14

Essential Shell Programming

The activities of the shell are not restricted to command interpretation alone. The shell has a whole set of internal commands that can be strung together as a language. We need two chapters to discuss this language. In this chapter, we focus on the Bourne shell—the lowest common denominator of all shells. We have reserved the discussion of the advanced features of the Korn and Bash shells for Part II of the book. However, everything discussed here applies to both these shells too. The C shell uses totally different programming constructs and has been separately treated in Appendix A.

A shell program runs in *interpretive* mode. It is not compiled into a separate executable file as a C program is. Each statement is loaded into memory when it is to be executed. Shell scripts consequently run slower than those written in high-level languages. However, what makes shell programs powerful is that external UNIX commands blend easily with the shell's internal constructs. Speed is not a factor in many jobs we do, and in many cases, using the shell is an advantage—especially in system administrative tasks. *The UNIX system administrator must be an accomplished shell programmer.*

What You Will Learn

- How shell scripts are executed, and the role of the *interpreter line*.
- Make shell scripts interactive using **read**.
- Use *positional parameters* to read command line arguments.
- The role of the **exit** statement in terminating a script.
- Elementary decision making with the || and && operators.
- Comprehensive decision making with the **if** conditional.
- Use **if** in tandem with **test** to perform numeric and string comparison, and test a file's attributes.
- Use the wild-card pattern matching features of **case** for decision making.
- Integer computing and string handling using **expr**.
- Use a **while** loop to repeatedly execute a set of commands.
- Use a **for** loop with a list.
- Manipulate the positional parameters with the **set** and **shift** statements.
- Use **trap** to control the behavior of a shell script when it receives signals.

TOPICS OF SPECIAL INTEREST

- Redirect some statements to /dev/tty so the other statements can be manipulated collectively.
- Exploit the hard linking feature with $0 to make a script behave in different ways depending on the name by which it is invoked.
- Use a *here document* as the fourth source of standard input to run any interactive shell script noninteractively.

14.1 SHELL SCRIPTS

When a group of commands have to be executed regularly, they should be stored in a file, and the file itself executed as a **shell script** or **shell program**. Though it's not mandatory, we normally use the .sh extension for shell scripts. This makes it easy to match them with wild-cards.

Shell scripts are executed in a separate child shell process, and this sub-shell need not be of the same type as your login shell. In other words, even if your login shell is Bourne, you can use a Korn sub-shell to run your script. By default, the child and parent shells belong to the same type, but you can provide a special *interpreter line* in the first line of the script to specify a different shell for your script.

Tip: Generally, Bourne shell scripts run without problem in the Korn and Bash shells. There are two issues in Bash, however. First, Bash evaluates $0 differently. This has to be handled by appropriate code in the script. Second, it doesn't recognize escape sequences used by **echo** (like \c and \n) unless the -e option is used. To make **echo** behave in the normal manner, place the statement **shopt -s xpg_echo** in your rc file (probably, ~/.bashrc).

Use your **vi** editor to create the shell script, **script.sh** (Fig. 14.1). The script runs three **echo** commands and shows the use of variable evaluation and command substitution. It also prints the calendar of the current month.

```
#!/bin/sh
# script.sh: Sample shell script
echo "Today's date: `date`"
echo "This month's calendar:"
cal `date "+%m 20%y"`                    # This month's calendar
echo "My shell: $SHELL"
```

Fig. 14.1 script.sh

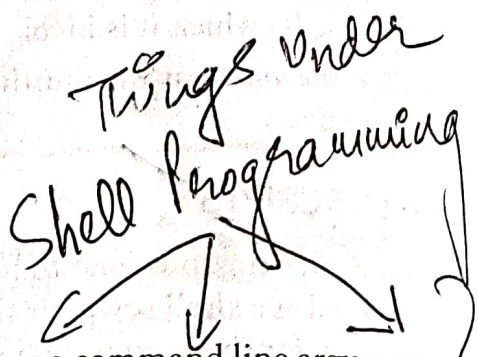
Note the comment character (#) that can be placed anywhere in a line; the shell ignores all characters placed on its right. However, this doesn't apply to the first line which also begins with a #. This is the **interpreter line** that was mentioned previously. It always begins with #! and is followed by the pathname of the shell to be used for running the script. Here, this line specifies the Bourne shell.

To run the script, make it executable first and then invoke the script name:

```
$ chmod +x script.sh
$ script.sh
Today's date: Mon Jan  6 10:02:42 IST 2003
This month's calendar:
     January 2003
Su Mo Tu We Th Fr Sa
            1  2  3  4
 5  6  7  8  9 10 11
12 13 14 15 16 17 18
19 20 21 22 23 24 25
26 27 28 29 30 31

My shell: /bin/sh
```

PATH *must include the* . *or else use* ./script.sh



The script is too simple to need any explanation—no inputs, no command line arguments and no control structures. We'll be progressively adding these features to our future scripts.

We mentioned that shell scripts are executed by a child shell. Actually, the child shell reads and executes each statement in sequence (in interpretive mode). You can also *explicitly* spawn a child of your choice with the script name as argument:

```
sh script.sh
```

Will spawn a Bourne shell

When used in this way, the Bourne sub-shell opens the file but ignores the interpreter line. The script doesn't need to have execute permission either. We'll make it a practice to use the interpreter line in all our scripts.

Tip: The pathname of the shell specified in the interpreter line may not match the actual pathname on your system. This sometimes happens with downloaded scripts. To prevent these scripts from breaking, make a symbolic link between the two locations. Note that root access is required to make a symbolic link between **/bin/ksh** and **/usr/bin/ksh**.

