Community Experience Distilled

Learning Linux Shell Scripting

Unleash the power of Shell scripts to solve real-world problems by breaking through the practice of writing tedious code

Ganesh Sanjiv Naik

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He completed his computer engineering in 1988. Since then, he has worked in this industry. He has worked on projects including micro-controller based projects to advanced Embedded Android projects. He has more than 20 years of professional experience and project accomplishment in information technology.

Ganesh has a passion and deep desire for teaching. He has trained 1,000 engineers in Linux and Android product development. He has developed a lot of training material as well as curriculum for various universities and training institutes.

He has an interest in spiritual study and practices such as meditation. He is a certified yoga teacher. His hobbies include yoga and martial arts.

He has worked as a corporate trainer for Indian Space Research Organization, Intel, GE, Samsung, Motorola, Penang Skill Development Center (Malaysia), various companies in Singapore as well as various other corporates in India and other countries. He has started a company called Levana Technologies, which works with the Penang Skill Development Center (Malaysia) for consulting and training activities. If you would like to send feedback, suggestions, or corrections in the book, he can be contacted at `https://in.linkedin.com/in/naikganesh`.

This book is his real-life experience….

He has worked as a consultant and corporate trainer in the following skills:

- Internet of Things
- Embedded Android, Android internals, and device driver development
- USB and PCI device driver development in Linux
- Embedded Linux and device driver development
- Unix Shell scripting with sed and awk
- Embedded C++ and C programming
- Operating systems, software engineering, and networking
- Problem solving—analysis, reasoning, and solution techniques for software engineers

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About the Reviewers

Advait Deo has more than 10 years of experience in database domain, has spent time on many aspects of databases until now, starting from Oracle version 8 until 12c. He mainly focuses on database performance tuning, integrating database with front end application, scripting, and automation. He is currently working as a senior database administrator for (world leader in retail business).

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I wish to dedicate this book to my Gurudev His Holiness Dr. Jayant Balaji Athavale. I wish to express gratitude for his guidance, which I have received for, how to become good human being, good professional and a seeker on the path of spiritual progress.

- Ganesh Sanjiv Naik

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Preface

Shell scripts are an essential part of any modern operating system, such as UNIX, Linux, Windows, and similar. The scripting language or its syntax may vary from OS to OS; but the fundamental principles remain the same. I first encountered Linux Shell scripts during the development of embedded Linux product development. Shell scripts were initializing the complete product from the basic booting procedure until users logged in and a complete operating system was initialized. Another situation was in the automation of regular activities, such as the build and release management of source codes of very complex products, where more than 10,000 files were a part of a single project. Similarly, another very common requirement comes while using the make utility, which is used to compile and build complex product source codes.

Initially, I had learned scripts to solve practical problems and customize already existing products. This book is the summary of what I have learned over the years in Linux Shell scripting during project development work, consultancy, and corporate trainings and their Q&A sessions.

In this book, you will learn about the very basics of Shell scripting to complex, customized automation. By the end of this book, you will be able to confidently use your own Shell scripts for the real-world problems out there. The idea is to be as practical as possible and give you the look and feel of what real-world scripting looks like.

This book covers bash, the GNU Bourne-Again Shell scripting. You can use the knowledge gained by reading this book for any shell of any of the UNIX flavors or distributions. You will need to take care of a few syntax changes if you are working in other shells, such as Korn, and similar. You should be able to read this book cover to cover, or you can just pick it up and read anything that you might find interesting. But perhaps most importantly, if you have a question about how to solve a particular problem or you need a hint, you will find it easy to find the right solution or something close enough to save your time and energy.

What this book covers

Chapter 1, *Getting Started and Working with Shell Scripting*, you will learn different ways to write and run Shell scripts. You will also learn ways to handle files and directories, and you will learn about working with permissions.

Chapter 2, *Drilling Deep into Process Management, Job Control, and Automation*, you will learn about basic process management. You will learn about command ps and job management using commands such as jobs, fg, bg, kill, and pkill. Later on, you will learn about process monitoring tools: top, iostat, vmstat and sar.

Chapter 3, *Using Text Processing and Filters in Your Scripts*, you will learn about using more, less, head, and tail commands. You will also learn text processing tools such as, cut, paste, comm, and uniq. You will learn about standard input, output, and error. Later on, you will learn about metacharacters and pattern matching using vi and grep.

Chapter 4, *Working with Commands*, you will learn about how shell interprets any command entered on the command line. You will also learn command substitution, separators, and pipes in detail.

Chapter 5, *Exploring Expressions and Variables*, you will learn about variables—environment variables. This will include how to export environment variables, set, shift, read-only variables, command-line arguments, and about creating and handling arrays.

Chapter 6, *Neat Tricks with Shell Scripting*, you will learn about debugging, the here operator, interactive Shell scripts for taking input from the keyboard, and file handling.

Chapter 7, *Performing Arithmetic in Shell Scripts*, you will learn about doing arithmetic operations in various ways, such as using declare, let, expr, and arithmetic expressions. You will also learn about representing numbers in different bases, such as hex, octal, and binary. You will learn about using the bc utility for doing floating point or fractional arithmetic.

Chapter 8, *Automating Decision Making in Scripts*, you will learn about using decision making in scripts working with test, if…else, and switching case. You will also use select for loop with menu. For repeating tasks such as processing lists, you will learn about using for loop, while loop and do while. You will also learn about how to control loops using break and continue statements.

Chapter 9, Working with Functions, we will understand about functions in Shell scripts. You will learn about the definition and display of functions by removing the function from the shell. You will also learn about passing arguments to functions, sharing data between functions, declaring local variables in functions, returning results from functions, and running functions in background. You will finally learn about using source and . commands. We will use these commands to use the library of functions.

Chapter 10, Using Advanced Functionality in Scripts, you will learn about using traps and signals. You will also learn about creating menus with the help of the dialog utility.

Chapter 11, System Startup and Customizing a Linux System, you will learn about Linux system startup from power on until the user login and how to customize a Linux system environment.

Chapter 12, Pattern Matching and Regular Expressions with sed and awk, you will learn about regular expressions and using sed (stream editor) and awk for text processing. You will learn about the usage of various commands and options along with a lot of examples for using sed and awk.

What you need for this book

Any computer that has Linux OS installed on it will be sufficient for learning all the topics discussed in this book. I have personally tested all the commands and scripts in Ubuntu 12.10 distribution.

While learning, if you find that any utility has not installed alongside Ubuntu or any Debian-based distribution, then enter the following command to install this utility:

```
$ sudo apt-get update
$ sudo apt-get install package-name
```

The Internet should be available for the previous commands to run.

In Red Hat or any other rpm-based distribution, enter the following commands:

```
$ sudo yum update
$ sudo yum install package-name
```

If the Internet is connected, then using these commands, you can install any command or utility that is not already installed.

Who this book is for

This book is for the readers that are proficient at working with Linux, and who want to learn about Shell scripting to improve their efficiency and practical skills. The following are a few examples where we can use skills learned in this book:

- Shell scripting is for automating tasks such as taking a periodic backup
- Systems administration
- Database maintenance and backup
- Test processing and report generation
- The customization of system initialization

Conventions

In this book, you will find a number of text styles that distinguish between different kinds of information. Here are some examples of these styles and an explanation of their meaning.

Code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles are shown as follows: "In the output, `4d3` tells us that line number 4 is deleted in `file2`. Similarly, the `change` command will show us changes in the file as well."

A block of code is set as follows:

```
#!/bin/bash
# This is comment line
echo "Hello World"
ls
date
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
$ expr 4 * 10
expr: syntax error
With command expr, we cannot use * for multiplication. We need to use
\* for multiplication.
$ expr "4 * 10"
4 * 10
$ expr 4 \* 10
40
```

Any command-line input or output is written as follows:

```
$ sed '1,3d' datafile >  tempfile
$ awk -F: '/Marie/{print $1, $2}' people1.txt
```

New terms and **important words** are shown in bold.

> Warnings or important notes appear in a box like this.

> Tips and tricks appear like this.

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1
Getting Started and Working with Shell Scripting

Whoever works with Linux will come across shell as the first program to work with. The **Graphical user interface** (**GUI**) usage has become very popular due to the ease of use. Those who want to take advantage of the power of Linux will use the shell program by default.

Shell is a program which provides the user direct interaction with the operating system. Let's understand the stages in the evolution of the Linux operating system. Linux was developed as a free and open source substitute for UNIX OS. The chronology can be as follows:

- The UNIX operating system was developed by Ken Thomson and Dennis Ritchie in 1969. It was released in 1970. They rewrote the UNIX using C language in 1972.
- In 1991, Linus Torvalds developed the Linux kernel for the free operating system.

In this chapter, we will cover the following topics:

- Comparison of shells
- Working in shell
- Learning basic Linux commands
- Our first script—Hello World
- Compiler and interpreter—difference in process
- When not to use scripts
- Various directories
- Working more effectively with shell—basic commands
- Working with permissions

Comparison of shells

Initially, the UNIX OS used a shell program called **Bourne Shell**. Then eventually, many more shell programs were developed for different flavors of UNIX. The following is brief information about different shells:

- Sh—Bourne Shell
- Csh—C Shell
- Ksh—Korn Shell
- Tcsh—enhanced C Shell
- Bash—GNU Bourne Again Shell
- Zsh—extension to Bash, Ksh, and Tcsh
- Pdksh—extension to KSH

A brief comparison of various shells is presented in the following table:

Feature	Bourne	C	TC	Korn	Bash
Aliases	no	yes	yes	yes	yes
Command-line editing	no	no	yes	yes	yes
Advanced pattern matching	no	no	no	yes	yes
Filename completion	no	yes	yes	yes	yes
Directory stacks (pushd and popd)	no	yes	yes	no	yes
History	no	yes	yes	yes	yes
Functions	yes	no	no	yes	yes
Key binding	no	no	yes	no	yes
Job control	no	yes	yes	yes	yes
Spelling correction	no	no	yes	no	yes
Prompt formatting	no	no	yes	no	yes

What we see here is that, generally, the syntax of all these shells is 95% similar. In this book, we are going to follow Bash shell programming.

Tasks done by shell

Whenever we type any text in the shell terminal, it is the responsibility of shell to execute the command properly. The activities done by shell are as follows:

- Reading text and parsing the entered command
- Evaluating metacharacters such as wildcards, special characters, or history characters
- Process io-redirection, pipes, and background processing
- Signal handling
- Initializing programs for execution

We will discuss the preceding topics in the subsequent chapters.

Working in shell

Let's get started by opening the terminal, and we will familiarize ourselves with the Bash Shell environment:

1. Open the Linux terminal and type in:

   ```
   $ echo $SHELL
   /bin/bash
   ```

2. The preceding output in terminal says that the current shell is `/bin/bash` such as `BASH` shell:

   ```
   $ bash --version
   GNU bash, version 2.05.0(1)-release (i386-redhat-linux-gnu)
   Copyright 2000 Free Software Foundation, Inc.
   ```

Hereafter, we will use the word `Shell` to signify the `BASH` shell only. If we intend any other shell, then it will be specifically mentioned by name such as `KORN` and similar other shells.

In Linux, filenames in lowercase and uppercase are different; for example, the files `Hello` and `hello` are two distinct files. This is unlike Windows, where case does not matter.

As far as possible, avoid using spaces in filenames or directory names such as:

- Wrong file name—`Hello World.txt`
- Correct file name—`Hello_World.txt` or `HelloWorld.txt`

This will make certain utilities or commands fail or not work as expected, for example, the `make` utility.

While typing in filenames or directory names of the existing files or folders, use the tab completion feature of Linux. This will make working with Linux faster.

Learning basic Linux commands

The following table lists a few basic Linux commands:

Command	Description
`$ ls`	This command is used to check the contents of the directory.
`$ pwd`	This command is used to check the present working directory.
`$ mkdir work`	We will work in a separate directory called `work` in our `home` directory. Use this command to create a new directory called `work` in the current folder.
`$ cd work`	This command will change our working directory to the newly created directory `work`.
`$ pwd`	This command can be used to verify whether we moved to the expected directory.
`$ touch hello.sh`	This command is used to create a new empty file called `hello.sh` in the current folder.
`$ cp hello.sh bye.sh`	This command is used to copy one file into another file. This will copy `hello.sh` as `bye.sh`.
`$ mv bye.sh welcome.sh`	This command is used to rename a file. This will rename `bye.sh` as `welcome.sh`.
`$ ll`	This command will display detailed information about files.
`$ mv welcome.sh .welcome.sh` `$ ls`	Let's see some magic. Rename the file using the `mv` command and the run the `ls` command. Now, the `ls` command will not display our file `.welcome.sh`. That file gets hidden. Any filename or directory name starting with `"."` (dot) becomes hidden.
`$ ls -a`	This command is used to see hidden files.
`$ rm .welcolme.sh`	This command is used to delete the file.

> If we delete any file from GUI such as Graphical User Interface, then it will be moved to the `/home/user/.local/share/Trash/files/all deleted files` folder.

Our first script – Hello World

Since we learned basic commands to use Linux OS, we will now write our first Shell script called `hello.sh`. You can use any editor of your choice such as vi, gedit, nano, and other similar editors. I prefer to use the vi editor.

