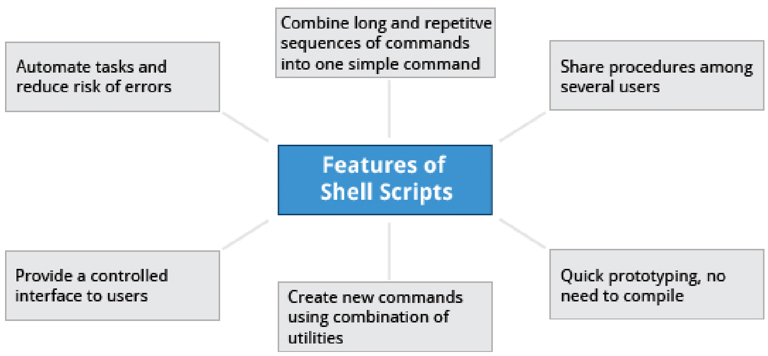
Chapter 15

Shell Scripting

Suppose you want to look up a filename, check if the associated file exists, and then respond accordingly, displaying a message confirming or not confirming the file's existence. If you only need to do it once, you can just type a sequence of commands at a terminal. However, if you need to do this multiple times, automation is the way to go. In order to automate sets of commands, you will need to learn how to write shell scripts. Most commonly in Linux, these scripts are developed to be run under the **bash** command shell interpreter. The graphic illustrates several of the benefits of deploying scripts.



Note**:** Many of the topics discussed in this and the next chapter have already been introduced earlier, while discussing things that can be done at the command line. We have elected to repeat some of that discussion in order to make the sections on scripting stand on their own, so the repetition is intentional.

Command Shell Choices

The command interpreter is tasked with executing statements that follow it in the script. Commonly used interpreters include: **/usr/bin/perl**, **/bin/bash**, **/bin/csh**, **/usr/bin/python** and **/bin/sh**.

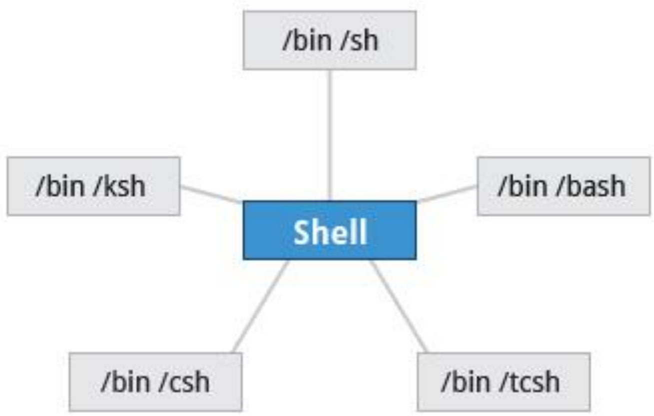
Typing a long sequence of commands at a terminal window can be complicated, time consuming, and error prone. By deploying shell scripts, using the command line becomes an efficient and quick way to launch complex sequences of steps. The fact that shell scripts are saved in a file also makes it easy to use them to create new script variations and share standard procedures with several users.

Linux provides a wide choice of shells; exactly what is available on the system is listed in **/etc/shells**. Typical choices are:

/bin/sh
/bin/bash
/bin/tcsh
/bin/csh
/bin/ksh
/bin/zsh

Most Linux users use the default bash shell, but those with long UNIX backgrounds with other shells may want to override the default.

To learn more about the UNIX Shell, you can read this short "*History of Command Shells*" article.



Shell Scripts

Remember from our earlier discussion, a shell is a command line interpreter which provides the user interface for terminal windows. It can also be used to run scripts, even in non-interactive sessions without a terminal window, as if the commands were being directly typed in. For example, typing **find . -name "*.c" -ls** at the command line accomplishes the same thing as executing a script file containing the lines:

#!/bin/bash
find . -name "*.c" -ls

The first line of the script, which starts with **#!**, contains the full path of the command interpreter (in this case **/bin/bash**) that is to be used on the file. As we have noted, you have quite a few choices for the scripting language you can use, such as **/usr/bin/perl**, **/bin/csh, /usr/bin/python,** etc.