14.2 read: MAKING SCRIPTS INTERACTIVE

The **read** statement is the shell's internal tool for taking input from the user, i.e., making scripts interactive. It is used with one or more variables. Input supplied through the standard input is read into these variables. When you use a statement like

```
read name
```

the script pauses at that point to take input from the keyboard. Whatever you enter is stored in the variable name. Since this is a form of assignment, no $ is used before name. The script, **emp1.sh** (Fig. 14.2), uses **read** to take a search string and filename from the terminal.

Shell scripts accept comments prefixed by # anywhere in a line. You know what the sequence \c does *(3.3)*. Run the script and specify the input when the script pauses twice:

```
#!/bin/sh
# emp1.sh: Interactive version - uses read to take two inputs
#
echo "Enter the pattern to be searched: \c"      # No newline
read pname
echo "Enter the file to be used: \c"             # Use echo -e or
read flname                                      # shopt -s xpg_echo in Bash
echo "Searching for $pname from file $flname"
grep "$pname" $flname
echo "Selected records shown above"
```

Fig. 14.2 `emp1.sh`

```
$ emp1.sh
Enter the pattern to be searched: director
Enter the file to be used: emp.lst
Searching for director from file emp.lst
9876|jai sharma      |director |production|12/03/50|7000
2365|barun sengupta  |director |personnel |11/05/47|7800
Selected records shown above
```

The script first asks for a pattern to be entered. Input the string `director`, which is assigned to the variable `pname`. Next, the script asks for the filename; enter the string `emp.lst`, which is assigned to the variable `flname`. **grep** then runs with these two variables as arguments.

A single **read** statement can be used with one or more variables to let you enter multiple arguments:

```
read pname flname
```

If the number of arguments supplied is less than the number of variables accepting them, any leftover variables will simply remain unassigned. However, when the number of arguments exceeds the number of variables, the remaining words are assigned to the *last* variable.

14.3 USING COMMAND LINE ARGUMENTS

Like UNIX commands (which are written in C), shell scripts also accept arguments from the command line. They can, therefore, run noninteractively and be used with redirection and pipelines. When arguments are specified with a shell script, they are assigned to certain special "variables"—rather **positional parameters**.

The first argument is read by the shell into the parameter $1, the second argument into $2, and so on. You can't technically call them shell variables because all variable names start with a letter. In addition to these positional parameters, there are a few other special parameters used by the shell. Their significance is noted below:

- $* — It stores the complete set of positional parameters as a single string.
- $# — It is set to the number of arguments specified. This lets you design scripts that check whether the right number of arguments have been entered.

```
#!/bin/sh
# emp2.sh: Non-interactive version  - uses command line arguments
#
echo "Program: $0                  # $0 contains the program name
The number of arguments specified is $#
The arguments are $*"              # All arguments stored in $*
grep "$1" $2
echo "\nJob Over"
```

Fig. 14.3 **emp2.sh**

$0— Holds the command name itself. You can link a shell script to be invoked by more than one name. The script logic can check $0 to behave differently depending on the name by which it is invoked.

The next script, **emp2.sh** (Fig. 14.3), runs **grep** with two positional parameters that are set by the script arguments, `director` and `emp.lst`:

```
$ emp2.sh director emp.lst
Program: emp2.sh
The number of arguments specified is 2
The arguments are director emp.lst
1006|chanchal singhvi |director |sales     |03/09/38|6700
6521|lalit chowdury   |director |marketing |26/09/45|8200

Job Over
```

When arguments are specified in this way, the first word (the command itself) is assigned to $0, the second word (the first argument) to $1, and the third word (the second argument) to $2. You can use more positional parameters in this way up to $9 (and using the **shift** statement, you can go beyond).

When you use a multiword string to represent a single command line argument, you must quote it. To look for `chanchal singhvi`, use **emp2.sh "chanchal singhvi" emp.lst**. You have noted this quoting requirement when using **grep** also *(13.1)*.

All assignments to positional and special parameters are made by the shell. You can't really tamper with their values, except in an indirect fashion, but you can use them to great advantage in several ways. They will be used over and over again in shell scripts, and are listed in Table 14.1.

Bash Shell: $0 in Bash prepends the `./` prefix to the script name. In the example above, it would have shown **./emp2.sh** instead of **emp2.sh**. You need to keep this in mind when you make use of $0 to develop portable scripts.

Table 14.1 Special Parameters Used by the Shell

Shell Parameter	Significance
$1, $2...	Positional parameters representing command line arguments
$#	Number of arguments specified in command line
$0	Name of executed command
$*	Complete set of positional parameters as a single string
"$@"	Each quoted string treated as a separate argument (recommended over $*)
$?	Exit status of last command
$$	PID of the current shell *(9.1.1)*
$!	PID of the last background job *(9.9.1)*

14.4 exit AND EXIT STATUS OF COMMAND

C programs and shell scripts have a lot in common, and one of them is that they both use the same command (or function in C) to terminate a program. It has the name **exit** in the shell and **exit()** in C. We'll take up the **exit** function in Part II of this book, but in this section, we'll examine the shell's **exit** command. The command is generally run with a numeric argument:

```
exit 0
exit 1
```

Used when everything went fine
Used when something went wrong

These are two very common **exit** values. You don't need to place this statement at the end of every shell script because the shell understands when script execution is complete. Rather, it's quite often used with a command when it fails.

Once **grep** couldn't locate a pattern *(13.1)*; we said then that the command *failed*. What we meant was that the **exit** function in the **grep** code was invoked with a nonzero argument (**exit(1)**). This value (1) is communicated to the calling program, usually the shell.

It's through the **exit** command or function that every command returns an **exit status** to the caller. Further, a command is said to return a *true* exit status if it executes successfully, and *false* if it fails. The **cat** command as used below:

```
$ cat foo
cat: can't open foo
```

returns a nonzero exit status because it couldn't open the file. The shell offers a variable ($?) and a command (**test**) that evaluates a command's exit status.