1. Create a new `hello.sh` file as follows:

```
#!/bin/bash
# This is comment line
echo "Hello World"
ls
date
```

2. Save the newly created file.

The `#!/bin/bash` line is called the shebang line. The combination of the characters `#` and `!` is called the magic number. The shell uses this to call the intended shell such as `/bin/bash` in this case. This should always be the first line in a Shell script.

The next few lines in the Shell script are self explanatory.

- Any line starting with `#`, will be treated as a comment line. An exception to this would be the first line with `#!/bin/bash`
- The `echo` command will print `Hello World` on the screen
- The `ls` command will display directory content on the console
- The `date` command will show the current date and time

We can execute the newly created file by the following commands:

- Technique one:

```
$ bash hello.sh
```

- Technique two:

```
$ chmod +x hello.sh
```

By running any of the preceding commands, we are adding executable permission to our newly created file. You will learn more about file permissions in later in this same chapter.

```
$ ./hello.sh
```

By running the preceding command, we are executing `hello.sh` as the executable file. By technique one, we passed filename as an argument to Bash shell.

The output of executing `hello.sh` will be as follows:

```
Hello World
hello.sh
Sun Jan 18 22:53:06 IST 2015
```

Since we have successfully executed our first script, we will proceed to develop a more advanced script, `hello1.sh`. Please create the new script `hello.sh` as follows:

```
#!/bin/bash
# This is the first Bash shell
# Scriptname : Hello1.sh
# Written by:  Ganesh Naik
echo "Hello $LOGNAME, Have a nice day !"
echo "Your are working in directory `pwd`."
echo "You are working on a machine called `uname -n`."
echo "List of files in your directory is."
ls      # List files in the present working directory
echo  "Bye for now $LOGNAME. The time is `date +%T`!"
```

The output of executing `hello.sh` will be as follows:

```
Hello student, Have a nice day !.
Your are working in directory /home/student/work.
You are working on a machine called ubuntu.
List of files in your directory is.
hello1.sh  hello.sh
Bye for now student. The time is 22:59:03!
```

You will learn about the `LOGNAME`, `uname`, and other similar commands as we go on with the book.

Compiler and interpreter – difference in process

In any program development, the following are the two options:

- **Compilation**: Using a compiler-based language such as C, C++, Java, and other similar languages
- **Interpreter**: Using interpreter-based languages such as Bash Shell scripting.

When we use a compiler-based language, we compile the complete source code, and as a result of compilation, we get a binary executable file. We then execute the binary to check the performance of our program.

On the contrary, when we develop the Shell script, such as an interpreter-based program, every line of the program is input to Bash shell. The lines of Shell script are executed one by one sequentially. Even if the second line of a script has an error, the first line will be executed by the shell interpreter.

When not to use scripts

Shell scripts have certain advantages over compiler-based programs, such as C or C++ language. However, Shell scripting has certain limitations as well.

The following are the advantages:

- Scripts are easy to write
- Scripts are quick to start and easy for debugging
- They save the time of development.
- Tasks of administration are automated
- No additional setup or tools are required for developing or testing Shell script

The following are the limitations of Shell scripts:

- Every line in Shell script creates a new process in the operating system. When we execute the compiled program such as C program, it runs as a single process for the complete program.
- Since every command creates a new process, Shell scripts are slow as compared to compiled programs.
- Shell scripts are not suitable if heavy math operations are involved.

- There are Problems with cross-platform portability.
- We cannot use Shell scripts in the following situations when:
    - Extensive file operations are required
    - We need data structures, such as linked lists or trees
    - We need to generate or manipulate graphics or GUIs
    - We need direct access to system hardware
    - We need a port or socket I/O
    - We need to use libraries or interface with legacy code
    - Proprietary, closed source applications are used (Shell scripts put the source code right out in the open for the entire world to see)

Various directories

We will explore the directory structure in Linux so that it will be useful later on:

- `/bin/`: This contains commands used by a regular user.
- `/boot/`: The files required for the operating system startup are stored here.
- `/cdrom/`: When CD-ROM is mounted, the CD-ROM files are accessible here.
- `/dev/`: The device driver files are stored in this folder. These device driver files will point to hardware-related programs running in kernel.
- `/etc/`: This folder contains configuration files and startup scripts.
- `/home/`: This folder contains a home folder of all users except the administrator.
- `/lib/`: The library files are stored in this folder.
- `/media/`: External media such as a USB pen drive is mounted in this folder.
- `/opt/`: The optional packages are installed in this folder.
- `/proc/`: This contains files which give information about kernel and every process running in OS.
- `/root/`: This is the administrators home folder.
- `/sbin/`: This contains commands used by the administrator or root user.
- `/usr/`: This contains secondary programs, libraries, and documentation about user-related programs.
- `/var/`: This contains variable data such as http, tftp, and similar other.
- `/sys/`: This dynamically creates the `sys` files

Working more effectively with shell – basic commands

Let us learn a few commands, which are required very often, such as `man`, `echo`, `cat` and similar:

- Enter the following command. It will show the various types of manual pages displayed by the `man` command:

  ```
  $ man man
  ```

  From the following table, you can get an idea about various types of `man` pages for the same command:

Section number	Subject area
1	User commands
2	System calls
3	Library calls
4	Special files
5	File formats
6	Games
7	Miscellaneous
8	System admin
9	Kernel routines

- We can enter the `man` command to display corresponding manual pages as follows:

  ```
  $ man 1 command
  $ man 5 command
  ```

- Suppose we need to know more about the `passwd` command, which is used for changing the current password of a user, you can type the command as follows:

  ```
  $ man command
    man -k passwd   // show all pages with keyword
    man -K passwd  // will search all manual pages for pattern
  $ man passwd
  ```

This will show information about the `passwd` command:

```
$ man 5 passwd
```

The preceding command will give information about the file `passwd`, which is stored in `/etc /passwd`.

- We can get brief information about the command as follows:

  ```
  $ whatis passwd
  ```

  Output:

  ```
  passwd (1ssl)        - compute password hashes
  passwd (1)           - change user password
  passwd (5)           - the password file
  ```

- Every command we type in the terminal has an executable binary program file associated with it. We can check the location of a binary file as follows:

  ```
  $ which passwd
  /usr/bin/passwd
  ```

  The preceding line tells us that the binary file of the `passwd` command is located in the `/usr/bin/passwd` folder.

- We can get complete information about the binary file location as well as manual page location of any command by following:

  ```
  $ whereis passwd
  ```

  The output will be as follows:

  ```
  passwd: /usr/bin/passwd /etc/passwd /usr/bin/X11/passwd /usr/
  share/man/man1/passwd.1.gz /usr/share/man/man1/passwd.1ssl.gz /
  usr/share/man/man5/passwd.5.gz
  ```

- Change the user login and effective user name:

  ```
  $ whoami
  ```

  This command displays the user name of the logged in user:

  ```
  $ su
  ```

  The `su` command (switch user) will make the user as the administrator; but, you should know the administrators, password. The `sudo` command (superuser do) will run the command with administrator's privileges. It is necessary that the user should have been added in the `sudoers` list.

  ```
  # who am i
  ```

  This command will show the effective user who is working at that moment.

  ```
  # exit
  ```

- Many a times, you might need to create new commands from existing commands. Sometimes, existing commands have complex options to remember. In such cases, we can create new commands as follows:

  ```
  $ alias ll='ls -l'
  $ alias copy='cp -rf'
  ```

  To list all declared aliases, use the following command:

  ```
  $ alias
  ```

  To remove an alias, use the following command:

  ```
  $ unalias copy
  ```

- We can check about the operating system details such as UNIX/Linux or the distribution that is installed by the following command:

  ```
  $ uname
  ```

  Output:

  ```
  Linux
  ```

  This will display the basic OS information (UNIX name)

- Linux kernel version information will be displayed by the following:

  ```
  $ uname -r
  ```

  Output:

  ```
  3.13.0-32-generic
  ```

- To get all the information about a Linux machine, use the following command:

  ```
  $ uname -a
  ```

  Output:

  ```
  Linux ubuntu 3.13.0-32-generic #57~precise1-Ubuntu SMP Tue Jul 15
  03:50:54 UTC 2014 i686 i686 i386 GNU/Linux
  ```

- The following commands will give you more information about the distribution of Linux:

  ```
  $ cat /proc/version   // detailed info about distribution
  $ cat /etc/*release
  # lsb_release -a   // will tell distribution info for Ubuntu
  ```

  The command `cat` is used for reading files and displayed on the standard output.

- Sometimes, we need to copy a file or directory in many places. In such situations, instead of copying the original file or directory again and again, we can create soft links. In Windows, a similar feature is called as creating a shortcut.

  ```
  $ ln  -s  file file_link
  ```

- To learn about the type of file, you can use the command file. In Linux, various types of files exist. Some examples are as follows:
  - Regular file (-)
  - Directory (d)
  - Soft link (l)
  - Character device driver (c)
  - Block device driver (b)
  - Pipe file (p)
  - Socket file (s)

- We can get information about a file using the following command:

  ```
  $ file   fil_name   // show type of file
  ```

- Printing some text on the screen for showing results to the user or to ask details is an essential activity.
  - The following command will create a new file called `file_name` using the `cat` command:

    ```
    $ cat > file_name
    line 1
    line 2
    line 3
    < Cntrl + D will save the file    >
    ```

  But this is very rarely used, as many powerful editors are already existing, such as vi or gedit.

  - The following command will print `Hello World` on the console. The `echo` command is very useful for Shell script writers:

    ```
    $ echo "Hello World"
    ```

  - The following command will copy the string `Hello World` to the `hello.c` file:

    ```
    $ echo "Hello World" >   hello.c
    ```

The command `echo` with `>` overwrites the content of the file. If content already exists in the file, it will be deleted and new content will be added in the file. In a situation, when we need to append the text to the file, then we can use the `echo` command as follows:

```
$ echo  "Hello World" >> hello.c  will append the text
```

◦ The following command will display the content of the file on screen:

```
$ cat hello.c
```

Working with permissions

The following are the types of permissions:

- **Read permission**: The user can read or check the content of the file
- **Write permission**: The user can edit or modify the file
- **Execute permission**: The user can execute the file

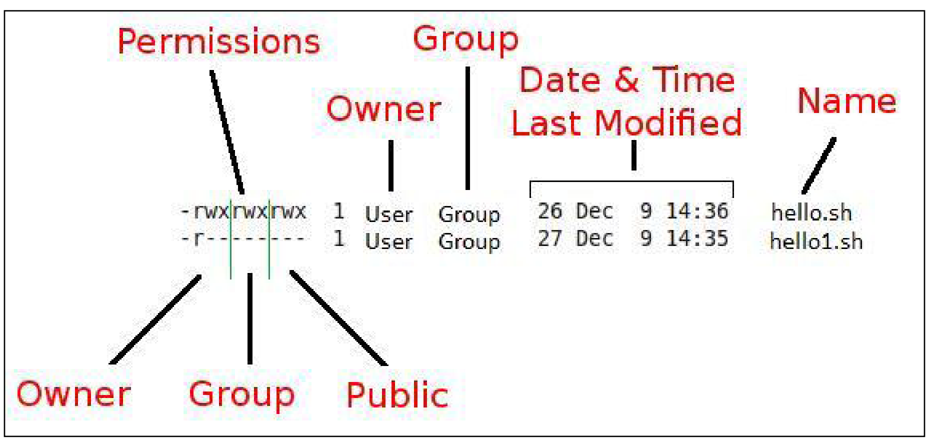
Changing file permissions

The following are the commands for changing the file permissions:

To check the file permission, give the following command:

```
$ ll file_name
```

The details of file permissions are as seen in the following image:



In the preceding diagram, as we can see, permissions are grouped in owner-user and group and other users' permissions. Permissions are of three types such as read, write, and execute permissions. As per the requirement, we may need to change permissions of the various files.

Command chmod

We can change the file or directory permissions by the following two ways:

Technique one – the symbolic method

The following command will add the read/write and execute permissions to the file wherein, `u` is for user, `g` is for group, and `o` is for others:

```
$ chmod ugo+rwx file_name
```

Alternatively, you can use the following command:

```
$ chmod +rwx file_name
```

Technique two – the numeric method

The following command will change the file permissions using the octal technique:

```
$ chmod +rwx file_name
```

The file permission `777` can be understood as `111 111 111`, which corresponds to the `rwx.rwx.rwx` permissions.

Setting umask

We will see how Linux decides the default permissions of the newly created file or folder:

```
$ umask
0002
```

The meaning of the preceding output is that, if we create a new directory, then from the permissions of `+rwx`, the permission `0002` will be subtracted. This means that for a newly created directory, the permissions will be `775` or `rwx rwx r-x`. For a newly created file, the file permissions will be `rw- rw- r--`. By default, for any newly created text file, the execute bit will never be set. Therefore, the newly created text file and directory will have different permissions even though the umask is same.

Setuid

Another very interesting functionality is the `setuid` feature. If the `setuid` bit is set for a script, then the script will always run with the owner's privileges irrespective of which user is running the script. If the administrator wants to run script written by him by other users, then he can set this bit.

Consider either of the following situations:

```
$ chmod u+s file_name
$ chmod 4777 file
```

The file permissions after any of the preceding two commands will be `drwsrwxrwx`.

