SunOS system for full filesystems using the percentage method with exceptions capability.

`fs_mon_SUNOS_excep.ksh`

Basic SunOS filesystem monitoring using the percent method with exceptions capability.

Chapter 18

`AIX_paging_mon.ksh`

Shell script to monitor AIX paging space.

`HP-UX_swap_mon.ksh`

Shell script to monitor HP-UX swap space.

`Linux_swap_mon.ksh`

Shell script to monitor Linux swap space.

`SUN_swap_mon.ksh`

Shell script to monitor SunOS swap space.

`all-in-one_swapmon.ksh`

Shell script to monitor AIX, HP-UX, Linux, and SunOS swap/paging space.

Chapter 19

`uptime_loadmon.ksh`

System load monitor using the `uptime` command.

`uptime_fieldtest.ksh`

Script to test the location of the latest uptime load information as it changes based on time.

`sar_loadmon.ksh`

Load monitor using the `sar` command.

`iostat_loadmon.ksh`

Load monitor using the `iostat` command.

`vmstat_loadmon.ksh`

Load monitor using the `vmstat` command.

Chapter 20

`stale_LV_mon.ksh`

This shell script is used to monitor AIX stale Logical Volumes.

`stale_PP_mon.ksh`

This shell script is used to monitor AIX stale Physical Partitions.

`stale_VG_PV_LV_PP_mon.ksh`

This shell script is used to monitor AIX stale partitions in Volume Groups, Physical Volumes, Logical Volumes, and Physical Partitions.

Chapter 21

`SSAidentify.ksh`

Shell script to control SSA disk subsystem disk-identification lights.

Chapter 22

`pingnodes.ksh`

This shell script is used to `ping` nodes. The operating system can be AIX, HP-UX, Linux, or SunOS.

Chapter 23

`AIXsysconfig.ksh`

This shell script is used to gather information about an AIX system's configuration.

Chapter 24

`chpwd_menu.ksh`

This shell script uses `sudo` to allow support personnel to change passwords.

Chapter 25

`enable_AIX_classic.ksh`

Enables all AIX ''classic'' print queues.

`print_UP_AIX.ksh`

Enables all AIX System V printers and queues.

`print_UP_HP-UX.ksh`

Enables all HP-UX System V printers and queues.

`print_UP_Linux.ksh`

Enables all Linux System V printers and queues.

`printing_only_UP_Linux.ksh`

Enables printing on Linux System V printers.

`queuing_only_UP_Linux.ksh`

Enables queuing on Linux System V printers.

`print_UP_SUN.ksh`

Enables all SunOS System V printers and queues.

`PQ_all_in_one.ksh`

Enables all printing and queuing on AIX, HP-UX, Linux, and SunOS by autodetecting the UNIX flavor.

Chapter 26

`search_group_id.Bash`

This shell script is used to parse the `/etc/passwd` file and use the `id` command to display the group name, as opposed to the GID.

`chk_passwd_gid_0.Bash`

This shell script searches the `/etc/passwd` file for users who are a member of group 0 (system/root group).

Chapter 27

`dirvish_ctrl`

This shell script is a menu interface to Dirvish snapshot backups.

Chapter 28

`broot`

Shell script to capture keystrokes of anyone gaining root access.

`banybody`

Shell script to capture keystrokes of any user defined in the shell script.

`log_keystrokes.ksh`

Shell script to log users' keystrokes as they type on the keyboard.

Functions

Chapter 1

`rotate_line`

This function is a progress indicator that appears as a twirling line.

`elapsed_time`

This function converts seconds into hours, minutes, and seconds format.

`ping_host`

This function detects the UNIX flavor, and then pings the host specified by the function's `$1` argument, using the correct syntax for that system.