The Parameter $? The parameter $? stores the exit status of the last command. It has the value 0 if the command succeeds and a nonzero value if it fails. This parameter is set by **exit**'s argument. If no exit status is specified, then $? is set to zero (true). Try using **grep** in these ways and you'll see it returning three different exit values:

```
$ grep director emp.lst >/dev/null; echo $?
0
$ grep manager emp.lst >/dev/null; echo $?
1
```

Success

Failure—in finding pattern

```
$ grep manager emp3.lst >/dev/null; echo $?
grep: can't open emp3.lst
2
```

Failure—in opening file

The exit status is extremely important for programmers. They use it to devise program logic that branches into different paths depending on the success or failure of a command. For example, there's no point in continuing with script execution if an important file doesn't exist or can't be read.

Tip: To find out whether a command executed successfully or not, simply use **echo $?** after the command. 0 indicates success, other values point to failure.

Note: Success or failure isn't as intuitive as it may seem. The designer of **grep** interpreted **grep**'s inability to locate a pattern as failure. The designer of **sed** thought otherwise. The command **sed -n '/manager/p' emp.lst** returns a true value even if manager is not found!

14.5 THE LOGICAL OPERATORS && AND ||—CONDITIONAL EXECUTION

The script **emp1.sh** has no logic to prevent display of the message, `Selected lines` shown above, when the pattern search fails. That is because we didn't use **grep**'s exit status to control the flow of the program. The shell provides two operators that allow conditional execution—the && and ||, which typically have this syntax:

cmd1 && *cmd2*
cmd1 || *cmd2*

The && delimits two commands; the command *cmd2* is executed only when *cmd1* succeeds. You can use it with **grep** in this way:

```
$ grep 'director' emp.lst && echo "pattern found in file"
1006|chanchal singhvi |director |sales     |03/09/38|6700
6521|lalit chowdury   |director |marketing |26/09/45|8200
pattern found in file
```

The || operator plays an inverse role; the second command is executed only when the first fails. If you "grep" a pattern from a file without success, you can notify the failure:

```
$ grep 'manager' emp.lst || echo "Pattern not found"
Pattern not found
```

The || goes pretty well with the **exit** command. You often need to terminate a script when a command fails. The script **emp2.sh** can be modified to include this feature. The following two lines ensure that the program is aborted when the **grep** command fails and a message is printed if it succeeds:

```
grep "$1" $2 || exit 2          # No point continuing if search fails
echo "Pattern found - Job Over" # Executed only if grep succeeds
```

This segment makes rudimentary decisions which the previous scripts couldn't. In fact, the && and || operators are recommended for making simple decisions. When complex decision making is involved, they have to make way for the **if** statement.

14.6 THE if CONDITIONAL

The **if** statement makes two-way decisions depending on the fulfillment of a certain condition. In the shell, the statement uses the following forms, much like the one used in other languages:

Form 1	Form 2	Form 3

if *command is successful*
then
  execute commands
else
  execute commands
fi
	if *command is successful*
	then
	  execute commands
	fi
		if *command is successful*
		then
		  execute commands
		elif *command is successful*
		then...
		else...
		fi

As in BASIC, **if** also requires a **then**. It evaluates the success or failure of the *command* that is specified in its "command line." If *command* succeeds, the sequence of commands following it is executed. If *command* fails, then the **else** statement (if present) is executed. This statement is not always required, as shown in Form 2. Every **if** is closed with a corresponding **fi**, and you'll encounter an error if one is not present.

What makes shell programming so powerful is that a command's exit status solely determines the course of action pursued by many of the shell's important constructs like **if** and **while**. All commands return an exit status as we saw with **cat** and **grep**, so you can imagine where shell programming can lead us.

In the next script, **emp3.sh** (Fig. 14.4), **grep** is first executed and a simple **if-else** construct tests the exit status of **grep**. This time we'll search /etc/passwd for the existence of two users; one exists in the file and the other doesn't:

```
$ emp3.sh ftp
ftp:*:325:15:FTP User:/users1/home/ftp:/bin/true
Pattern found - Job Over
$ emp3.sh mail
Pattern not found
```

```
#!/bin/sh
# emp3.sh: Using if and else
#
if grep "^$1" /etc/passwd 2>/dev/null   # Search username at beginning of line
then
        echo "Pattern found - Job Over"
else
        echo "Pattern not found"
fi
```

Fig. 14.4 **emp3.sh**

We'll discuss the third form of the **if** statement when we discuss **test**. The condition placed in the command line of the **if** statement will henceforth be referred to as the **control command**. You can use **if** in this way with any executable program. Amazing power indeed!

14.7 USING test AND [] TO EVALUATE EXPRESSIONS

When you use **if** to evaluate expressions, you need the **test** statement because the true or false values returned by expressions can't be *directly* handled by **if**. **test** uses certain operators to evaluate the condition on its right and returns either a true or false exit status, which is then used by **if** for making decisions. **test** works in three ways:

- Compares two numbers.
- Compares two strings or a single one for a null value.
- Checks a file's attributes.

These tests can be made by **test** in association with the shell's other statements also, but for the present we'll stick with **if**. **test** doesn't display any output but simply sets the parameter $?. In the following sections, we'll check this value.