Setgid

Similar to `setuid`, the `setgid` functionality gives the user the ability to run scripts with group owner's privileges, even if it is executed by any other user.

```
$ chmod g+s filename
```

Alternatively, you can use the following command:

```
$ chmod 2777 filename
```

File permissions after any of the preceding two commands will be `drwxrwsrwtx`.

Sticky bit

Sticky bit is a very interesting functionality. Let's say, in the administration department there are 10 users. If one folder has been set with sticky bit, then all other users can copy files to that folder. All users can read the files, but only the owner of the respective file can edit or delete the file. Other user can only read but not edit or modify the files if the sticky bit is set.

```
$ chmod +t filename
```

Alternatively, you can use the following command:

```
$ chmod 1777
```

File permissions after any of the preceding two commands will be `drwxrwxrwt`.

Summary

In this chapter, you learned different ways to write and run Shell scripts. You also learned ways to handle files and directories as well as work with permissions.

In the next chapter, you will learn about process management, job control, and automation.

2

Drilling Deep into Process Management, Job Control, and Automation

In the last chapter, we introduced ourselves to the Bash shell environment in Linux. You learned basic commands and wrote your first Shell script as well.

You also learned about process management and job control. This information will be very useful for system administrators in automation and solving many problems.

In this chapter, we will cover the following topics:

- Monitoring processes with ps
- Job management—working with fg, bg, jobs, and kill
- Exploring at and crontab

Introducing process basics

A running instance of a program is called as process. A program stored in the hard disk or pen drive is not a process. When that stored program starts executing, then we say that process has been created and is running.

Let's very briefly understand the Linux operating system boot-up sequence:

1. In PCs, initially the BIOS chip initializes system hardware, such as PCI bus, display device drivers, and so on.
2. Then the BIOS executes the boot loader program.

3. The boot loader program then copies kernel in memory, and after basic checks, it calls a kernel function called `start_kenel()`.
4. The kernel then initiates the OS and creates the first process called `init`.
5. You can check the presence of this process with the following command:

   ```
   $ ps -ef
   ```

6. Every process in the OS has one numerical identification associated with it. It is called a **process ID**. The process ID of the `init` process is 1. This process is the parent process of all user space processes.
7. In the OS, every new process is created by a system call called `fork()`.
8. Therefore, every process has a process ID as well as the parent process ID.
9. We can see the complete process tree using the following command:

   ```
   $ pstree
   ```

You can see the very first process as `init` as well as all other processes with a complete parent and child relation between them. If we use the `$ps -ef` command, then we can see that the `init` process is owned by root and its parent process ID is 0. This means that there is no parent for `init`:

```
student@ubuntu:~$ pstree
init─┬─NetworkManager─┬─dhclient
     │                ├─dnsmasq
     │                └─2*[{NetworkManager}]
     ├─accounts-daemon───{accounts-daemon}
     ├─acpid
     ├─anacron───sh───run-parts───apt───sleep
     ├─atd
     ├─avahi-daemon───avahi-daemon
     ├─bamfdaemon───2*[{bamfdaemon}]
     ├─bluetoothd
     ├─colord───2*[{colord}]
     ├─console-kit-dae───64*[{console-kit-dae}]
     ├─cron
     ├─cupsd
     ├─2*[dbus-daemon]
     ├─dbus-launch
     ├─dconf-service───2*[{dconf-service}]
     ├─gconfd-2
     ├─geoclue-master
     ├─6*[getty]
```

Therefore, except the `init` process, all other processes are created by some other process. The `init` process is created by the kernel itself.

The following are the different types of processes:

- **Orphan process**: If by some chance the parent process is terminated, then the child process becomes an orphan process. The process which created the parent process, such as the grandparent process, becomes the parent of orphan child process. In the last resort, the `init` process becomes the parent of the orphan process.
- **Zombie process**: Every process has one data structure called the process control table. This is maintained in the operating system. This table contains the information about all the child processes created by the parent process. If by chance the parent process is sleeping or is suspended due to some reason and the child process is terminated, then the parent process cannot receive the information about the child process termination. In such cases, the child process that has been terminated is called the zombie process. When the parent process awakes, it will receive a signal regarding the child process termination and the process control block data structure will be updated. The child process termination is then completed.
- **Daemon process**: Until now, we had started every new process in a Bash terminal. Therefore, if we print any text with the `$ echo "Hello"` command, it will be printed in the terminal itself. There are certain processes that are not associated with any terminal. Such processes are called a daemon process. These processes are running in background. An advantage of the daemon process is they are immune to the changes happening to Bash shell, which has created it. When we want to run certain background processes, such as DHCP server and so on, then the daemon processes are very useful.

Monitoring processes using ps

We have used the command `ps` in the introduction. Let's learn more about it:

- To list the process associated with our current Bash shell terminal, enter the following command:

  `$ ps`

```
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 2797 pts/0    00:00:00 ps
student@ubuntu:~$
student@ubuntu:~$
```

- To list processes along with the parent process ID associated with the current terminal, enter the following command:

  $ ps -f

```
student@ubuntu:~$
student@ubuntu:~$
student@ubuntu:~$ ps -f
UID        PID  PPID  C STIME TTY          TIME CMD
student   2621  2610  0 19:14 pts/0    00:00:00 bash
student   2864  2621  0 19:31 pts/0    00:00:00 ps -f
student@ubuntu:~$
student@ubuntu:~$
```

  We can see the process ID in the `PID` column and the parent process ID in the `PPID` column in the preceding output.

- To list processes with the parent process ID along with the process state, enter the following command:

  $ ps -lf

```
student@ubuntu:~$
student@ubuntu:~$
student@ubuntu:~$ ps -lf
F S UID        PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S student   2621  2610  0  80   0 -  1817 wait   19:14 pts/0    00:00:00 bash
0 R student   2928  2621  0  80   0 -  1237 -      19:35 pts/0    00:00:00 ps -lf
student@ubuntu:~$
student@ubuntu:~$
student@ubuntu:~$
```

  In the preceding output, the column with `S` (state) shows the current state of a process, such as `R` for running and `S` for suspended state.

- To list all the processes running in the operating system including system processes, enter the following command:

  $ ps -ef

```
student@ubuntu:~$
student@ubuntu:~$ ps -ef
UID        PID  PPID  C STIME TTY          TIME CMD
root         1     0  0 19:06 ?        00:00:01 /sbin/init
root         2     0  0 19:06 ?        00:00:00 [kthreadd]
root         3     2  0 19:06 ?        00:00:00 [ksoftirqd/0]
root         5     2  0 19:06 ?        00:00:00 [kworker/0:0H]
root         7     2  0 19:06 ?        00:00:00 [rcu_sched]
root         8     2  0 19:06 ?        00:00:00 [rcu_bh]
root         9     2  0 19:06 ?        00:00:00 [migration/0]
root        10     2  0 19:06 ?        00:00:03 [watchdog/0]
root        11     2  0 19:06 ?        00:00:00 [khelper]
root        12     2  0 19:06 ?        00:00:00 [kdevtmpfs]
root        13     2  0 19:06 ?        00:00:00 [netns]
root        14     2  0 19:06 ?        00:00:00 [writeback]
root        15     2  0 19:06 ?        00:00:00 [kintegrityd]
root        16     2  0 19:06 ?        00:00:00 [bioset]
root        17     2  0 19:06 ?        00:00:00 [kworker/u17:0]
root        18     2  0 19:06 ?        00:00:00 [kblockd]
root        19     2  0 19:06 ?        00:00:00 [ata_sff]
root        20     2  0 19:06 ?        00:00:00 [khubd]
root        21     2  0 19:06 ?        00:00:00 [md]
root        22     2  0 19:06 ?        00:00:00 [devfreq_wq]
```

  The process names in `[]` are kernel threads. If you are interested in more options to learn about the `ps` command, you can use the following command:

  $ man ps.

  To find a particular process, you can use the following command:

  $ ps -ef | grep "process_name"

  The command with `grep` will display the process with `process_name`.

- If we want to terminate the running process, enter following command:

  `$ kill  pid_of_process_to_be_killed`

```
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 3796 pts/0    00:00:00 sleep
 3797 pts/0    00:00:00 ps
student@ubuntu:~$
student@ubuntu:~$
student@ubuntu:~$ kill 3796
[1]+  Terminated              sleep 10000
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 3799 pts/0    00:00:00 ps
student@ubuntu:~$ _
```

- Many a time, if the process is not killed by the `$ kill` command, you may need to pass additional option to ensure that the required process is killed, which is shown as follows:

  `$ kill -9 pid_of_process_to_be_killed`

- We can terminate the process by the name of a process instead of using the process ID as follows:

  `$ pkill command_name`

  `$ pkill sleep`

  Or:

  `$ pkill  -9  command_name`

```
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 3828 pts/0    00:00:00 sleep
 3829 pts/0    00:00:00 ps
student@ubuntu:~$
student@ubuntu:~$ pkill sleep
[1]+  Terminated              sleep 10000
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 3832 pts/0    00:00:00 ps
student@ubuntu:~$
student@ubuntu:~$
```

- To know more about various flags of `kill`, enter following command:

  ```
  $ kill -l
  ```

  This displays all the signals or software interrupts used by the operating system. When we enter the `$ kill` command, the operating system sends the `SIGTERM` signal to the process. If the process is not killed by this command, then we enter the following command:

  ```
  $ kill -9 process_name
  ```

  This sends `SIGKILL` to the process to be killed.

Process management

Since we have understood the command to check processes, we will learn more about managing different processes as follows:

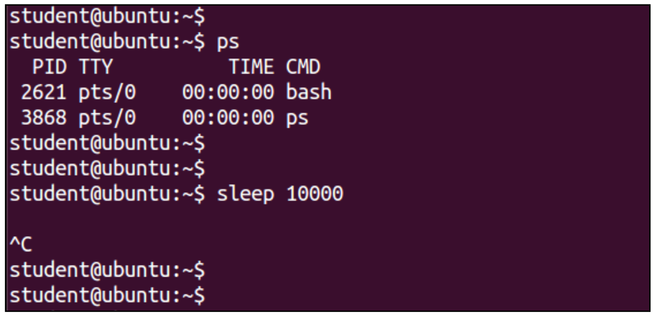
- In a Bash shell, when we enter any command or start any program, it starts running in foreground. In such a situation, we cannot run more than one command in the foreground. We need to create many terminal windows for starting many processes. If we need to start many processes or programs from the same terminal, then we will need to start them as background processes.
- If we want to start a process in the background, then we need to append the command in the Bash shell by `&`.
- If I want to start my program `Hello` as the background process, then the command would be as follows:
- **`$ Hello &`**
- If we terminate any command by `&`, then it starts running as the background process.

For example, we will issue a simple `sleep` command, which creates a new process. This process sleeps for the duration, which is mentioned in the integer value next to the `sleep` command:

1. The following used command will make the process sleep for `10000` seconds. This means we will not be able to use any other command from the same terminal:

   ```
   $ sleep 10000
   ```

2. Now, you can press the *Ctrl* + *C* key combination to terminate the process created by the `sleep` command.



```
student@ubuntu:~$
student@ubuntu:~$ ps
  PID TTY          TIME CMD
 2621 pts/0    00:00:00 bash
 3868 pts/0    00:00:00 ps
student@ubuntu:~$
student@ubuntu:~$
student@ubuntu:~$ sleep 10000

^C
student@ubuntu:~$
student@ubuntu:~$
```

3. Now, use the following command:

   `$ sleep 10000 &`

   The preceding command will create a new process, which will be put to sleep for `10000` seconds; but this time, it will start running in the background. Therefore, we will be able to enter the next command in the Bash terminal.

4. Since the newly created process is running in the background, we can enter new commands very easily in the newly created terminal:

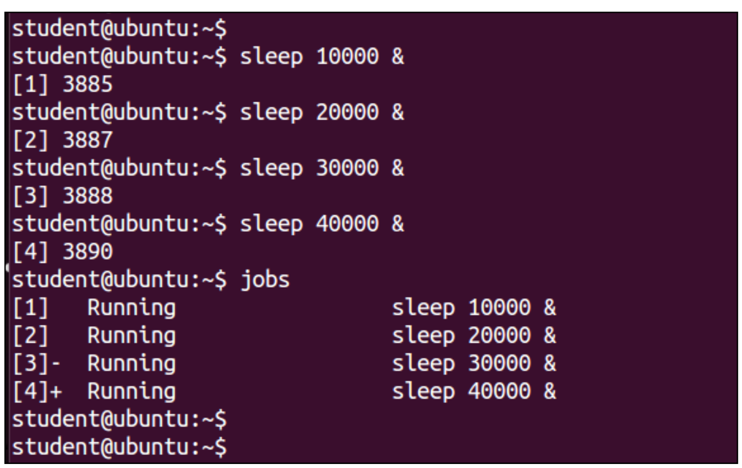
   `$ sleep 20000 &`

   `$ sleep 30000 &`

   `$ sleep 40000 &`

5. To check the presence of all the processes, enter the following command:

   `$ jobs`



```
student@ubuntu:~$
student@ubuntu:~$ sleep 10000 &
[1] 3885
student@ubuntu:~$ sleep 20000 &
[2] 3887
student@ubuntu:~$ sleep 30000 &
[3] 3888
student@ubuntu:~$ sleep 40000 &
[4] 3890
student@ubuntu:~$ jobs
[1]   Running                 sleep 10000 &
[2]   Running                 sleep 20000 &
[3]-  Running                 sleep 30000 &
[4]+  Running                 sleep 40000 &
student@ubuntu:~$
student@ubuntu:~$
```

The jobs command lists all the processes running in terminal, including foreground and background processes. You can clearly see their status as running, suspended, or stopped. The numbers in `[]` show the job ID. The `+` sign indicates which command will receive `fg` and `bg` commands by default. We will study them in the next topics.