A Simple Bash Script

Let's write a simple bash script that displays a one line message on the screen. Either type:

$ cat > hello.sh
#!/bin/bash
echo "Hello Linux Foundation Student"

and press **ENTER** and **CTRL-D** to save the file, or just create **hello.sh** in your favorite text editor. Then, type **chmod +x hello.sh** to make the file executable by all users.

You can then run the script by typing **./hello.sh** or by doing:

$ bash hello.sh
Hello Linux Foundation Student

Note: If you use the second form, you do not have to make the file executable.

Interactive example using bash scripts

Now, let's see how to create a more interactive example using a bash script. The user will be prompted to enter a value, which is then displayed on the screen. The value is stored in a temporary variable, **name**. We can reference the value of a shell variable by using a **$** in front of the variable name, such as **$name**. To create this script, you need to create a file named **getname.sh** in your favorite editor with the following content:

```
#!/bin/bash
# Interactive reading of a variable
echo "ENTER YOUR NAME"
read name
# Display variable input
echo The name given was :$name
```

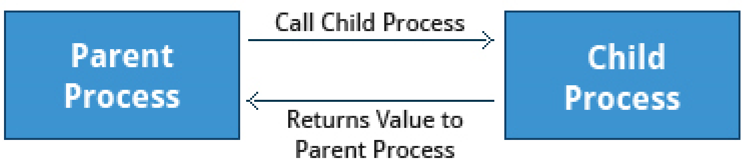
Once again, make it executable by doing **chmod +x getname.sh**.

In the above example, when the user types **./getname.sh** and the script is executed, the user is prompted with the string **ENTER YOUR NAME**. The user then needs to enter a value and press the **Enter** key. The value will then be printed out.

Note: The hash-tag/pound-sign/number-sign (**#**) is used to start comments in the script and can be placed anywhere in the line (the rest of the line is considered a comment). However, note the special magic combination of **#!**, used on the first line, is a unique exception to this rule.

Return values

All shell scripts generate a return value upon finishing execution, which can be explicitly set with the **exit** statement. Return values permit a process to monitor the exit state of another process, often in a parent-child relationship. Knowing how the process terminates enables taking any appropriate steps which are necessary or contingent on success or failure.



Viewing return values

As a script executes, one can check for a specific value or condition and return success or failure as the result. By convention, success is returned as **0**, and failure is returned as a non-zero value. An easy way to demonstrate success and failure completion is to execute ls on a file that exists as well as one that does not, the return value is stored in the environment variable represented by **$?**:

$ ls /etc/logrotate.conf
/etc/logrotate.conf

$ echo $?
0

In this example, the system is able to locate the file **/etc/logrotate.conf** and **ls** returns a value of **0** to indicate success. When run on a non-existing file, it returns **2**. Applications often translate these return values into meaningful messages easily understood by the user.

Basic Syntax and special characters

Scripts require you to follow a standard language syntax. Rules delineate how to define variables and how to construct and format allowed statements, etc. The table lists some special character usages within bash scripts:

Character	Description
#	Used to add a comment, except when used as \#, or as #! when starting a script
\	Used at the end of a line to indicate continuation on to the next line
;	Used to interpret what follows as a new command to be executed next
$	Indicates what follows is an environment variable
>	Redirect output
>>	Append output
<	Redirect input
|	Used to pipe the result into the next command

There are other special characters and character combinations and constructs that scripts understand, such as **(..)**, **{..}**, **[..]**, **&&**, **||**, **'**, **"**, **$((...))**, some of which we will discuss later.

Splitting long commands over multiple lines

Sometimes, commands are too long to either easily type on one line, or to grasp and understand (even though there is no real practical limit to the length of a command line).

In this case, the concatenation operator (****), the backslash character, is used to continue long commands over several lines.