14.7.1 Numeric Comparison

The numerical comparison operators (Table 14.2) used by **test** have a form different from what you would have seen anywhere. They always begin with a - (hyphen), followed by a two-letter string, and enclosed on either side by whitespace. Here's a typical operator:

```
-ne     Not equal
```

The operators are quite mnemonic; -eq implies equal to, -gt implies greater than, and so on. Numeric comparison in the shell is confined to integer values only; decimal values are simply truncated. To illustrate how numeric tests are performed, we'll assign some values to three variables and numerically compare them:

```
$ x=5; y=7; z=7.2
$ test $x -eq $y ; echo $?
1                                    Not equal
$ test $x -lt $y ; echo $?
0                                    True
$ test $z -gt $y ; echo $?
1                                    7.2 is not greater than 7!
$ test $z -eq $y ; echo $?
0                                    7.2 is equal to 7!
```

The last two tests prove conclusively that numeric comparison is restricted to integers only. Having used **test** as a standalone feature, you can now use it as **if**'s control command. The next script, **emp3a.sh** (Fig. 14.5) uses **test** in an **if-elif-else-fi** construct (Form 3) to evaluate the shell parameter, $#. It displays the usage when no arguments are input, runs **grep** if two arguments are entered and displays an error message otherwise.

```
#!/bin/sh
# emp3a.sh: Using test, $0 and $# in an if-elif-if construct
#
if test $# -eq 0 ; then
    echo "Usage: $0 pattern file" >/dev/tty
elif test $# -eq 2 ; then
    grep "$1" $2 || echo "$1 not found in $2" >/dev/tty
else
    echo "You didn't enter two arguments" >/dev/tty
fi
```

Fig. 14.5 `emp3a.sh`

Why did we redirect the **echo** output to /dev/tty? Simple, we want the script to work both with and without redirection. In either case, the output of the **echo** statements must appear *only* on the terminal. These statements are used here as "error" messages even though they are not directed to the standard error. Now run the script four times and redirect the output every time:

```
$ emp3a.sh > foo
Usage: emp3a.sh pattern file
$ emp3a.sh ftp > foo
You didn't enter two arguments
$ emp3a.sh henry /etc/passwd > foo
henry not found in /etc/passwd
$ emp3a.sh ftp /etc/passwd > foo
$ cat foo
ftp:*:325:15:FTP User:/users1/home/ftp:/bin/true
```

The importance of /dev/tty as a mechanism of explicitly redirecting an output stream shows up in this example. You must appreciate this and use this feature in shell scripts when you like to have the redirection option open. The above script works just as well even if you don't redirect it.

Tip: An application may need to be designed in a flexible manner to allow redirection of an entire script or its participation in a pipeline. In that case, you need to ensure that messages meant to draw the attention of the user (mainly from **echo**) are redirected to >/dev/tty.

Table 14.2 Numerical Comparison Operators Used by **test**

Operator	*Meaning*
-eq	Equal to
-ne	Not equal to
-gt	Greater than
-ge	Greater than or equal to
-lt	Less than
-le	Less than or equal to

Shorthand for `test` **test** is so widely used that fortunately there exists a shorthand method of executing it. A pair of rectangular brackets enclosing the expression can replace it. Thus, the following two forms are equivalent:

```
test $x -eq $y
[ $x -eq $y ]
```

Note that you must provide whitespace around the operators (like `-eq`), their operands (like `$x`) and inside the `[` and `]`. The second form is easier to handle and will be used henceforth. But don't forget to be liberal in the use of whitespace here!

Note: It is a feature of most programming languages that you can use a condition like **`if (x)`**, where x is a variable or expression. If x is greater than 0, the statement is said to be true. We can also apply the same logic here and use **`if [ $x ]`** as a shorthand form of **`if [ $x -gt 0 ]`**.

14.7.2 String Comparison

test can be used to compare strings with yet another set of operators (Table 14.3). Equality is performed with = and inequality with the C-type operator `!=`. Other **test** checks can be negated by the `!` too. Thus, `[ ! -z $string ]` negates `[ -z $string ]`.

Our next script, **emp4.sh** (Fig. 14.6) behaves both interactively and noninteractively. When run without arguments, it turns interactive and takes two inputs from you. It then runs **emp3a.sh**, the script developed previously, with the supplied inputs as arguments. However, when **emp4.sh** itself is run with at least one argument, it runs **emp3a.sh** with the same arguments. In either case, **emp3a.sh** is run, which finally checks for the actual number of arguments entered before making a search with **grep**.

When the script runs in the interactive mode, the check for a null string is made with `[ -z "$pname" ]` as well as with `[ ! -n "$flname" ]`, since they are really two different ways of saying the same thing. Note the use of `$*` in the noninteractive mode; this is the way you can use the same set of arguments to run another script. Very soon, we'll find a good reason to change `$*` to `"$@"`. Let's first run the script interactively:

```
$ emp4.sh
Enter the string to be searched: [Enter]
You have not entered the string
$ emp4.sh
Enter the string to be searched: root
Enter the filename to be used: /etc/passwd
root:x:0:1:Super-User:/:/usr/bin/bash
```

From `emp3a.sh`

See how two scripts cooperated in displaying root's entry from `/etc/passwd`. When we run the script with arguments, **emp4.sh** bypasses all of the above activities and calls **emp3a.sh** to perform all validation checks:

```
$ emp4.sh jai
You didn't enter two arguments
```

```
#!/bin/sh
# emp4.sh: Checks user input for null values - Finally runs emp3a.sh
#                                              developed previously
if [ $# -eq 0 ] ; then
   echo "Enter the string to be searched: \c"
   read pname
   if [ -z "$pname" ] ; then              # -z checks for a null string
      echo "You have not entered the string" ; exit 1
   fi
   echo "Enter the filename to be used: \c"
   read flname
   if [ ! -n "$flname" ] ; then           # ! -n is the same as -z
      echo "You have not entered the filename" ; exit 2
   fi
   emp3a.sh "$pname" "$flname"            # Runs the script that will do the job
else
   emp3a.sh $*                            # We'll change $* to "$@" soon
fi
```