6. If you want to make any existing background process to run in the foreground, then use the following command:

   `$ fg 3`

   The preceding command will make the job number `3` to run in the foreground instead of the background.

   If we want to make the process to stop executing and get it suspended, then press *Ctrl* + *Z*. This key combination makes the foreground process to stop executing. Please note that the process has stopped but not terminated.

```
student@ubuntu:~$ fg 3
sleep 30000

^Z
[3]+  Stopped                 sleep 30000
student@ubuntu:~$
student@ubuntu:~$ jobs
[1]   Running                 sleep 10000 &
[2]   Running                 sleep 20000 &
[3]+  Stopped                 sleep 30000
[4]-  Running                 sleep 40000 &
student@ubuntu:~$ _
```

7. To make the stopped process continue running in background, use the following command:

   `$ bg job_number`

   `$ bg 3`

   The preceding command will make suspended job numbered process `3` to run in background.

8. If you wish to terminate the process, you can use the job ID or process ID as follows:

```
$ jobs -l   //  This will list jobs with pid
$ kill pid      or
$ kill %job_id  // This will kill job
$ kill %3
```

Process monitoring tools – top, iostat, and vmstat

We can view the native performance of various processes in OS using tools which will be discussed further. To view a dynamic real-time view of the top running processes in OS, use the following command:

$top

```
top - 22:05:50 up  2:58,  2 users,  load average: 0.04, 0.03, 0.05
Tasks: 171 total,   2 running, 168 sleeping,   1 stopped,   0 zombie
Cpu(s):  0.3%us,  0.3%sy,  0.0%ni, 99.0%id,  0.3%wa,  0.0%hi,  0.0%si,  0.0%st
Mem:   2063524k total,   942860k used,  1120664k free,    98244k buffers
Swap:  2094076k total,        0k used,  2094076k free,   444288k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 1189 root      20   0  107m  65m  12m S  1.0  3.3   0:22.54 Xorg
 2264 student   20   0  250m  54m  31m S  0.3  2.7   0:09.02 unity-2d-shell
 2275 student   20   0  102m  30m  22m S  0.3  1.5   0:20.20 vmtoolsd
 2610 student   20   0 89996  19m  10m S  0.3  1.0   0:05.55 gnome-terminal
 4071 student   20   0  2856 1168  872 R  0.3  0.1   0:00.54 top
    1 root      20   0  3768 2092 1284 S  0.0  0.1   0:01.51 init
    2 root      20   0     0    0    0 S  0.0  0.0   0:00.00 kthreadd
    3 root      20   0     0    0    0 S  0.0  0.0   0:00.22 ksoftirqd/0
    5 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 kworker/0:0H
    7 root      20   0     0    0    0 S  0.0  0.0   0:00.68 rcu_sched
    8 root      20   0     0    0    0 S  0.0  0.0   0:00.00 rcu_bh
    9 root      RT   0     0    0    0 S  0.0  0.0   0:00.00 migration/0
   10 root      RT   0     0    0    0 S  0.0  0.0   0:03.96 watchdog/0
   11 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 khelper
   12 root      20   0     0    0    0 S  0.0  0.0   0:00.00 kdevtmpfs
   13 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 netns
   14 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 writeback
   15 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 kintegrityd
   16 root       0 -20     0    0    0 S  0.0  0.0   0:00.00 bioset
```

An explanation of the `top` command generated output is as follows:

The `$top` command displays a lot of information about the running system.

The first line of the display is shown as follows:

```
top - 22:05:50 up  2:58,  2 users,  load average: 0.04, 0.03, 0.05
```

The description of fields in the first line is as follows:

- Current time
- System uptime
- Number of users logged in
- Load average of 5, 10, and 15 minutes, respectively

The second line is shown as follows:

```
Tasks: 171 total,   2 running, 168 sleeping,   1 stopped,   0 zombie
```

This line shows the summary of tasks or processes. It shows the total number of all the processes, which includes the total number of running, sleeping, stopped, and zombie processes.

The third line is shown as follows:

```
Cpu(s):  0.3%us,  0.3%sy,  0.0%ni, 99.0%id,  0.3%wa,  0.0%hi,  0.0%si,  0.0%st
```

This line shows information about CPU usage in % in different modes as follows:

- * **us** (**user**): CPU usage in % for running (un-niced) the user processes
- * **sy** (**system**): CPU usage in % for running the kernel processes
- * **ni** (**niced**): CPU usage in % for running the niced user processes
- * **wa** (**IO wait**): CPU usage in % for waiting for the IO completion
- * **hi** (**hardware interrupts**): CPU usage in % for serving hardware interrupts
- * **si** (**software interrupts**): CPU usage in % for serving software interrupts
- * **st** (**time stolen**): CPU usage in % for time stolen for this vm by the hypervisor

The fourth line is shown as follows:

```
Mem:   2063524k total,   942860k used,  1120664k free,    98244k buffers
Swap:  2094076k total,        0k used,  2094076k free,   444288k cached
```

This line provides information about memory usage. It shows the physical memory that is used, free, available, and used for buffers. The next line shows the swap memory that is available, used, free, and cached.

After this line, we see the table of values with the following columns:

- `PID`: This is the ID of the process
- `USER`: This is the user that is the owner of the process
- `PR`: This is the priority of the process
- `NI`: This is the "NICE" value of the process
- `VIRT`: This is the virtual memory used by the process
- `RES`: This is the physical memory used for the process
- `SHR`: This is the shared memory of the process
- `S`: This indicates the status of the process: S=sleep, R=running, and Z=zombie (S)
- `%CPU`: This is the % of CPU used by this process
- `%MEM`: This is the % of RAM used by the process
- `TIME+`: This is the total time of activity of this process
- `COMMAND`: This is the name of the process

Let's take a look at the performance monitoring tools—`iostat`, `vmstat`, and `sar`:

- To view the statistics of the CPU and the input/output device's utilization, use the following command:

  `$ iostat`

```
student@ubuntu:~$ iostat
Linux 3.13.0-32-generic (ubuntu)        02/04/2015      _i686_  (1 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.37    0.08    0.49    0.44    0.00   98.62

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
sda               3.05        38.06        10.34     478399     129968
```

  `$ iostat -c`

  Shows only CPU statistics

  `$ iostat -d`

  Shows only disk statistics

- To view the virtual memory statistics, use the following command:

  `$vmstat`

```
student@ubuntu:~$ vmstat
procs -----------memory---------- ---swap-- -----io---- -system-- ----cpu----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa
 2  0      0 1124376  98496 444392    0    0    38    10   40   92  0  0 99  0
student@ubuntu:~$
```

$ vmstat -s

This shows various event counters and memory statistics

$ vmstat -t 1 5

Runs for every one second stops after executing for five intervals

$ sar -u 2 3

This will show the CPU activity report every 2 seconds, 3 times:

```
student@ubuntu:~$ sar -u 2 3
Linux 3.13.0-32-generic (ubuntu)        02/04/2015      _i686_  (1 CPU)

10:44:37 PM     CPU     %user     %nice   %system   %iowait    %steal     %idle
10:44:39 PM     all      0.50      0.00      1.49      1.00      0.00     97.01
10:44:41 PM     all      0.51      0.00      0.51      0.00      0.00     98.99
10:44:43 PM     all      0.51      0.00      0.51      0.00      0.00     98.99
Average:        all      0.50      0.00      0.84      0.34      0.00     98.32
student@ubuntu:~$
```

Understanding "at"

Many a times we need to schedule a task for a future time, say in the evening at 8 P.M. on a specific day. We can use the `at` command in such a situation.

Sometimes we need to repeat the same task at a specific time, periodically, every day, or every month. In such situations, we can use the `crontab` command.

Let's learn more about the utility of the `at` command. To use the `at` command, the syntax is as follows:

$ at time date

The following are the examples of the `at` command:

- The `Control + D` command will save the `at` job. The task will be executed at 11.15 A.M. This command will log messages to the `log.txt` file at 11.15 A.M.:

  $ at 11.15 AM

  at > echo "Hello World" > $HOME/log.txt

  at > Control + D

- The following command will send an e-mail on March 31, 2015 at 10 A.M.:

  ```
  $ at 10am mar 31 2015
  at> echo "taxes due" | mail jon
  at> ^D
  ```

- The following command will make the task run on May 20 at 11 A.M.:

  ```
  $ at 11 am may 20
  ```

- All the jobs which are scheduled by the `at` command can be listed using the following command:

  ```
  $ atq
  ```

- To remove a specific job listed by the `atq` command, we can use the following command:

  ```
  $ atrm  job-id
  ```

Understanding "crontab"

If we need to run a specific task repetitively, then the solution is to use crontab.

The syntax of the command is as follows:

```
$  crontab   -e
```

This will open a new editor. The following diagram is the syntax to add tasks. The fields to use for repeating tasks at what time are explained here:

```
*     *     *   *    *        command to be executed
-     -     -   -    -
|     |     |   |    |
|     |     |   |    +----- day of week (0 to 6) (Sunday=0)
|     |     |   +------- month (1 to 12)
|     |     +--------- day of       month (1 to 31)
|     +----------- hour (0 to 23)
+------------- min (0 to 59)
```

Finally, to save the jobs, use the following:

```
wq        # save and quite crontab job
```

The following are a few examples of the `crontab` command:

- Use the following command to run a script every 5 minutes, every day:

```
5 * * * *      $HOME/bin/daily.job >> $HOME/tmp/out  2>&1
```

- Use the following command to run 5 minutes after midnight every day:

```
5 0 * * *      $HOME/bin/daily.job >> $HOME/tmp/out  2>&1
```

- Use the following command to run at 2.15 P.M. on the first of every month—the output is mailed to Paul:

```
15 14 1 * * *     $HOME/bin/monthly
```

- Use the following command to run at 10 P.M. on weekdays, send the e-mail to `ganesh@abc.com`:

```
0 22 * *  1-5   sendmail ganesh@abc.com  < ~/work/email.txt
```

- The `sendmail` utility is used for sending e-mails. We can use the mail utility also as follows:

```
sendmail user@example.com  < /tmp/email.txt
```

- The following commands are self-explanatory from text of echo:

```
23  0-23/2  *  *  *  echo "run 23 minutes after midn, 2 am, 4 am, 
everyday
5 4 *  *  sun        echo "run at 5 after 4 every Sunday"
```

The following are a few more `crontab` command examples:

Min	Hour	Day / month	Month	Day / week	Execution time
45	0	5	1,6,12	*	00:45 hrs on the 5th of January, June, and December.
0	18	*	10	1-5	6.00 P.M. every weekday (Monday-Friday) only in October.
0	0	1,10,15	*	*	Midnight on the 1st ,10th, and 15th of the month
5,10	0	10	*	1	At 12.05 and 12.10 every Monday and on the 10th of every month

We can add macros in the crontab file. Use the following to restart my_program after each reboot:

```
@reboot  /bin/my_program
@reboot echo `hostname` was rebooted at `date` | mail -s "Reboot notification" ganesh.admin@some-corp.com
```

The following is the summary of a few more macros:

Entry	Description	Equivalent To
@reboot	Run once at startup	None
@weekly	Run once a week	0 0 * * 0
@daily	Run once a day	0 0 * * *
@midnight	(same as @daily)	0 0 * * *
@hourly	Run once an hour	0 * * * *

Summary

In this chapter, we studied about the basic process management. You learned about the ps command. Using commands like jobs, fg, bg, kill, and pkill, we studied about job management. Later on, you learned about the top, iostat, and vmstat process monitoring tools.

In the next chapter, you will learn about standard input/output, various meta-characters, and text filters used in Shell scripting.

3

Using Text Processing and Filters in Your Scripts

In the last chapter, you studied about basic process management. You learned about the `ps` command. You also studied about job management using commands such as `jobs`, `fg`, `bg`, `kill`, `pkill` as well as various other tools such as top, iostat, and vmstat.

In this chapter, you will cover the following topics:

- Using more, less, head, and tail
- Using diff, cut, paste, comm, and uniq
- Working with grep
- Understand standard input, output, and standard error
- Understand various metacharacters and their usage

Text filtering tools

Normally, Shell scripting involves report generation, which will include processing various text files and filtering their output to finally produce desirable results. Lets start discussing the two Linux commands, namely, `more` and `less`:

more: Sometimes we get a very large output on the screen for certain commands, which cannot be viewed completely on one screen. In such cases, we can use the `more` command to view the output text one page at a time. Add "`| more`" after the command, as follows:

```
$ ll /dev | more
```

The | is called pipe. You will learn more about it in the next chapters. In this command, pressing the spacebar will move the output on the screen one page at a time, or pressing *Enter* will move the screen by one line at a time.

less: Instead of more, if you use less it will show a screen containing the full text all at once. We can move forward as well as backwards. This is a very useful text filtering tool.