Here is an example of a command installing a long list of packages on a system using Debian package management:

```
$~/> cd $HOME
$~/> sudo apt-get install autoconf automake bison build-essential \
   chrpath curl diffstat emacs flex gcc-multilib g++-multilib \
   libsdl1.2-dev libtool lzop make mc patch \
   screen socat sudo tar texinfo tofrodos u-boot-tools unzip \
   vim wget xterm zip
```

The command is divided into multiple lines to make it look readable and easier to understand. The **** operator at the end of each line causes the shell to combine (concatenate) multiple lines and executes them as one single command.

Putting multiple commands on a single line

Users sometimes need to combine several commands and statements and even conditionally execute them based on the behavior of operators used in between them. This method is called chaining of commands.

There are several different ways to do this, depending on what you want to do. The **;** (semicolon) character is used to separate these commands and execute them sequentially, as if they had been typed on separate lines. Each ensuing command is executed whether or not the preceding one succeeded.

Thus, the three commands in the following example will all execute, even if the ones preceding them fail:

```
$ make ; make install ; make clean
```

However, you may want to abort subsequent commands when an earlier one fails. You can do this using the **&&** (and) operator as in:

```
$ make && make install && make clean
```

If the first command fails, the second one will never be executed. A final refinement is to use the **||** (or) operator, as in:

```
$ cat file1 || cat file2 || cat file3
```

In this case, you proceed until something succeeds and then you stop executing any further steps.

Chaining commands is not the same as piping them; in the later case succeeding commands begin operating on data streams produced by earlier ones before they complete, while in chaining each step exits before the next one starts.

Output redirection

Most operating systems accept input from the keyboard and display the output on the terminal. However, in shell scripting you can send the output to a file. The process of diverting the output to a file is called output redirection. We have already used this facility in our earlier sections on how to use the command line.

The **>** character is used to write output to a file. For example, the following command sends the output of **free** to **/tmp/free.out**:

$ free > /tmp/free.out

To check the contents of **/tmp/free.out**, at the command prompt type **cat /tmp/free.out**.

Two **>** characters (**>>**) will append output to a file if it exists, and act just like **>** if the file does not already exist.

Input redirection

Just as the output can be redirected to a file, the input of a command can be read from a file. The process of reading input from a file is called input redirection and uses the **<** character.

The following three commands (using **wc** to count the number of lines, words and characters in a file) are entirely equivalent and involve input redirection, and a command operating on the contents of a file:

$ wc < /etc/passwd
49 105 2678 /etc/passwd

$ wc /etc/passwd
49 105 2678 /etcpasswd

$ cat /etc/passwd | wc
49 105 2678

Built in shell commands

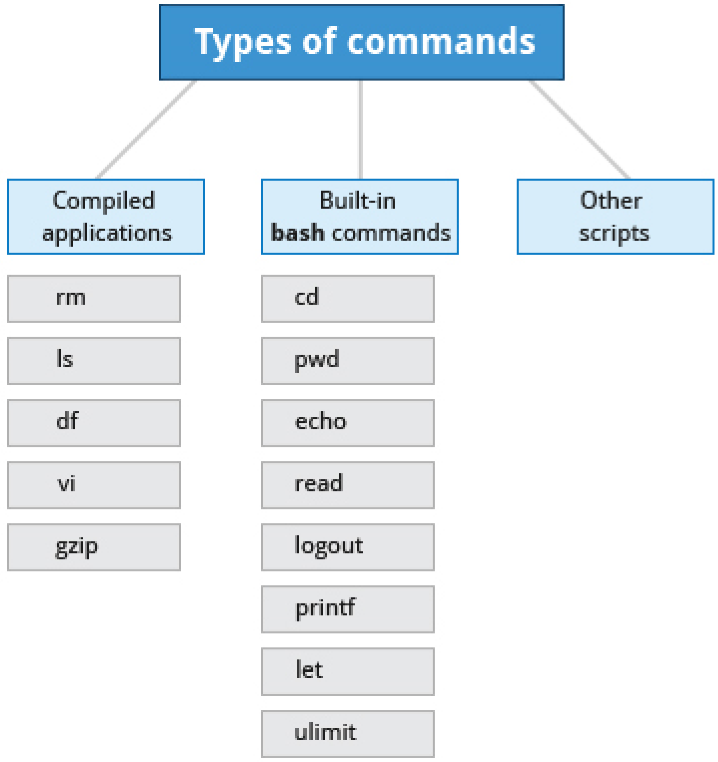
Shell scripts execute sequences of commands and other types of statements. These commands can be:

- Compiled applications
- Built-in bash commands
- Shell scripts or scripts from other interpreted languages, such as perl and Python.

Compiled applications are binary executable files, generally residing on the filesystem in well-known directories such as **/usr/bin**. Shell scripts always have access to applications such as **rm**, **ls**, **df**, **vi**, and **gzip**, which are programs compiled from lower level programming languages such as C.

In addition, bash has many built-in commands, which can only be used to display the output within a terminal shell or shell script. Sometimes, these commands have the same name as executable programs on the system, such as echo which can lead to subtle problems. bash built-in commands include
and **cd**, **pwd**, **echo**, **read**, **logout**, **printf**, **let**, and **ulimit**. Thus, slightly different behavior can be expected from the built-in version of a command such as **echo** as compared to **/bin/echo**.

A complete list of bash built-in commands can be found in the bash man page, or by simply typing **help**, as we review on the next page.



Script Parameters

Users often need to pass parameter values to a script, such as a filename, date, etc. Scripts will take different paths or arrive at different values according to the parameters (command arguments) that are passed to them. These values can be text or numbers as in:

$ ./script.sh /tmp
$ ./script.sh 100 200

Within a script, the parameter or an argument is represented with a **$** and a number or special character. The table lists some of these parameters.

Parameter	Meaning
$0	Script name
$1	First parameter
$2, $3, etc.	Second, third parameter, etc.
$*	All parameters
$#	Number of arguments

Using script parameters

If you type in the script shown in the figure, make the script executable with **chmod +x param.sh**. Then, run the script giving it several arguments, as shown. The script is processed as follows:

$0 prints the script name: **param.sh**
$1 prints the first parameter: **one**
$2 prints the second parameter: **two**
$3 prints the third parameter: **three**
$* prints all parameters: **one two three four five**
The final statement becomes: **All done with param.sh**

Command Substitution

At times, you may need to substitute the result of a command as a portion of another command. It can be done in two ways:

- By enclosing the inner command in **$( )**
- By enclosing the inner command with backticks **(`)**

The second, backticks form, is deprecated in new scripts and commands. No matter which method is used, the specified command will be executed in a newly launched shell environment, and the standard output of the shell will be inserted where the command substitution is done.

Virtually any command can be executed this way. While both of these methods enable command substitution, the **$( )** method allows command nesting. New scripts should always use this more modern method. For example:

$ ls /lib/modules/$(uname -r)/

In the above example, the output of the command **uname –r** (which will be something like **5.7.3** , is inserted into the argument for the **ls** command.

Environment variables

Most scripts use variables containing a value, which can be used anywhere in the script. These variables can either be user or system-defined. Many applications use such environment variables (already covered in some detail in *Chapter 12: User Environment*) for supplying inputs, validation, and controlling behavior.

As we discussed earlier, some examples of standard environment variables are **HOME**, **PATH**, and **HOST**. When referenced, environment variables must be prefixed with the **$** symbol, as in **$HOME**. You can view and set the value of environment variables. For example, the following command displays the value stored in the **PATH** variable:

$ echo $PATH

However, no prefix is required when setting or modifying the variable value. For example, the following command sets the value of the **MYCOLOR** variable to blue:

$ MYCOLOR=blue

You can get a list of environment variables with the **env**, **set**, or **printenv** commands.