Fig. 14.6 emp4.sh

```
$ emp4.sh jai emp.lst
9876|jai sharma       |director |production|12/03/50|7000
$ emp4.sh "jai sharma" emp.lst
You didn't enter two arguments
```

The last message could take you by surprise as `jai sharma` should have been treated as a single argument by the script. Indeed it has been, but `$*` doesn't understand it as such; `jai` and `sharma` are embedded in `$*` as separate arguments. `$#` thus makes a wrong argument count. The solution to this is simple: Replace `$*` in the script with `"$@"` (with quotes) and then run the script again:

```
$ emp4.sh "jai sharma" emp.lst
9876|jai sharma       |director |production|12/03/50|7000
```

Tip: It's safer to use `"$@"` instead of `$*`. When you employ multiword strings as arguments to a shell script, it's only `"$@"` that interprets each quoted argument as a separate argument. As the output above suggests, if you use `$*`, the shell makes a wrong count of the arguments.

test also permits the checking of more than one condition in the same line, using the `-a` (AND) and `-o` (OR) operators. You can now simplify the earlier script to illustrate this feature. Accept both inputs in succession and then make the check with a compound **if** statement:

```
if [ -n "$pname" -a -n "$flname" ] ; then
   emp3a.sh "$pname" "$flname"
else
   echo "At least one input was a null string" ; exit 1
fi
```

The **test** output is true only if both variables are nonnull strings, i.e., the user enters some nonwhitespace characters when the script pauses twice.

Tip: Observe that we have been quoting our variables wherever possible. Quoting is essential when you assign multiple words to a variable. To try that out, drop the quotes to use the statement `if [ -z $pname ]`. When you input two words, or even a null string to be assigned to pname, you'll often encounter an error. Quoting is safe with no adverse consequences.

Table 14.3 String Tests Used by **test**

Test	*True if*
s1 = *s2*	String *s1* = *s2*
s1 != *s2*	String *s1* is not equal to *s2*
-n *stg*	String *stg* is not a null string
-z *stg*	String *stg* is a null string
stg	String *stg* is assigned and not null
s1 == *s2*	String *s1* = *s2* (Korn and Bash only)

14.7.3 File Tests

test can be used to test the various file attributes like its type (file, directory or symbolic link) or its permissions (read, write, execute, SUID, etc.). Both **perl** and the UNIX system call library also offer these facilities (Table 14.4). Let's test some attributes of the file `emp.lst` at the prompt:

```
$ ls -l emp.lst
-rw-rw-rw-   1 kumar    group        870 Jun  8 15:52 emp.lst
$ [ -f emp.lst ] ; echo $?                    An ordinary file?
0                                             Yes
$ [ -x emp.lst ] ; echo $?                    An executable file?
1                                             No
$ [ ! -w emp.lst ] || echo "False that file is not writable"
False that file is not writable
```

The ! negates a test, so `[ ! -w foo ]` negates `[ -w foo ]`. Using these features, you can design a script, **filetest.sh** (Fig. 14.7), that accepts a filename as argument and then performs a number of tests on it. Test the script with two filenames—one that doesn't exist and one that does:

```
$ filetest.sh emp3.lst
File does not exist
$ filetest.sh emp.lst
File is both readable and writable
```

This completes the discussion on the three domains of **test**—numeric comparison, testing of strings and file attributes. Even though we used **test** with the **if** statement in all of our examples, **test** returns an **exit** status only, and can thus be used with any shell construct that uses an exit status. **test** also finds wide application in the **while** statement.

```
#!/bin/sh
# filetest.sh: Tests file attributes
#
if [ ! -e $1 ] ; then
    echo "File does not exist"
elif [ ! -r $1 ] ; then
    echo "File is not readable"
elif [ ! -w $1 ] ; then
    echo "File is not writable"
else
    echo "File is both readable and writable"
fi
```

Fig. 14.7 **filetest.sh**

Table 14.4 File-related Tests with **test**

Test	*True if File*
`-f` *file*	*file* exists and is a regular file
`-r` *file*	*file* exists and is readable
`-w` *file*	*file* exists and is writable
`-x` *file*	*file* exists and is executable
`-d` *file*	*file* exists and is a directory
`-s` *file*	*file* exists and has a size greater than zero
`-e` *file*	*file* exists (Korn and Bash only)
`-u` *file*	*file* exists and has SUID bit set
`-k` *file*	*file* exists and has sticky bit set
`-L` *file*	*file* exists and is a symbolic link (Korn and Bash only)
f1 `-nt` *f2*	*f1* is newer than *f2* (Korn and Bash only)
f1 `-ot` *f2*	*f1* is older than *f2* (Korn and Bash only)
f1 `-ef` *f2*	*f1* is linked to *f2* (Korn and Bash only)

14.8 THE case CONDITIONAL

The **case** statement is the second conditional offered by the shell. It doesn't have a parallel either in C (**switch** is similar) or **perl**. The statement matches an expression for more than one alternative, and uses a compact construct to permit multiway branching. **case** also handles string tests, but in a more efficient manner than **if**. The general syntax of the **case** statement is as follows:

```
case expression in
    pattern1) commands1 ;;
    pattern2) commands2 ;;
    pattern3) commands3 ;;
        .....
esac
```

```
#!/bin/sh
# menu.sh: Uses case to offer 5-item menu
#
echo "        MENU\n
1. List of files\n2. Processes of user\n3. Today's Date
4. Users of system\n5. Quit to UNIX\nEnter your option: \c"
read choice
case "$choice" in
    1) ls -l ;;
    2) ps -f ;;
    3) date  ;;
    4) who   ;;
    5) exit  ;;
    *) echo "Invalid option"       # ;; not really required for the last option
esac
```

Fig. 14.8 menu.sh

case first matches *expression* with *pattern1*. If the match succeeds, then it executes *commands1*, which may be one or more commands. If the match fails, then *pattern2* is matched, and so forth. Each command list is terminated with a pair of semicolons, and the entire construct is closed with **esac** (reverse of **case**).