The syntax of usage is as follows:

```
$ command |  less
e.g. $ ll /proc | less
```

This command will show a long listing of directory listing of the `/proc` folder. Let's say that we want to see if the `cpuinfo` file is present in the directory or not? Just press the arrow key up or down to scroll through the display. With the `more` command, you can not scroll backwards. You can move forward only. With page up and down key presses, you can move forward or backward one page at a time, which is very fast.

In addition to scrolling forward or backward, you can search for pattern using / for forward search and *?* for backward search. You can use *N* for repeating the search in a forward or backward direction.

Head and tail

For testing the next few commands, we will need a file with a sequence of numbers 1 to 100. For this, use the following command:

```
$ seq 100 > numbers.txt
```

The preceding command created a file with the numbers 1 to 100 on separate lines. The following example shows the usage of the `head` command:

```
$ head  // will display top 10 lines
$ head  -3  numbers.txt   // will show first 3 lines
$ head +5 numbers.txt   // will show from line 5. Some shell may not work
this command
```

The following example shows the usage of the `tail` command:

```
$ tail  // will display last 10 lines
$ tail  -5  numbers.txt  // will show last 5 lines
$ tail +15 numbers.txt  // will show from line 15 onwards. Some shell may
not work
```

To print lines 61 to 65 from `numbers.txt` into file `log.txt`, type the following:

```
$ head -65 numbers.txt | tail -5 > log.txt
```

The diff command

The `diff` command is used to find differences between two files. Let's see a few examples to find out its usage.

The content of `file1` is as follows:

```
I go for shopping on Saturday
I rest completely on Sunday
I use Facebook & Tweeter for social networking
```

The content of `file2` is as follows:

```
Today is Monday.
I go for shopping on Saturday
I rest completely on Sunday
I use Facebook & Tweeter for social networking
```

Then, type the `diff` command:

```
$ diff file1 file2
```

Output:

```
0a1
> Today is Monday
```

In the output, `0a1` tells us that line number 1 is added in `file2`.

Let's learn another example with line deletion.

The content of `file1` is as follows:

```
Today is Monday
I go for shopping on Saturday
I rest completely on Sunday
I use Facebook & Tweeter for social networking
```

The content of `file2` is as follows:

```
Today is Monday
I go for shopping on Saturday
I rest completely on Sunday
```

Then, type the `diff` command:

```
$ diff file1 file2
```

The output is as follows:

```
4d3
< I use Facebook & Tweeter for social networking.
```

In the output, `4d3` tells us that line number 4 is deleted in `file2`. Similarly, the `change` command will show us changes in file as well.

The cut command

The `cut` command is used to extract specified columns/characters of a text, which is given as follows:

- `-c`: Will specify the filtering of characters
- `-d`: Will specify the delimiter for fields
- `-f`: Will specify the field number

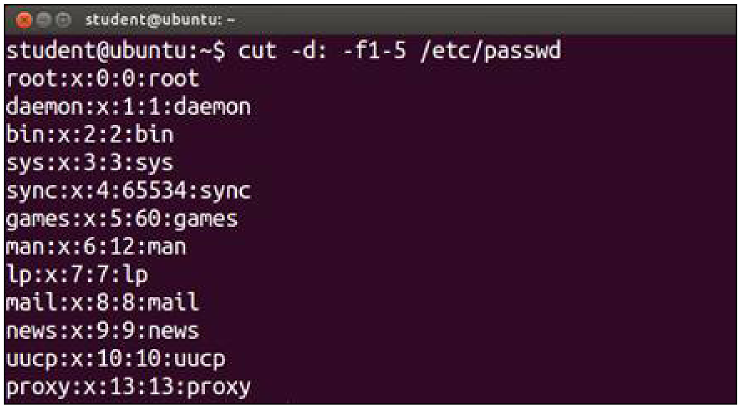
The following are few examples that show the usage of the `cut` command:

- Using the next command, from the `/etc/passwd` file, the fields 1 and 3 will be displayed. The display will contain the login name and user ID. We used the `-d:` option to specify that the field or columns are separated by a colon (`:`):

  ```
  $ cut -d: -f1,3 /etc/passwd
  ```

- Using this command, from the `/etc/passwd` file, the fields 1 to 5 will be displayed. The display will contains the login name, encrypted password, user ID, group ID, and user name:

  ```
  $ cut -d: -f1-5 /etc/passwd
  ```



```
student@ubuntu:~$ cut -d: -f1-5 /etc/passwd
root:x:0:0:root
daemon:x:1:1:daemon
bin:x:2:2:bin
sys:x:3:3:sys
sync:x:4:65534:sync
games:x:5:60:games
man:x:6:12:man
lp:x:7:7:lp
mail:x:8:8:mail
news:x:9:9:news
uucp:x:10:10:uucp
proxy:x:13:13:proxy
```

- This command will show characters 1 to 3 and 8 to 12 from the `emp.lst` file:

  `$ cut -c1-3,8-12 /home/student/emp.lst`

- The output of the `date` command is sent as an input to the `cut` command and only the first three characters are printed on screen, which is shown as follows:

  ```
  $ date | cut -c1-3
  Mon
  ```

The paste command

Using this utility, we can paste two files horizontally, such as `file_1`, which will become the first column and `file_2` will become the second column:

`$ paste file_1 file_2`

The join command

Consider two files, namely, `one.txt` and `two.txt`.

- The content of `one.txt` is as follows:

  ```
  1 India
  2 UK
  3 Canada
  4 US
  5 Ireland
  ```

- The content of `two.txt` is as follows:

```
1 New Delhi
2 London
3 Toronto
4 Washington
5 Dublin
```

In this case, for both the files, the common fields are the fields which have serial numbers that are the same in both files. We can combine both files by following command:

```
$ join one.txt two.txt
```

The output will be as follows:

```
1 India New Delhi
2 UK London
3 Canada Toronto
4 US Washington
5 Ireland Dublin
```

The uniq command

The following are a few examples showing the usage of the `uniq` command:

- This command removes duplicate adjacent lines from the file:

```
$ cat test
aa
aa
cc
cc
bb
bb
yy
zz
$ uniq test
```

This output removes the duplicate adjacent lines from `test` file, shown as follows:

```
aa
cc
bb
yy
zz
```

- The next command prints only duplicate lines:

  ```
  $ uniq -d test
  ```

  Output:

  ```
  aa
  cc
  bb
  ```

The comm command

The `comm` command shows the lines unique to `file_1`, `file_2` along with the common lines in them. We can use various options while using the command in the scripts:

```
$ cat file_1
Barack Obama
David Cameron
Narendra Modi

$ cat file_2
Barack Obama
Engela Merkel
Vladimir Putin

$ comm –nocheck-order file_1 file_2
      Barack Obama
  David Cameron
    Engela Merkel
  Narendra Modi
    Vladimir Putin
```

In the preceding example, we can see:

- The first column shows unique lines in `file_1`
- The second column shows unique lines in `file_2`
- The last column shows the content common in both the files

The output shows that the unique files in `file_1` are `David Cameron` and `Narendra Modi`. Unique files in the second file are `Engela Merkel` and `Vladimir Putin`. The command name in both the files is `Barack Obama`, which is displayed in the third column.

The tr command

The `tr` command is a Linux utility for text processing such as translating, deleting, or squeezing repeated characters, which is shown as follows:

```
$ tr '[a-z]' '[A-Z]' < filename
```

This will translate the lower case characters to upper case:

```
$ tr '|' '~' < emp.lst
```

This will squeeze multiple spaces into a single space:

```
$ ls -l | tr -s " "
```

In this example, the `-s` option squeezes multiple contiguous occurrences of the character into a single char.

Additionally, the `-d` option can remove the characters.

Sort: It sorts the contents of a text file, line by line.

- `-n`: Will sort as per the numeric value
- `-d`: Will sort as per the dictionary meaning
- `-r`: Will sort in the reverse order
- `-t`: Option to specify delimiter for fields
- `+num`: Specifies sorting field numbers
- `-knum`: Specifies sorting filed numbers
- `$ sort +4 sample.txt`: This will sort according to the 4th field

- `$ sort -k4 sample.txt`: This will sort according to the 4th field

Sr	Examples of command usage	Explanation
1	sort `sample.txt`	Alphabetically sorting of lines
2	sort -u `sample.txt`	Duplicate entries are sorted
3	sort -r `sample.txt`	Reverse sort
4	sort-n -k3 `sample.txt`	Numerical sorting of the 3rd field

IO redirection

You will learn the very useful concept of I/O redirection in this section.

File descriptors

All I/O, including files, pipes, and sockets, are handled by the kernel via a mechanism called the **file descriptor**. A file descriptor is a small unsigned integer, an index into a file-descriptor table maintained by the kernel and used by the kernel to reference open files and I/O streams. Each process inherits its own file-descriptor table from its parent. The first three file descriptors are 0, 1, and 2. File descriptor 0 is standard input (stdin), 1 is standard output (stdout), and 2 is standard error (stderr). When you open a file, the next available descriptor is 3, and it will be assigned to the new file.

Redirection

When a file descriptor is assigned to something other than a terminal, it is called I/O redirection. The shell performs redirection of output to a file by closing the standard output file descriptor 1 (the terminal) and then assigning that descriptor to the file. When redirecting standard input, the shell closes file descriptor 0 (the terminal) and assigns that descriptor to a file. The Bash shells handle errors by assigning a file to the file descriptor 2.

The following command will take input from the `sample.txt` file:

```
$ wc  <  sample.txt
```

The preceding command will take content from the `sample.text` file.
The `wc` command will print the number of lines, words, and characters in the `sample.txt` file.

```
$ echo "Hello world" > log.txt
```

This command will redirect output to be saved in the `log.txt` file.

```
$ echo "Welcome to Shell Scripting" >> log.txt
```

This command will append the `Hello World` text in the `log.txt` file.

The single `>` will overwrite or replace the existing text in log file. And double `>>` will append the text in the log file.

Let's see a few more examples:

```
$ tr '[A-Z]' '[a-z]' < sample.txt
```

The preceding `tr` command will read text from the `sample.txt` file. The `tr` command will convert all uppercase letters to lower case letters and will print converted text on screen:

```
$ ls > log.txt
$ cat log.txt
```

The output of command will be as follows:

```
dir_1
sample.txt
extra.file
```

In this example command, `ls` is sending directory content to file `log.txt`. Whenever we want to store the result of the command in the file, we can use the preceding example.

```
$ date >> log.txt
$ cat log.txt
```

Output:

```
dir_1
dir_2
file_1
file_2
file_3
Sun Sept 17 12:57:22 PDT 2004
```

In the preceding example, we are redirecting and appending the result of the `date` command to the `log.txt` file.

```
$ gcc hello.c 2> error_file
```

The `gcc` is a C language compiler program. If an error is encountered during compilation, then it will be redirected to `error_file`. The `>` character is used for a success result and `2>` is used for error results redirection. We can use `error_file` for debugging purposes:

```
$ find . -name "*.sh" > success_file 2> /dev/null
```

In the preceding example, we are redirecting output or success results to `success_file` and errors to `/dev/null`. `/dev/null` is used to destroy the data, which we do not want to be shown on screen.

```
$ find . -name "*.sh" &> log.txt
```

The preceding command will redirect both output and error to `log.txt`.

```
$ find . -name "*.sh"  > log.tx 2>&1
```

The preceding command will redirect result to `log.txt` and send errors to where the output is going, such as `log.txt`.

```
$ echo "File needs an argument" 1>&2
```

The preceding command will send a standard output to the standard error. This will merge the output with the standard error.