Chapter 2

`build_random_line`

This function is uses a random number to pick an array element.

```
load_default_keyboard
```

This function loads a default keyboard layout into an array. All of the following 24 functions are different methods to process a file line-by-line:

```
cat_while_read_LINE
while_read_LINE_bottom
cat_while_LINE_line
while_LINE_line_bottom
cat_while_LINE_line_cmdsub2
while_LINE_line_bottom_cmdsub2
for_LINE_cat_FILE
for_LINE_cat_FILE_cmdsub2
while_line_outfile
while_read_LINE_FD_IN
cat_while_read_LINE_FD_OUT
while_read_LINE_bottom_FD_OUT
while_LINE_line_bottom_FD_OUT
while_LINE_line_bottom_cmdsub2_FD_OUT
for_LINE_cat_FILE_FD_OUT
for_LINE_cat_FILE_cmdsub2_FD_OUT
while_line_outfile_FD_IN
while_line_outfile_FD_OUT
while_line_outfile_FD_IN_AND_OUT
while_LINE_line_FD_IN
while_LINE_line_cmdsub2_FD_IN
while_read_LINE_FD_IN_AND_OUT
while_LINE_line_FD_IN_AND_OUT
while_LINE_line_cmdsub2_FD_IN_AND_OUT
```

Chapter 3

There are no functions to list in Chapter 3.

Chapter 4

```
dots
```

This function is used as a progress indicator showing a series of dots every 10 seconds or so.

```
rotate
```

This function is used as a progress indicator showing the appearance of a rotating line.

```
elapsed_time
```

This function converts seconds to hours, minutes, and seconds format.

Chapter 5

`parse_fixed_length_records`

This function parses through a fixed-length record file using the `cut` command.

`parse_variable_length_records`

This function parses through a variable-length record file using the `cut` command.

`merge_fixed_length_records`

This function appends the filename of the record file to the end of each record in the file.

`merge_variable_length_records`

This function appends the filename of the record file to the end of each record in the file.

Chapter 6

`pre_event`

Function to allow for pre events before processing.

`post_event`

Function to allow for post events after processing.

Chapter 7

`elapsed_time`

This function converts seconds to hours, minutes, and seconds format.

`verify_copy`

This function verifies that that file sizes match between the local machine and one or more remote machine(s).

`ready_to_run`

This function starts at the beginning of the shell script and loops until the `$READY_TO_RUN` file is found on the system.

Chapter 8

`increment_by_1`

This Expect proc (function) increments a number by 1.

Chapter 9

There are no functions to list in Chapter 9.

Chapter 10

`mon_proc_end`

This function loops until the monitored process ends execution.

`mon_proc_start`

This function loops until the monitored process starts execution.

`pre_event_script`

This function executes as a pre event before processing starts.

`startup_event_script`

This function executes as a startup event.

`post_event_script`

This function executes after processing completes.

`test_string`

This function is used to test text strings.

`proc_watch`

This function watches as a monitored process starts and stops.

Chapter 11

`get_random_number`

This function produces a pseudo-random number between 1 and 32,767.

`in_range_random_number`

Creates a pseudo-random number less than or equal to the `$UPPER_LIMIT` value, which is user-defined.

`in_range_fixed_length_random_number_typeset`

This function creates a right-justified fixed-length pseudo-random number using the `typeset` command.

`get_random_number`

This function creates a pseudo-random number using the shell's `RANDOM` variable.

`get_date_time_stamp`

This function displays a date/time stamp.

`get_second`

This function displays the current clock second.

`my_program`

This function is where the program to execute is defined.

`build_random_line`

This function creates a line of random text characters.

`elapsed_time`

This function converts seconds to hours, minutes, and seconds format.

`load_default_keyboard`

This function loads the `KEYS` array with a default U.S. QWERTY keyboard layout.

Chapter 12

`in_range_random_number`

This function creates pseudo-random numbers within one and a ''max value.''

`load_default_keyboard`

This function is used to load a U.S. 102-key board layout into a keyboard file.

`check_for_and_create_keyboard_file`

If the `$KEYBOARD_FILE` does not exist, asks the user to load the ''standard'' keyboard layout, which is done with the `load_default_keyboard` function.

`build_manager_password_report`

Builds a file to print for the secure envelope.

Chapter 13

There are no functions to list in Chapter 13.

Chapter 14

There are no functions to list in Chapter 14.

Chapter 15

There are no functions to list in Chapter 15.

Chapter 16

```
check_HTTP_server
```

This function is used to check an application web server and application URL pages.