Consider a simple script, **menu.sh** (Fig. 14.8) that uses **case**. The script accepts values from 1 to 5, and performs some action depending on the number keyed in. The five menu choices are displayed with a multi-line **echo** statement.

case matches the value of `$choice` with the strings 1, 2, 3, 4 and 5. If the user enters a 1, the `ls -l` command is executed. Option 5 quits the program. The last option (*) matches any option not matched by by the previous options. We'll make good use of the * later.

You can see today's date by choosing the third option:

```
$ menu.sh
        MENU

1. List of files
2. Processes of user
3. Today's Date
4. Users of system
5. Quit to UNIX
Enter your option: 3
Tue Jan  7 18:03:06 IST 2003
```

case can't handle relational and file tests, but it matches strings with compact code. It is also very effective when the string is fetched by command substitution. If you cut out the first field from the **date** output, you can use this **case** construct to do different things, depending on the day of the week:

```
case `date | cut -d" " -f1` in
                                        Outputs three-character day string
```

```
    Mon) tar -cvf /dev/fd0 $HOME ;;
    Wed) scp -r $HOME mercury:/home/henry ;;
    Fri) find $HOME -newer .last_full_backup_time -print > tarilist ;;
      *) ;;
esac
```

case can also handle numbers, but only by treating them as strings. Some of our previous programs used **if** and **test** to check the value of `$#`. You can use **case** to match `$#` *directly* (without using **test**) with specific values (0, 1, 2, etc.), but you can't use it to make numeric checks (of the type `$# -gt 2`).

14.8.1 Matching Multiple Patterns

case can also specify the same action for more than one pattern. Programmers frequently encounter a logic that has to test a user response for both `y` and `Y` (or `n` and `N`). Like **grep -E** and **egrep**, **case** uses the `|` to delimit multiple patterns. For instance, the expression `y|Y` can be used to match `y` in both upper and lowercase:

```
echo "Do you wish to continue? (y/n): \c"
read answer
case"$answer" in
    y|Y) ;;                          Null statement, no action to be performed
    n|N) exit ;;
esac
```

The same logic would require a larger number of lines if implemented with **if**. **case** becomes an automatic choice when the number of matching options is high.

14.8.2 Wild-Cards: case Uses Them

case has a superb string matching feature that uses wild-cards. It uses the filename matching metacharacters *, ? and the character class *(8.3.3)—but only to match strings and not files in the current directory*. The revised **case** construct of a previous example lets the user answer the question in several ways:

```
case "$answer" in
      [yY][eE]*) ;;                  Matches YES, yes, Yes, YEs, yES, etc.
       [nN][oO]) exit ;;             Matches NO, no, nO and No
             *) echo "Invalid response"When everything else fails
esac
```

Wild-card usage in the first two options appears simple enough. Note that the * appears in two options. In the first option, it behaves like a normal wild-card. In the last option, it provides a refuge for all other nonmatched options. Note that the last **case** option doesn't need `;;` but you can provide them if you want.

14.9 expr: COMPUTATION AND STRING HANDLING

The Bourne shell can check whether an integer is greater than another, but it doesn't have any computing features at all. It has to rely on the external **expr** command for that purpose. This command combines two functions in one:

- Performs arithmetic operations on integers.
- Manipulates strings.

We'll use **expr** to perform both these functions, but with not-very-readable code when it comes to string handling. If you are using the Korn shell or Bash, you have better ways of handling these things *(21.7)*, but you must also understand the helplessness of Bourne. It's quite possible that you have to debug someone else's script which contains **expr**.

14.9.1 Computation

expr can perform the four basic arithmetic operations as well as the modulus (remainder) function:

```
$ x=3 y=5                                   Multiple assignments without a ;
$ expr 3 + 5
8
$ expr $x - $y
-2
$ expr 3 \* 5                               Asterisk has to be escaped
15
$ expr $y / $x
1                                           Decimal portion truncated
$ expr 13 % 5
3
```

The operand, be it +, -, * etc., must be enclosed on either side by whitespace. Observe that the multiplication operand (*) has to be escaped to prevent the shell from interpreting it as the filename metacharacter. Since **expr** can handle only integers, division yields only the integral part.

expr is often used with command substitution to assign a variable. For example, you can set a variable z to the sum of two numbers:

```
$ x=6 y=2 ; z=`expr $x + $y`
$ echo $z
8
```

Perhaps the most common use of **expr** is in incrementing the value of a variable. All programming languages have a shorthand method of doing that, and it is natural that UNIX should also have its own:

```
$ x=5
$ x=`expr $x + 1`                           This is the same as C's x++
$ echo $x
6
```

If you are using the Korn shell or Bash, then you can turn to Section 21.5 for a discussion on the **let** statement that both shells use to handle computation.

14.9.2 String Handling

Though **expr**'s string handling facilities aren't exactly elegant, Bourne shell users hardly have any choice. For manipulating strings, **expr** uses two expressions separated by a colon. The string to be worked upon is placed on the left of the :, and a regular expression is placed on its right. Depending on the composition of the expression, **expr** can perform three important string functions:

- Determine the length of the string.
- Extract a substring.
- Locate the position of a character in a string.