The summary of all I/O redirection commands will be as follows:

< sample.txt	The command will take input from `sample.txt`
> sample.txt	The success result will be stored in `sample.txt`
>> sample.txt	The successive outputs will be appended to `sample.txt`
2> sample.txt	The error results will be stored in `sample.txt`
2>> sample.txt	The successive error output will be appended to `sample.txt`
&> sample.txt	This will store success and errors, such as in `sample.txt`
>& sample.txt	This will store success and errors, such as in `sample.txt` (same as above)
2>&1	This will redirect an error to where output is going
1>&2	This will redirects output to where error is going
>|	This overrides no clobber when redirecting the output
<> filename	This uses the file as both standard input and output if a device file (from `/dev`)
cat xyz > success_file 2> error_file	This stores success and failure in different files

The following is the summary of various metacharacters:

Char	Meaning	Example	Possible output
*	Match with zero or multiple number of any character	$ ls –l *.c file*	`Sample.c`, `hello.c`, `file1`, `file_2`, `filebc`
?	Match any single character	$ ls –l file?	`filea`, `fileb`, `file1`
[..]	Match with any single character with in the bracket	$ ls –l file[abc]	`filea`, `fileb`,`filec`
;	Command separator	$cat filea; date	Displays the content of `filea` and displays the current date and time
|	Pipe two commands	$ cat filea | wc -l	Prints the number of lines of `filea`
()	Group commands, used when the output of the command group has to be redirected	$ (echo "***x.c***";cat x.c)>out	Redirects the content of `x.c` with a heading `***x.c***` to the file out

Run the following command:

```
$ touch filea fileb filec fileab filebc filead filebd filead
$ touch file{1,2,3}
```

Try the following command out:

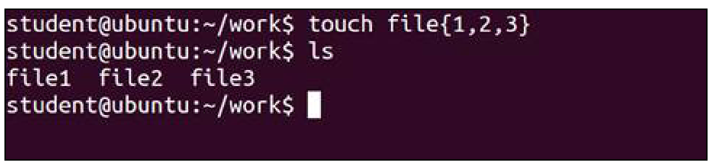
```
$ ls  s*
$ ls  file
$ ls  file[abc]
$ ls  file[abc][cd]
$ ls  file[^bc]
$ touch file file1 file2 file3 … file20
$ ls ?????
file1
file2
file3
$ ls file*
file file1 file10 file2 file3
```

```
$ ls file[0-9]
file1 file2 file3
$ ls file[0-9]*
file1 file10 file2 file3
$ ls file[!1-2]
file3
```

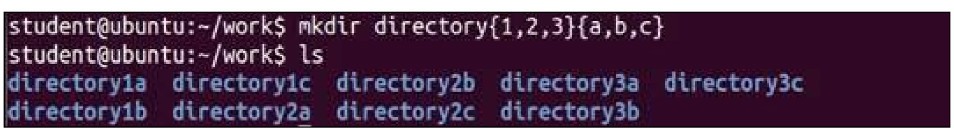
Brace expansion

Curly braces allow you to specify a set of characters from which the shell automatically forms all possible combinations. To make this work, the characters to be combined with the given string must be specified as a comma separated list with no spaces:

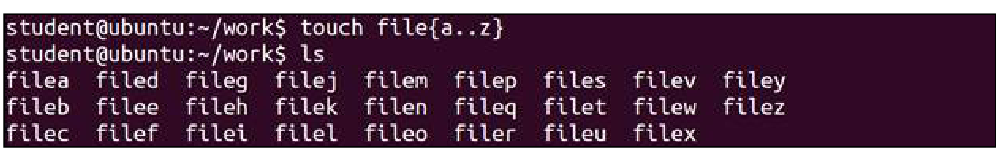
```
$ touch file{1,2,3}
$ ls
```




```
$ mkdir directory{1,2,3}{a,b,c}
$ ls
```




```
$ touch file{a..z}
$ ls
```



The following is the summary of various io-redirection and logical operators:

<table>
<tr><th>Char</th><th>Meaning</th><th>Example</th><th>Possible Output</th></tr>
<tr><td>></td><td>Output Redirection</td><td>$ ls > ls.out</td><td>Output of ls command is redirected(overwritten) to ls.out file</td></tr>
<tr><td>>></td><td>Output Redirection (append)</td><td>$ ls >> ls.out</td><td>Output of ls command is redirected(appended) to ls.out file</td></tr>
<tr><td><</td><td>Input Redirection</td><td>$ tr 'a' 'A' < file1</td><td>The tr command read input from file1 instead of keyboard(stdin)</td></tr>
<tr><td>`cmd`
or
$(cmd)</td><td>Command substitution</td><td>$echo `date`
or
$ echo $(date)</td><td>The command date is substituted with the result and sent to echo for display</td></tr>
<tr><td>||</td><td>OR Conditional Execution</td><td>$ test $x –gt 10 || $x –lt 15</td><td>Check whether x value is greater than 10 or less than 15</td></tr>
<tr><td>&&</td><td>AND Conditional Execution</td><td>$ test $x –gt 10 && $x –lt 15</td><td>Check whether x value is greater than 10 and less than 15</td></tr>
</table>

For example:

```
$ ls || echo "Command un-successful"
$ ls a abcd || echo "Command un-successful"
```

These commands will print `Command un-successful` if the `ls` command is unsuccessful.

Pattern matching with the vi editor

For learning pattern matching, we will ensure that the pattern that we will search should be highlighted when the searched pattern is found.

The configuration file for vi is `/etc/vimrc`.

In the vi editor, give the following command to highlight search:

Sr.	Commands	Description
1	`:set hlsearch`	This highlights search pattern
2	`:se[t] showmode`	Show when you are in insert mode
3	`:se[t] ic`	Ignore case when searching
4	`:set noic`	Shows case sensitive search

The mentioned user should open the file in vi, press the *Esc* button so that it goes into command mode and then enter colon followed by these commands.

The following are commands for pattern search and replace:

Sr.	Commands	Description
1	`/pat`	This searches for the pattern pat and places the cursor where the pattern occurs
2	`/`	This repeats the last search
3	`:%s/old/new/g`	Globally, all the occurrences of `old` will be replaced by `new`
4	`:#,#s/old/new/g`	Where `#,#` should be replaced with the numbers of the two lines (say between line numbers 3 and 6). For example: 3,6s/am/was/g

The following is an example of regular expression for replacing `Tom` by `David`:

```
:1,$s/tom/David/g    // from line 1 to end ($), replace tom by David
:1,$s/\<[tT]om\>/David/g  //   start and end of word   \<    \>
```

This is another example of regular expression.

Create the `love.txt` file, as follows:

```
Man has love for Art
World is full of love
Love makes world wonderful
love  looove lve
love
Love love  lover loves
I like "Unix" more than DOS
```

```
I love "Unix"/
I said I love "Unix"
I love "unix" a lot
```

Use the following commands for testing pattern searching facilities:

Command	Description
`:set hlsearch`	This will highlight the search pattern, when it is found
`/love/`	This will highlight any pattern matching with `love` n-forward N-backward
`/^love/`	This will highlight the line starting with `love`
`/love$/`	This will highlight the line ending with `love`
`/^love$/`	This will highlight line containing only word `love`
`/l.ve/`	This will highlight any character match for `.`
`/o*ve/`	This will highlight `love`, `loooove`, `lve`
`/[Ll]ove/`	This will search for patterns Love and love
`/ove[a-z]/`	This will highlight any matching character in the `a` to `z` range
`/ove[^a-zA-Z0-9" "]/`	Except alphabets or numbers, this will match punctuation marks such as `,` `;` `:` and similar
`:%s/unix/Linux/g`	This will replace `unix` by `Linux`
`:1,$s/unix/Linux/g`	This will replace `unix` by `Linux` from line 1 to end (`$`)
`:1,$s/\<[uU]nix\>/Linux/g`	This will start and end of word `\<` `\>`
`/^[A-Z]..$`	This will highlight the line starting with uppercase, two chars and end line
`/^[A-Z][a-z ]*3[0-5]/`	This will highlight any line ending with 30 to 35
`/[a-z]*\ ./`	This will highlight any line with lower case and ending with `"."`

Pattern searching using grep

The **g/RE/p** stands for **globally search for the regular expression (RE) and print out the line**.

Return status – success 0, pattern not found 1, file not found 2

```
$  ps -ef | grep root
```

The preceding command will show all processes running currently whose user ID is "root"

```
$  ll /proc | grep "cpuinfo"
```

The preceding command will show the file with the name `cpuinfo` from the `/proc` directory.

```
$  grep -lir "text" *   // only file names  //
$ grep -ir  "text" dir_name   // show lines of files //
```

We will try the following commands on the `love.txt` file:

Metacharacter	Function	Example	Description
`^`	Beginning-of-line anchor	`'^mango'`	Will display all lines beginning with `mango`
`$`	End-of-line anchor	`'mango'$'`	Will display all lines ending with `mango`
`.`	Matches single character	`'m..o'`	Will display lines containing `m`, followed by two characters, followed by an `o`
`*`	Matches zero or more characters preceding the asterisk	`'*mango'`	Will display lines with zero or more spaces, followed by the pattern `mango`
`[ ]`	Matches single character in the set	`'[Mm]ango'`	Will display lines containing `Mango` or `mango`
`[^]`	Matches single character not in the set	`'[^A-M] ango'`	Will display lines not containing a character in the range `A` through `M`, followed by `ango`
`\<`	Beginning-of-word anchor	`'\<mango'`	Will display lines containing a word that begins with `mango`
`\>`	End-of-word anchor	`'mango\>'`	Will display lines containing a word that ends with `mango`

We will create a new file `sample.txt`, as follows:

```
Apple  Fruit    5  4.5
Potato  Vegetable  4  .5
Onion  Vegetable  .3  8
Guava  Fruit    5  1.5
Almonds  Nuts    1  16
Tomato  Vegetable  3  6
Cashew  Nuts    2  12
Mango    Fruit    6  6
Watermelon  Fruit    5  1
```

We will try the following commands on the `sample.txt` file:

Sr. no.	Command	Description
1	`grep Fruit sample.txt`	This will show all lines with pattern `Fruit`.
2	`grep Fruit  G*`	This searches pattern `Fruit` in all files starting with `G`.
3	`grep '^M' sample.txt`	This searches all lines starting with `M`.
4	`grep '6$' sample.txt`	This searches lines ending with `6`.
5	`grep '1\..' sample.txt`	This displays lines containing 1 and any character after it.
6	`grep '\.6' sample.txt`	This shows lines containing `.6`.
7	`grep '^[AT]' sample.txt`	This searches lines starting with `A` or `T`.
8	`grep '[^0-9]' sample.txt`	This contains at least one alphabet.
9	`grep '[A-Z][A-Z] [A-Z]' sample.txt`	This searches the upper case, upper case space, and upper case word.
10	`grep '[a-z]\{8\}' sample.txt`	This displays all lines in which there are at least eight consecutive lowercase letters.
11	`grep '\<Fruit' sample.txt`	This displays all lines containing a word starting with Fruit. The `\<` is the beginning-of-word anchor.
12	`grep '\<Fruit\>' sample.txt`	This displays the line if it contains the word `Fruit`. The `\<` is the beginning-of-word anchor and the `\>` is the end-of-word anchor.
12	`grep '\<[A-Z].*o\>' sample.txt`	This displays all lines containing a word starting with an uppercase letter, followed by any number of characters and a word ending in `o`.
14	`grep -n '^south' sample.txt`	This displays line numbers also.
15	`grep –i 'pat' sample.txt`	This displays case insensitive search.
16	`grep -v 'Onion' sample.txt > temp` `mv temp sample.txt`	This deletes the line containing pattern.
17	`grep  –l 'Nuts'  *`	This lists files containing pattern.
18	`grep –c 'Nuts' sample.txt`	This prints the number of lines where pattern is present.
19	`grep  –w 'Nuts' sample.txt`	This counts where the whole world pattern is present, not a part of the word.

Summary

In this chapter, you learned about using more, less, head, and tail commands, and text processing tools like cut, paste, comm, and uniq. We also learned what standard input, output, and standard error are. Later on, you learned about metacharacters and pattern matching using vi and grep.

In the next chapter, you will learn about analyzing shell interpretation of commands, working with command substitution, command separators, and pipes.

4

Working with Commands

In the last chapter, you learned about using `more`, `less`, `head`, and `tail` commands, and text processing tools like diff, cut, paste, comm, and uniq. You learned what standard input, output, and standard error are. You also learned about metacharacters and pattern matching using vi and grep.

In this chapter, you will cover the following topics:

- Analyzing shell interpretation of commands
- Working with command substitution
- Working with command separators
- Working with pipes

Learning shell interpretation of commands

When we log in, the `$` sign will be visible in the shell terminal (`#` prompt if logged in as root or administrator). The Bash shell runs scripts as interpreter. Whenever we type a command, the BASH shell will read them as series of words (tokens). Each word is separated by a space ( ), semi colon (`;`), or any other command delimiter. We terminate the command by pressing the *Enter* key. This will insert a new line character at the end of the command. The first word is taken as a command, then consecutive words are treated as options or parameters.

The shell processes the command line as follows:

- If applicable, substitution of history commands
- Converting command line into tokens and words
- Updating history

- Processing of quotes
- Defining functions and substitution of alias
- Setting up of pipes, redirection, and background
- Substitution of variables (such as `$name` and `$user`) is performed
- Command substitution (`echo `cal`` and `echo `date``) is performed
- Globing is performed (file name substitution, such as `rm *`)
- Execution of the command

The sequence of execution of different types of commands will be as follows:

- Aliases (`l`, `ll`, `egrep`, and similar)
- Keywords (`for`, `if`, `while`, and similar)
- Functions (user defined or shell defined functions)
- Built-in commands (`bg`, `fg`, `source`, `cd`, and similar)
- Executable external commands and scripts (command from the `bin` and `sbin` folder)

Whenever a command is given in a shell or terminal, the complete command will be tokenized, and then shell will check if the command is alias.

Aliases, keywords, functions, and built-in commands are executed in the current shell, therefore their execution is fast as compared to executable external commands or scripts. Executable external commands will have a corresponding binary file or Shell script file in the file system, which will be stored in any folder. The shell will search the binary file or script of a command by searching in the `PATH` environment variable. If we want to know what the type of command it is, such as if it is an alias or a function or internal command, it can be found out by the `type` built-in command, which is shown as follows:

```
$ type mkdir
mkdir is /bin/mkdir

$ type cd
cd is a shell builtin

$ type ll
ll is aliased to `ls -alF'

$ type hello
```

```
hello is a function
hello ()
{
       echo "Hello World !";
}


$ type for
for is a shell keyword
```

Checking and disabling shell internal commands

Bash has provision of a few built-in commands to change the sequence of command line processing. We can use these built-in commands to change default behavior of command-line processing.