Chapter 17

```
load_EXCEPTIONS_data
```

This function loads the data in the `$EXCEPTIONS` file while ignoring the lines commented out with a hash mark (#).

```
load_FS_data
```

This function loads the current filesystem statistics for processing.

```
check_exceptions
```

This function tests if a filesystem is out of limits.

```
display_output
```

This function displays the `$OUTFILE`.

```
get_OS_info
```

This function queries the system for the UNIX flavor.

```
???Author: Are descriptions to come for these?load_AIX_FS_data
```

This function loads AIX filesystem data.

```
load_HP_UX_FS_data
```

This function loads HP-UX filesystem data.

```
load_LINUX_FS_data
```

This function loads Linux filesystem data.

```
load_OpenBSD_FS_data
```

This function loads OpenBSD filesystem data.

```
load_Solaris_FS_data
```

This function loads Solaris filesystem data.

Chapter 18

There are no functions to list in Chapter 18.

Chapter 19

There are no functions to list in Chapter 19.

Chapter 20

There are no functions to list in Chapter 20.

Chapter 21

`man_page`

Function to create man page type information about the proper usage of the `SSAidentify.ksh` shell script.

`twirl`

Progress indicator that looks like a ''twirling'' or rotating line.

`all_defined_pdisks`

Function that lights all disk-identification lights for all defined pdisks.

`all_varied_on_pdisks`

Function that lights all disk-identification lights that are in varied-on Volume Groups.

`list_of_disks`

Function that acts on each pdisk by turning on/off the SSA disk-identification lights.

Chapter 22

`ping_host`

This function executes the correct `ping` command based on UNIX, the UNIX flavor, AIX, HP-UX, Linux, or SunOS.

`ping_nodes`

This function is used to `ping` a list of nodes stored in a file. This function requires the `ping_host` function.

Chapter 23

All of these functions are used in gathering system information from an AIX system. Refer to Chapter 13 for more details in the `AIXsysconfig.ksh` shell script.

```
get_host
get_OS
get_OS_level
get_ML_for_AIX
get_TZ
get_real_mem
get_arch
get_devices
get_long_devdir_listing
get_tape_drives
get_cdrom
get_adapters
get_routes
get_netstats
get_fs_stats
get_VGs
get_varied_on_VGs
get_LV_info
get_paging_space
get_disk_info
get_VG_disk_info
get_HACMP_info
get_printer_info
get_process_info
get_sna_info
get_udp_x25_procs
get_sys_cfg
get_long_sys_config
get_installed_filesets
check_for_broken_filesets
last_logins
```

Chapter 24

There are no functions to list in Chapter 24.

Chapter 25

```
AIX_classic_printing
```

This function enables all AIX ''Classic'' print queues in a down state.

```
AIX_SYSV_printing
```

This function enables printing and queuing on all printers and queues in a down state.

`CUPS_printing`

This function enables CUPS printing and queuing on all printers and queues in a down state.

`HP_UX_printing`

This function enables printing and queuing on all printers and queues in a down state.

`Linux_printing`

This function enables printing and queuing on all printers and queues in a down state.

`OpenBSD_printing`

This function enables printing and queuing on all printers and queues in a down state.

`Solaris_printing`

This function enables printing and queuing on all printers and queues in a down state.

Chapter 26

There are no functions to list in Chapter 26.

Chapter 27

`display_main_menu`

This function displays the main menu of the `dirvish_ctrl` shell script.

`read_input`

This function will read in input until 99 is entered.

`parse_conf`

This function is used to parse through the Dirvish `master.conf` file.

`build_default_conf`

This function creates a new Dirvish backup server definition.

`run_all`

This function executes the `dirvish-runall` command.

`run_backup`

This function executes one particular Dirvish backup.

`chk_create_dir`

This function creates a new Dirvish bank.

`locate_restore_image`

This function is used to locate Dirvish archives and restore specific files to a local ''restore area.''

`expire_backup`

This function is used to delete expired Dirvish backups.

`add_backup`

This function is used to add a new Dirvish backup.

`delete_backup`

This function is used to delete Dirvish backup definitions (deletes a Dirvish vault).

`manage_banks`

This function is used to create and delete Dirvish banks.

`check_root_user`

This function checks to ensure the user executing the script is root.

`check_config`

This function queries the system for the specified Dirvish `default.conf` file for a particular backup.

Chapter 28

`cleanup_exit`

This function emails the captured keystroke `script` file before exiting the shell script.

Index

SYMBOLS

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

S

T

U

V

W

X

Y

Z