The Length of a String The length of a string is a relatively simple matter; the regular expression .* signifies to **expr** that it has to print the number of characters matching the pattern, i.e., the length of the entire string:

```
$ expr "abcdefghijkl" : '.*'                    Space on either side of : required
12
```

Here, **expr** has counted the number of occurrences of any character (.*). This feature is useful in validating data entry. Consider that you want to validate the name of a person accepted through the keyboard so that it doesn't exceed, say, 20 characters in length. The following **expr** sequence can be quite useful for this task:

```
while echo "Enter your name: \c" ; do                    echo always returns true
    read name
    if [ `expr "$name" : '.*'` -gt 20 ] ; then
        echo "Name too long"
    else
        break                                            break terminates a loop
    fi
done
```

Extracting a Substring **expr** can extract a string enclosed by the escaped characters \(and \). If you wish to extract the 2-digit year from a 4-digit string, you must create a pattern group and extract it this way:

```
$ stg=2003
$ expr "$stg" : '..\(..\)'                       Extracts last two characters
03
```

Note the pattern group \(..\). This is the tagged regular expression (TRE) used by **sed** *(13.11.3)*, but it is used here with a somewhat different meaning. It signifies that the first two characters in the value of $stg have to be ignored and two characters have to be extracted from the third character position. (There's no \1 and \2 here.)

Locating Position of a Character **expr** can also return the location of the first occurrence of a character inside a string. To locate the position of the character d in the string value of $stg, you have to count the number of characters which are not d ([^d]*), followed by a d:

```
$ stg=abcdefgh ; expr "$stg" : '[^d]*d'
4
```

expr duplicates some of the features of the **test** statement, and also uses the relational operators in the same way. They are not pursued here because **test** is a built-in feature of the shell, and is consequently faster. The Korn shell and Bash have built-in string handling facilities; they don't need **expr**. These features are taken up in Chapter 21.

14.10 $0: CALLING A SCRIPT BY DIFFERENT NAMES

In our discussion on links *(11.2.2)*, we raised the possibility of invoking a file by different names and doing different things depending on the name by which it is called. In fact, there are a number of UNIX commands that do exactly that. Now that we know how to extract a string with **expr**, it's time we designed a single script, **comc.sh** (Fig. 14.9), that compiles, edits or runs the last modified C program. The script file will have three more names, but before developing it, let's understand the compiling mechanism used by the **cc** or **gcc** compiler.

A C program has the `.c` extension. When compiled with `cc` *filename*, it produces a file named `a.out`. However, we can provide a different name to the executable using the `-o` option, For instance, **`cc -o foo foo.c`** creates an executable named `foo`. We must be able to extract the "base" filename after dropping the extension, and with **expr** it should be a simple matter.

First, we store the name of the C program that was last modified, in the variable `lastfile`. Next, we extract the base filename by dropping the `.c` extension using the TRE feature of **expr**. The **case** conditional now checks the name (saved in the variable `command`) by which the program is invoked. Observe that the first option (`runc`) simply executes the value evaluated by the variable `executable`. The only thing left to do now is to create three links:

```
ln comc.sh comc
ln comc.sh runc
ln comc.sh vic
```

Now you can run **vic** to edit the program, **comc** to compile it and **runc** to execute the object code. We'll only compile it here:

```
$ comc
hello.c compiled successfully
```

Note that this script works only with a C program that is stored, along with any functions, in one file. If functions are stored in separate files, this script won't work. In that case, **make** is the solution and is discussed in Chapter 22.

```
#!/bin/sh
# comc.sh: Script that is called by different names
#
lastfile=`ls -t *.c | head -n 1`
command=$0
executable=`expr $lastfile : '\(.*\).c'`    # Assigning a special parameter to a variable - OK
case $command in                             # Removes .c; foo.c becomes foo
        *runc) $executable ;;
         *vic) vi $lastfile ;;               # Runs the executable
        *comc) cc -o $executable $lastfile &&
               echo "$lastfile compiled successfully" ;;
esac
```

Fig. 14.9 comc.sh

14.11 while: LOOPING

None of the pattern scanning scripts developed so far offers the user another chance to rectify a faulty response. Loops let you perform a set of instructions repeatedly. The shell features three types of loops—**while**, **until** and **for**. All of them repeat the instruction set enclosed by certain keywords as often as their control command permits.

The **while** statement should be quite familiar to most programmers. It repeatedly performs a set of instructions until the control command returns a true exit status. The general syntax of this command is as follows:

```
while condition is true
do                                        Note the do keyword
    commands
done                                      Note the done keyword
```

The *commands* enclosed by **do** and **done** are executed repeatedly as long as *condition* remains true. You can use any UNIX command or **test** as the *condition*, as before.

We'll start with an orthodox **while** loop application. The script, **emp5.sh** Fig. 14.10), accepts a code and description in the same line, and then writes the line to `newlist`. It then prompts you for more entries. The loop iteration is controlled by the value of `$answer`.

We have redirected the output of two **echo** statements to /dev/tty for reasons that will be apparent later. We'll make a small but significant modification later, but let's run it first:

```
$ emp5.sh
Enter the code and description: 03 analgesics
Enter any more (y/n)? y
```

```
#!/bin/sh
# emp5.sh: Shows use of the while loop
#
answer=y          # Must set it to y first to enter the loop
while [ "$answer" = "y" ]      # The control command
do
    echo "Enter the code and description: \c" >/dev/tty
    read code description      # Read both together
    echo "$code|$description" >> newlist    # Append a line to newlist
    echo "Enter any more (y/n)? \c" >/dev/tty
    read anymore
    case $anymore in
        y*|Y*) answer=y ;;     # Also accepts yes, YES etc.
        n*|N*) answer=n ;;     # Also accepts no, NO etc.
            *) answer=y ;;     # Any other reply means y
    esac
done
```