- The build-in command will disable aliases and functions for the command which will be following the command. The shell will search for the external command and the built-in command will search for the command passed as an argument, as follows:

  ```
  $ command ls
  ```

  This will make aliases and functions be ignored and the external `ls` command will execute.

- The `builtin` command will work as follows:

  ```
  $ builtin BUILT-IN
  ```

  This will ignore aliases and functions from the shell environment and only built-in commands and external commands will be processed.

- The `break` built-in command will work as follows:

  ```
  $ builtin -n break
  ```

  This will make the break built-in to be disabled and the external command `break` will be processed.

- To display all shell built-in commands, give the command as follows:

  ```
  $ enable
  ```

- The output on the screen will show the following as shell internal commands:

.	command	eval	history	pwd	test
..	compgen	exec	jobs	read	times
[	complete	exit	kill	readarray	trap
alias	compopt	export	let	readonly	true
bg	continue	false	local	return	type
bind	declare	fc	logout	set, unset	typeset
break	dirs	fg	mapfile	shift	ulimit
builtin	disown	getopts	popd	shopt	umask
caller	echo	hash	printf	source	unalias
cd	enable	help	pushd	suspend	wait

- The shell built-in command can be disabled by following:

  ```
  $ enable -n built-in-command
  ```

  For example: `$ enable -n test`

  In this case, in my shell, if we have to test an external command, then instead of the internal `test` command, the external `test` command will be executed.

The exit status

In Shell scripting, we need to check if the last command has successfully executed or not. For example, whether a file or directory is present or not. As per the result, our Shell script will continue processing.

For this purpose, the BASH shell has one status variable `?`. The status of the last command execution is stored in `?`. The range of numerical value stored in `?` will be from 0 to 255. If successful in execution, then the value will be 0; otherwise, it will be non-zero, which is as follows:

```
$ ls
$ echo $?
0
```

Here, zero as the return value indicates success.

In the next case, we see:

```
$ ls /root
$ echo $?
2
```

Here, non-zero value indicates an error in the last command execution.

In the next case, we see:

```
$ find / -name hello.c
$ echo $?
```

The return value will indicate if the `hello.c` file is present or not!

Command substitution

In the keyboard, there is one interesting key, the backward quote such as "`". This key is normally situated below the *Esc* key. If we place text between two successive back quotes, then `echo` will execute those as commands instead of processing them as plane text.

Alternate syntax for `$(command)` is the backtick character "`", which we can see as follows:

```
$(command) or `command`
```

For example:

- We need to use proper double quoted inverted commas, as follows:

  ```
  $ echo "Hello, whoami"
  ```

- The next command will print the text as it is; such as `Hello, whoami`:

  ```
  Hello, whoami
  ```

- Use proper double inverted commas:

  ```
  $ echo "Hello, `whoami`."
  Hello, student
  ```

  When we enclose `whoami` text in the "`" character, the same text which was printed as plain text will run as a command, and the command output will be printed on screen.

- Use proper double inverted commas:

  ```
  $ echo "Hello, $(whoami)."
  Hello, student.
  ```

  Same like the earlier explanation.

Another example:

```
echo "Today is date"
```

Output:

```
Today is date
```

A similar example:

```
echo "Today is `date`"
```

Or:

```
echo "Today is $(date)"
```

Output:

```
Today is Fri Mar 20 15:55:58 IST 2015
```

Further, similar examples include:

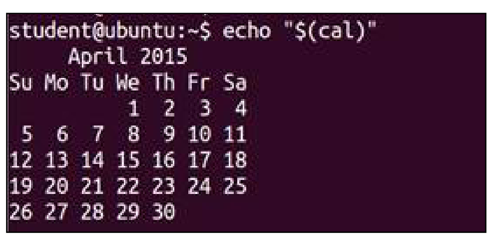
```
$ echo $(cal)
```

```
student@ubuntu:~$ echo $(cal)
April 2015 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
```

In this example, new lines are lost.

Another example:

```
$ echo "$(cal)"
```



```
student@ubuntu:~$ echo "$(cal)"
     April 2015
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
```

Here, the display is properly formatted.

Next, nesting of commands is as follows:

```
$ pwd
/home/student/work
```

$ dirname="$(basename $(pwd)) "

$ echo $dirname

```
student@ubuntu:~$ pwd
/home/student
student@ubuntu:~$
student@ubuntu:~$ dirname="$(basename $(pwd))"
student@ubuntu:~$
student@ubuntu:~$ echo $dirname
student
```

This command shows us that the base directory for the current directory is `student`.

Command separators

Commands can also be combined in such a way that they are executed in a particular sequence.

Command1; command2

A command line can consist of multiple commands. Each command is separated by a semicolon, and the command line is terminated with a newline. The exit status is that of the last command in the chain of commands.

The first command is executed, and the second one is started as soon as the first one has finished.

$ w; date

Output:

```
student@ubuntu:~$ w; date
 15:57:23 up  8:02,  2 users,  load average: 0.01, 0.03, 0.05
USER     TTY      FROM             LOGIN@   IDLE   JCPU   PCPU WHAT
student  tty7                      01:05   15:01m 15.40s  0.18s gnome-session --session=ubuntu
student  pts/1    :0               01:05    3.00s  0.19s  0.00s w
Fri Mar 20 15:57:23 IST 2015
```

$ w ; date > whoandwhen

Output of the `date` command will be redirected to the `whoandwhen` file.

In the preceding example, we can see that when we put multiple commands on the same line, but separated by the "`;`" command, then those commands execute sequentially one by one.

```
$ date; who am i
Tue Mar 10 23:21:38 PDT 201
student  pts/0        2015-03-10 23:12 (:0.0)
```

In the preceding example, the `date` command is executed first and the `who am I` command will be executed next. Both the commands are typed on same lines, separated by the ";" " command.

Command grouping

Commands may also be grouped so that all of the output is either piped to another command or redirected to a file.

```
$ ( ls; pwd; date ) > outputfile
```

The output of each of the commands is sent to the file called `outputfile`. The spaces inside the parentheses are necessary.

```
$ ( w ; date ) > whoandwhen
```

The output of the `w` command and `date` will be redirected to the `whoandwhen` file:

```
$ (echo "***x.c***";cat x.c) > log.txt
```

Output:

This redirects the content of `x.c` with a heading `***x.c***` to the file out.

```
$ (pwd; ls; date) > log.txt
```

Output:

This redirects output of commands `pwd`, `ls`, and `date` in the `log.txt` file.

Logical operators

Let's now take a look at logical operators.

Command1 & command2

The first command is started in the background to continue until it has finished; immediately after starting first command, the second command is started and it will run in the foreground:

```
$ find / -name "*.z" & s
----------------     -----
Command1            command2
```

In the preceding example, first command such as find will start running in the background and while the `find` command is running in background, the `ls` command will start running in foreground.

Command1 && command2

The second command is only started if the first command is successful. To achieve this, the shell checks the exit (return) status of the first command and starts the second command only if and when that exit status is found to be "0".

```
$ ls /home/ganesh  &&  echo "Command executed successfully"
Since we are working as user ganesh,
$ ls /root  && echo "Command executed successfully"
```

Since we are working as a normal user, we cannot access the `/root` directory. Therefore, nothing will be printed on screen.

Command1 || command2

The second command is only started if the first command fails. The shell checks the exit status of the first command and starts the second command only if that exit status is not equal to "0".

```
$ ls /root  ||  echo "Command execution failed"
```

Example:

```
$ ls || echo "command ls failed"
```

In the preceding example, if `ls` runs successfully, then `echo` will not be called. If the `ls` command fails such as `$ ls /root` and if user is not root, then `ls` will fail and the `echo` command will print `command ls failed`.

When `&&` or `||` are used, the exit status of the first command is checked first, then the decision to perform the next will be taken.

For example:

```
$ ls
$ echo $?
  0
$ ls /root
    ls: /root: Permission denied
$ echo $?
  1
$ tar cvzf /dev/st0 /home /etc | | mail -s "Something went wrong with the backup" root
```

If we give the command as follows:

```
$ cd /home/student/work/temp/; rm -rf *
```

Initially, the shell will change to the `/home/student/work/temp` folder, and then it will delete all files and folders.

If we give the command as follows:

```
cd /backup/ol/home/student/work/temp/ && rm * -rf
```

This will first change to the required folder, and then the `rm` command will be called for deletion. The problem with "`;`" is that even if the shell fails to change to the required folder, the `rm` command will execute and it will delete all the files and folders from your original folder. This will be really dangerous.

For example:

```
$ [[ "a" = "b" ]]; echo ok
ok
```

In this case, the `[[  ]]` expression will evaluate to false. Since the semicolon will not check the status of the earlier command, `ok` will be printed even if the first `[[ ]]` fails.

```
$ [[ "a" = "b" ]] && echo ok
```

In this case, the `[[  ]]` expression will evaluate to false. As the first expression is false, the "`&&`" operator will not proceed to execute the next command.

In this case, `ok` will be printed only if `[[ ]]` is true.

Pipes

We have already used pipes in many earlier sessions. It is a tool for inter-process communication.

```
$ command_1 | command_2
```

In this case, the output of `command_1` will be send as an input to `command_2`. The limitation is that the communication is half duplex. This means the data can flow in only one direction. Normally for inter-process communication, you need to open files then get the file descriptor. This will be used to write to the pipe file. Again, we need to create a `Fifo` file by special commands. The preceding technique simplifies all this process. We only need to insert "`|`" in between the two processes. The operating system creates one intermediate buffer. This buffer is used for storing the data from one command and will be used again for the second command.

A simple example is as follows:

```
$ who | wc
```

The preceding simple command will be carrying out three different activities. First, it will copy the output of the `who` command to the temporary file. Then the `wc` command will read the temporary file and display the result. Finally, the temporary file will be deleted.

Normally, there will be two processes. The first command is the writer process. The second process is the reader process. The writer process will write to `temp_file` and the reader will read from `temp_file`. Examples of writer processes are `ps`, `ls`, and `date`. Examples of reader processes are `wc`, `cat`, and `sort`.

Summary

In this chapter, you learned about how the shell interprets any command entered on the command line. We also studied command substitution and separators in detail.

In the next chapter, you will learn about variables and environment variables. You will also learn about how to export environment variables, and then you will learn about read only variables, command line arguments, and arrays.

5

Exploring Expressions and Variables

In the last chapter, you learned about how shell interprets any command, which is entered in the terminal or the command line. We also studied command substitution and separators in detail.

In this chapter, we will cover following topics:

- Working with environment variables
- Exporting variables
- Working with read-only variables
- Working with command line arguments (special variables, set and shift, and getopt)
- Working with arrays

Understanding variables

Let's learn about creating variables in shell.

Declaring variables in Linux is very easy. We just need to use the variable name and initialize it with the required content.

```
$ person="Ganesh Naik"
```

To get the content of the variable we need to prefix `$` before the variable.

For example:

```
$ echo person
person
$ echo $person
Ganesh Naik
```

The `unset` command can be used to delete a variable:

```
$ a=20
$ echo $a
$ unset a
```

The `unset` command will clear or remove the variable from shell environment as well.

```
$ person="Ganesh Naik"
$ echo $person
$ set
```

Here, the `set` command will show all variables declared in shell.

```
$ declare  -x variable=value
```

Here, the `declare` command with the `-x` option will make it an environmental or global variable. We will understand more about environmental variables in the next sessions.

```
$ set
```

Again here, the `set` command will display all variables as well as functions that have been declared.

```
$ env
```

Here, the `env` command will display all environmental variables.

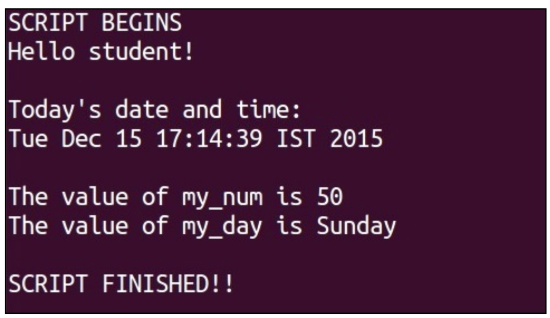
```
variable=value
```

Whenever we declare a `variable`, that `variable` will be available in the current terminal or shell. This `variable` will not be available to any other processes, terminal, or shell.

Let's write a Shell script as follows:

```
#!/bin/bash
# This script clears the window, greets the user,
# and displays the current date and time.
```

```
clear                                   # Clear the window
echo "SCRIPT BEGINS"
echo "Hello $LOGNAME!"                  # Greet the user
echo

echo "Today's date and time:"
date                          # Display current date and time
echo          # Will print empty line

my_num=50
my_day="Sunday"

echo "The value of my_num is $my_num"
echo "The value of my_day is $my_day"
echo

echo "SCRIPT FINISHED!!"
echo
```



Let's see the effect of `$`, `""`, `''` and \ on variable behavior:

```
#!/bin/bash

planet="Earth"

echo $planet
echo "$planet"
echo '$planet'
echo \$planet

echo Enter some text
read planet
```

```
echo '$planet' now equals $planet

exit 0
```

Output:

```
Earth
Earth
$planet
$planet
Enter some text
Venus
$planet now equals Venus
```

You will learn about the `read` command in the next chapters. Using `read`, we can ask the user to enter data, which can be stored in a variable.