Exporting environment variables

While we discussed the export of environment variables in the section on the "*User Environment*", it is worth reviewing this topic in the context of writing bash scripts.

By default, the variables created within a script are available only to the subsequent steps of that script. Any child processes (sub-shells) do not have automatic access to the values of these variables. To make them available to child processes, they must be promoted to environment variables using the export statement, as in:

export VAR=value

or

VAR=value ; export VAR

While child processes are allowed to modify the value of exported variables, the parent will not see any changes; exported variables are not shared, they are only copied and inherited.

Typing export with no arguments will give a list of all currently exported environment variables.

Functions

A function is a code block that implements a set of operations. Functions are useful for executing procedures multiple times, perhaps with varying input variables. Functions are also often called subroutines. Using functions in scripts requires two steps:

1. Declaring a function
2. Calling a function

The function declaration requires a name which is used to invoke it. The proper syntax is:

```
function_name () {
  command...
}
```

For example, the following function is named **display**:

```
display () {
  echo "This is a sample function"
}
```

The function can be as long as desired and have many statements. Once defined, the function can be called later as many times as necessary. In the full example shown in the figure, we are also showing an often-used refinement: how to pass an argument to the function. The first argument can be referred to as **$1**, the second as **$2**, etc.

The if statement

Conditional decision making, using an **if** statement, is a basic construct that any useful programming or scripting language must have.

When an **if** statement is used, the ensuing actions depend on the evaluation of specified conditions, such as:

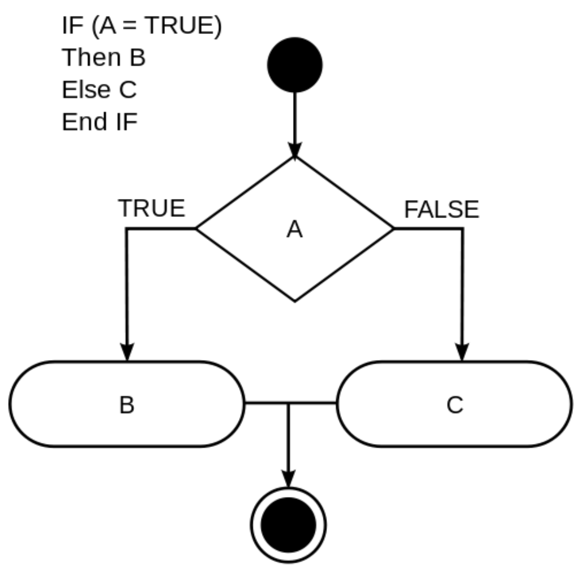
- Numerical or string comparisons
- Return value of a command (0 for success)
- File existence or permissions.

In compact form, the syntax of an **if** statement is:

if TEST-COMMANDS; then CONSEQUENT-COMMANDS; fi

A more general definition is:

if condition
then
    statements
else
    statements
fi



Using the if statement

In the following example, an **if** statement checks to see if a certain file exists, and if the file is found, it displays a message indicating success or failure:

```
if [ -f "$1" ]
then
   echo file "$1 exists"
else
   echo file "$1" does not exist
fi
```

We really should also check first that there is an argument passed to the script (**$1**) and abort if not.

Notice the use of the square brackets (**[]**) to delineate the test condition. There are many other kinds of tests you can perform, such as checking whether two numbers are equal to, greater than, or less than each other and make a decision accordingly; we will discuss these other tests.

In modern scripts, you may see doubled brackets as in **[[-f /etc/passwd]]**. This is not an error. It is never wrong to do so and it avoids some subtle problems, such as referring to an empty environment variable without surrounding it in double quotes; we will not talk about this here.

The elif statement

You can use the **elif** statement to perform more complicated tests, and take action appropriate actions. The basic syntax is:

```
if [ sometest ] ; then
   echo Passed test1
elif [ somothertest ] ; then
   echo Passed test2
fi
```

In the example shown we use strings tests which we will explain shortly, and show how to pull in an environment variable with the **read** statement.