Fig. 14.10 emp5.sh

```
Enter the code and description: 04 antibiotics
Enter any more (y/n)? [Enter]                    No response, assumed to be y
Enter the code and description: 05 OTC drugs
Enter any more (y/n)? n
```

When you see the file `newlist`, you'll know what you have achieved:

```
$ cat newlist
03|analgesics
04|antibiotics
05|OTC drugs
```

Did redirection with `/dev/tty` achieve anything here? No, nothing yet, but after we make a small change in the script, it will. Note that you added a record to `newlist` with the >> symbol. This causes `newlist` to be opened every time **echo** is called up. The shell avoids such multiple file openings and closures by providing a redirection facility at the **done** keyword itself:

```
done > newlist
```

Make this change in the script and remove the redirection provided with the >> symbols. This form of redirection speeds up execution time as `newlist` is opened and closed only once. Because this action redirects the standard output of all commands inside the loop, we redirected some statements to `/dev/tty` because we want their output to come to the terminal.

Note: Redirection is also available at the **fi** and **esac** keywords, and includes input redirection and piping:

```
done < param.lst        Statements in loop take input from param.lst
done | while true       Pipes output to a while loop
fi > foo                Affects statements between if and fi
esac > foo              Affects statements between case and esac
```

14.11.1 Using `while` to Wait for a File

Let's now consider an interesting **while** loop application. There are situations when a program needs to read a file that is created by another program, but it also has to wait until the file is created. The script, **monitfile.sh** (Fig. 14.11), periodically monitors the disk for the existence of the file, and then executes the program once the file has been located. It makes use of the external **sleep** command that makes the script pause for the duration (in seconds) as specified in its argument.

The loop executes repeatedly as long as the file `invoice.lst` can't be read (`! -r` means not readable). If the file becomes readable, the loop is terminated and the program `alloc.pl` is executed. This script is an ideal candidate to be run in the background like this:

```
monitfile.sh &
```

We used the **sleep** command to check every 60 seconds for the existence of the file. **sleep** is also quite useful in introducing some delay in shell scripts.

```
#!/bin/sh
# monitfile.sh: Waits for a file to be created
#
while [ ! -r invoice.lst ]      # While the file invoice.lst can't be read
do
   sleep 60                     # sleep for 60 seconds
done
alloc.pl                        # Execute this program after exiting loop
```

Fig. 14.11 `monitfile.sh`

14.11.2 Setting Up an Infinite Loop

Suppose you, as system administrator, want to see the free space available on your disks every five minutes. You need an infinite loop, and it's best implemented by using **true** as a dummy control command with **while**. **true** does nothing except return a true exit status. Another command named **false** returns a false value. You can set up this loop in the background as well:

```
while true ; do                 # This form is also permitted
   df -t                        # df reports free space on disk
   sleep 300
done &                          # & after done runs loop in background
```

With the job now running in the background, you can continue your other work, except that every five minutes you could find your screen filled with **df** output *(15.6.1)*. You can't now use the interrupt key to kill this loop; you'll have to use **kill $!**, which kills the last background job *(9.9.1)*.

Note: The shell also offers an **until** statement which operates with a reverse logic used in **while**. With **until**, the loop body is executed as long as the condition remains *false*. Some people would have preferred to have written a previous **while** control command as **until [-r invoice.lst]**. This form is easily intelligible.

14.12 for: LOOPING WITH A LIST

The shell's **for** loop differs in structure from the ones used in other programming languages. There is no three-part structure as used in C, **awk** and **perl**. Unlike **while** and **until**, **for** doesn't test a condition, but uses a list instead:

```
for variable in list
do
   commands                     # Loop body
done
```

The loop body also uses the keywords **do** and **done**, but the additional parameters here are *variable* and *list*. Each whitespace-separated word in *list* is assigned to *variable* in turn, and *commands* are executed until *list* is exhausted. A simple example can help you understand things better:

```
$ for file in chap20 chap21 chap22 chap23 ; do
>    cp $file ${file}.bak
>    echo $file copied to $file.bak
> done
chap20 copied to chap20.bak
chap21 copied to chap21.bak
chap22 copied to chap22.bak
chap23 copied to chap23.bak
```

The *list* here comprises a series of character strings (chap20 and onwards, representing filenames) separated by whitespace. Each item in the list is assigned to the variable `file`. `file` first gets the value chap20, then chap21, and so on. Each file is copied with a `.bak` extension and the completion message displayed after every file is copied.

14.12.1 Possible Sources of the List

The list can consist of practically any of the expressions that the shell understands and processes. **for** is probably the most often used loop in the UNIX system, and it's important that you understand it thoroughly.

List from Variables You can use a series of variables in the command line. They are evaluated by the shell before executing the loop:

```
$ for var in $PATH $HOME $MAIL ; do echo "$var" ; done
/bin:/usr/bin:/home/local/bin:/usr/bin/X11:.:/oracle/bin
/home/henry
/var/mail/henry
```

You have to provide the semicolons at the right places if you want to enter the entire loop in a single line. The three output lines represent the values of the three environment variables.

List from Command Substitution You can also use command substitution to create the list. The following **for** command line picks up its list from the file `clist`:

```
for file in `cat clist`
```

This method is most suitable when the list is large and you don't consider it practicable to specify its contents individually. It's also a clean arrangement because you can change the list without having to change the script.

List from Wild-cards When the list consists of wild-cards, the shell interprets them as *filenames*. **for** is thus indispensable for making substitutions in a set of files with **sed**. Take, for instance, this loop which works on every HTML file in the current directory:

```
for file in *.htm *.html ; do
  sed 's/strong/STRONG/g
  s/img src/IMG SRC/g' $file > $$
  mv $$ $file
  gzip $file
done
```