Testing for files

bash provides a set of file conditionals, that can be used with the **if** statement, including those in the table.

You can use the **if** statement to test for file attributes, such as:

- File or directory existence
- Read or write permission
- Executable permission.

For example, in the following example:

```
if [ -x /etc/passwd ] ; then
   ACTION
fi
```

the **if** statement checks if the file **/etc/passwd** is executable, which it is not. Note the very common practice of putting:

; then

on the same line as the **if** statement.

You can view the full list of file conditions typing:

man 1 test.

Condition	Meaning
`-e file`	Checks if the file exists.
`-d file`	Checks if the file is a directory.
`-f file`	Checks if the file is a regular file (i.e. not a symbolic link, device node, directory, etc.)
`-s file`	Checks if the file is of non-zero size.
`-g file`	Checks if the file has **`sgid`** set.
`-u file`	Checks if the file has **`suid`** set.
`-r file`	Checks if the file is readable.
`-w file`	Checks if the file is writable.
`-x file`	Checks if the file is executable.

Boolean Expressions

Boolean expressions evaluate to either TRUE or FALSE, and results are obtained using the various Boolean operators listed in the table.

Operator	Operation	Meaning
&&	AND	The action will be performed only if both the conditions evaluate to true.
||	OR	The action will be performed if any one of the conditions evaluate to true.
!	NOT	The action will be performed only if the condition evaluates to false.

Note that if you have multiple conditions strung together with the **&&** operator, processing stops as soon as a condition evaluates to false. For example, if you have **A && B && C** and A is true but B is false, C will never be executed.

Likewise, if you are using the **||** operator, processing stops as soon as anything is true. For example, if you have **A || B || C** and A is false and B is true, you will also never execute C.

Tests in boolean expressions

Boolean expressions return either TRUE or FALSE. We can use such expressions when working with multiple data types, including strings or numbers, as well as with files. For example, to check if a file exists, use the following conditional test:

[-e <filename>]

Similarly, to check if the value of **number1** is greater than the value of **number2**, use the following conditional test:

[$number1 -gt $number2]

The operator **-gt** returns TRUE if **number1** is greater than **number2**.

Example of testing of strings

You can use the **if** statement to compare strings using the operator **==** (two equal signs). The syntax is as follows:

if [string1 == string2] ; then
ACTION
fi

Note that using one **=** sign will also work, but some consider it deprecated usage. Let's now consider an example of testing strings.

In the example illustrated here, the **if** statement is used to compare the input provided by the user and accordingly display the result.

Numerical tests

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

The syntax for comparing numbers is as follows:

exp1 -op exp2

Arithmetic Expressions

Arithmetic expressions can be evaluated in the following three ways (spaces are important!):

- Using the **expr** utility
  expr is a standard but somewhat deprecated program. The syntax is as follows:

  expr 8 + 8
  echo $(expr 8 + 8)

- Using the **$((...))** syntax
  This is the built-in shell format. The syntax is as follows:

  echo $((x+1))

- Using the built-in shell command **let**. The syntax is as follows:

  let x=(1 + 2); echo $x

In modern shell scripts, the use of **expr** is better replaced with **var=$((...))**.

Summary

- Scripts are a sequence of statements and commands stored in a file that can be executed by a shell. The most commonly used shell in Linux is bash**.**
- Command substitution allows you to substitute the result of a command as a portion of another command.
- Functions or routines are a group of commands that are used for execution.
- Environmental variables are quantities either preassigned by the shell or defined and modified by the user.
- To make environment variables visible to child processes, they need to be exported**.**
- Scripts can behave differently based on the parameters (values) passed to them.
- The process of writing the output to a file is called output redirection.

- The process of reading input from a file is called input redirection.
- The **if** statement is used to select an action based on a condition.
- Arithmetic expressions consist of numbers and arithmetic operators, such as **+**, **-**, and *****.