From the preceding script execution, we can observe that `$variable` and `"$ variable"` can be used for displaying the content of the variable. But if we use `'$variable'` or `\$variable`, then special functionality of the `$` symbol is not available. The `$` symbol is used as a simple text character instead of utilizing its special functionality of getting variable content.

Working with environment variables

Environmental variables are inherited by any subshells or child processes. For example, `HOME`, `PATH`. Every shell terminal has the memory area called environment. Shell keeps all details and settings in the environment. When we start a new terminal or shell, this environment is created every time.

We can view environment variables by the following command:

```
$ env
```

Or:

```
$ printenv
```

Output:

```
student@ubuntu:~/Desktop/work$
student@ubuntu:~/Desktop/work$ env
SSH_AGENT_PID=2251
GPG_AGENT_INFO=/tmp/keyring-uthSRq/gpg:0:1
TERM=xterm
SHELL=/bin/bash
XDG_SESSION_COOKIE=ca107c3f47929bd197ef224e00000002-1429721473.254990-367780197
WINDOWID=62914565
GNOME_KEYRING_CONTROL=/tmp/keyring-uthSRq
USER=student
LS_COLORS=rs=0:di=01;34:ln=01;36:mh=00:pi=40;33:so=01;35:do=01;35:bd=40;33;01:cd=40;33;0
1:or=40;31;01:su=37;41:sg=30;43:ca=30;41:tw=30;42:ow=34;42:st=37;44:ex=01;32:*.tar=01;31
:*.tgz=01;31:*.arj=01;31:*.taz=01;31:*.lzh=01;31:*.lzma=01;31:*.tlz=01;31:*.txz=01;31:*.
zip=01;31:*.z=01;31:*.Z=01;31:*.dz=01;31:*.gz=01;31:*.lz=01;31:*.xz=01;31:*.bz2=01;31:*.
bz=01;31:*.tbz=01;31:*.tbz2=01;31:*.tz=01;31:*.deb=01;31:*.rpm=01;31:*.jar=01;31:*.war=0
1;31:*.ear=01;31:*.sar=01;31:*.rar=01;31:*.ace=01;31:*.zoo=01;31:*.cpio=01;31:*.7z=01;31
:*.rz=01;31:*.jpg=01;35:*.jpeg=01;35:*.gif=01;35:*.bmp=01;35:*.pbm=01;35:*.pgm=01;35:*.p
pm=01;35:*.tga=01;35:*.xbm=01;35:*.xpm=01;35:*.tif=01;35:*.tiff=01;35:*.png=01;35:*.svg=
01;35:*.svgz=01;35:*.mng=01;35:*.pcx=01;35:*.mov=01;35:*.mpg=01;35:*.mpeg=01;35:*.m2v=01
;35:*.mkv=01;35:*.webm=01;35:*.ogm=01;35:*.mp4=01;35:*.m4v=01;35:*.mp4v=01;35:*.vob=01;3
5:*.qt=01;35:*.nuv=01;35:*.wmv=01;35:*.asf=01;35:*.rm=01;35:*.rmvb=01;35:*.flc=01;35:*.a
```

This is the output of the `$ env` command. The list of environment variables will be quite extensive. I advise you to browse through the complete list. We can change the content of any of these environment variables.

Environmental variables are defined in a terminal or shell. They will be available in subshells or child shells created from the current shell terminal. You will learn about these activities in the next few sections. You have already learned that every command in shell creates a new subshell from the current shell.

The following is a brief summary of the few environmental variables:

Variable	*Description*
HOME	the user's home directory
PATH	the search path for commands
PWD	current working directory
IFS	the internal field separator; i.e., the character that separates individual arguments from each other
PS1	the primary shell prompt
PS2	the secondary shell prompt
PS3	the tertiary shell prompt (see select)
?	the exit status or (return value) of the most recent child process
$	the process ID of the current shell itself
#	the number of arguments passed to the shell
0-9	argument 0 (usually the command itself), argument 1, and so on , as passed to the shell
*	all arguments (with the exception of argument 0) as separate words or arguments
@	all arguments (with the exception of argument 0) as separate words or arguments

Whenever any user logs in, the `/etc/profile` Shell script is executed.

For every user, the `.bash_profile` Shell script is stored in the `home` folder. The complete path or location is `/home/user_name/.profile`.

Whenever a new terminal is created, every new terminal will execute the script `.bashrc`, which is located in the home folder of every user.

The local variable and its scope

In the current shell, we can create and store user defined variables. These may contain characters, digits, and "_". A variable should not start with a digit. Normally for environment variables, upper case characters are used.

If we create a new variable, it will not be available in subshells. The newly created variable will be available only in the current shell. If we run Shell script, then local variables will not be available in the commands called by Shell script. Shell has one special variable `$$`. This variable contains the process ID of the current shell.

Let's try a few commands:

```
$ echo $$
1234
```

This is the process ID of the current shell.

```
$ name="Ganesh Naik"
$ echo $name
Ganesh Naik
```

We declared the variable name and initialized it.

```
$ bash
```

This command will create a new subshell.

```
$ echo $$
1678
```

This is the process ID of the newly created subshell.

```
$ echo $name
```

Nothing will be displayed, as the local variables from the parent shell are not inherited in the newly created child shell or subshell:

```
$ exit
```

We will exit the subshell and return to the original shell terminal.

```
$ echo $$
1234
```

This is the process ID of the current shell or parent shell.

```
$ echo $name
Ganesh Naik
```

This is displaying the variable's presence in the original shell or parent shell.

Variables created in the current shell will not be available in a subshell or child shell. If we need to use a variable in a child shell, then we need to export them using the `export` command.

Exporting variables

Using the `export` command, we are making variables available in the child process or subshell. But if we declare new variables in the child process and export it in the child process, the variable will not be available in parent process. The parent process can export variables to child, but the child process cannot export variables to the parent process.

Whenever we create a Shell script and execute it, a new shell process is created and the Shell script runs in that process. Any exported variable values are available to the new shell or to any subprocess.

We can export any variable as follows:

```
$ export NAME
```

Or:

```
$ declare -x NAME
```

Let's understand the concept of exporting the variable by the following example:

```
$ PERSON="Ganesh Naik"
$ export PERSON
$ echo $PERSON
Ganesh Naik
$ echo $$
515
```

The process ID of the current shell or parent shell is `515`.

`$ bash`

This will start a subshell.

`$ echo $$`

`555`

This is the process ID of new or subshell.

```
$ echo $PERSON
Ganesh Naik
$ PERSON="Author"
$ echo $PERSON
Author
$ exit
```

This will terminate the subshell, and will be placed in the parent shell.

```
$ echo $$
515
```

This is the process ID of the parent shell.

```
$ echo $PERSON
Author
```

Let's write Shell script to use the concept we learned:

```
# Ubuntu Timezone files location : /usr/share/zoneinfo/
# redhat "/etc/localtime"  instead of "/etc/timezone"
# In Redhat
# ln -sf /usr/share/zoneinfo/America/Los_Angeles /etc/localtime

export TZ=America/Los_Angeles
echo "Your Timezone is = $TZ"
date
export TZ=Asia/Tokyo
echo "Your Timezone is = $TZ"
date

unset TZ
```

```
echo "Your Timezone is = $(cat /etc/timezone)"
# For Redhat or Fedora /etc/localtime
date
```

```
Your Timezone is set to: America/Los_Angeles
Wed Apr 22 10:52:53 PDT 2015
Your Timezone is set to: Asia/Tokyo
Thu Apr 23 02:52:53 JST 2015
Your Timezone is set to: Asia/Kolkata
Wed Apr 22 23:22:53 IST 2015
```

The `date` command checks the TZ environmental variable. We initialized the TZ for `Los_Angeles`, then to `Tokyo`, and then finally we removed it. We can see the difference in the date command output.

Let's write another Shell script to study the parent and child process and exportation of variables.

Create the `export1.sh` Shell script:

```
#!/bin/bash
foo="The first variable foo"
export bar="The second variable bar"
./export2.sh

Create another shell script export2.sh
#!/bin/bash
echo "$foo"
echo "$bar"
```

```
student@ubuntu:~/Desktop/work$
student@ubuntu:~/Desktop/work$ ./export1.sh

The second variable bar
student@ubuntu:~/Desktop/work$
```

The Shell script `export1.sh` runs as a *parent* process and `export2.sh` is started as a *child* process of `export1.sh`. We can clearly observe that the variable `bar`, which was exported, is available in the child process; but variable `foo`, which was not exported, is not available in the child process.

Working with read-only variables

During Shell scripting, we may need a few variables, which cannot be modified. This may be needed for security reasons. We can declare variables as read-only using following command read-only:

The usage is as follows:

```
$ readonly currency=Dollars
```

Let's try to remove the variable:

```
$ unset currency
bash: unset: currency: cannot unset: readonly variable
```

If we try to change or remove the ready-only variable in the script, it will give the following error:

```
#!/bin/bash
AUTHOR="Ganesh Naik"
readonly AUTHOR
AUTHOR="John"
```

This would produce the following result:

```
/bin/sh: AUTHOR: This variable is read only.
```

Another technique:

```
Declare  -r  variable=1
echo "variable=$variable"
(( var1++ ))
```

Output after execution of the script:

```
line 4: variable: readonly variable
```

Working with command line arguments (special variables, set and shift, getopt)

Command line arguments are required for the following reasons:

- They inform the utility or command as to which file or group of files to process (reading/writing of files)
- Command line arguments tell the command/utility which option to use

Check the following command line:

```
student@ubuntu:~$  my_program   arg1  arg2  arg3
```

If my_command is a bash Shell script, then we can access every command line positional parameters inside the script as follows:

```
$0 would contain "my_program"    # Command
$1 would contain "arg1"      # First parameter
$2 would contain "arg2"      # Second parameter
$3 would contain "arg3"      # Third parameter
```

The following is the summary of positional parameters:

$0	Shell script name or command
$1–$9	Positional parameters 1–9
${10}	Positional parameter 10
$#	Total number of parameters
$*	Evaluates to all the positional parameters
$@	Same as $*, except when double quoted
"$*"	Displays all parameters as "$1 $2 $3", and so on
"$@"	Displays all parameters as "$1" "$2" "$3", and so on

Let's create a script param.sh as follows:

```
#!/bin/bash
echo "Total number of parameters are = $#"
echo "Script name = $0"
echo "First Parameter is $1"
echo "Second Parameter is $2"
echo "Third Parameter is $3"
echo "Fourth Parameter is $4"
echo "Fifth Parameter is $5"
echo "All parameters are = $*"
```

Then as usual, give execute permission to script and then execute it:

```
./parameter.sh London Washington Delhi Dhaka Paris
```

Output:

```
Total number of parameters are = 5
Command is = ./parameter.sh
First Parameter is London
```

```
Second Parameter is Washington
Third Parameter is Delhi
Fourth Parameter is Dhaka
Fifth Parameter is Paris
All parameters are = London Washington Delhi Dhaka Paris
```

Understanding set

Many times we may not pass arguments on the command line, but we may need to set parameters internally inside the script.

We can declare parameters by the `set` command as follows:

```
$ set USA Canada UK France
$ echo $1
USA
$ echo $2
Canada
$ echo $3
UK
$ echo $4
France
```

We can use this inside the `set_01.sh` script as follows:

```
#!/bin/bash
set USA Canada UK France
echo $1
echo $2
echo $3
echo $4
```

Run the script as:

```
$ ./set.sh
```

Output:

```
USA
Canada
UK
France
```

Table declare Options	
Option	**Meaning**
–a	An array will be created
–f	Displays function names and definitions
–F	Displays only the function names
–i	Makes variables integer types
–r	Makes variables read-only
–x	Exports variables

We give commands as follows:

```
set One Two Three Four Five
echo $0      # This will show command
echo $1       # This will show first parameter
echo $2
echo $*    # This will list all parameters
echo $#    # This will list total number of parameters
echo ${10} ${11}  # Use this syntax for parameters for 10th and
         # 11th parameters
```

Let us write script `set_02.sh` as follows:

```
#!/bin/bash
echo The date is $(date)
set $(date)
echo The month is $2
exit 0
```

Output:

```
student@ubuntu:~/Desktop/work$ bash set_02.sh
The date is Thu Apr 23 00:36:53 IST 2015
The month is Apr
student@ubuntu:~/Desktop/work$
```

In the script `$(date)`, the command will execute and the output of that command will be used as `$1`, `$2`, `$3` and so on. We have used `$2` to extract the month from the output.

Let's write script `set_03.sh` as follows:

```
#!/bin/bash

echo "Executing script $0"
echo $1 $2 $3

set eins zwei drei
echo "One two three in German are:"
echo "$1"
echo  "$2"
echo  "$3"

textline="name phone address birthdate salary"
set $textline
echo  "$*"
echo 'At this time $1 = ' $1 'and $4 = ' $4
```

Output:

```
student@ubuntu:~/Desktop/work$ bash set_03.sh
Executing script set_03.sh

One two three in German are:
eins
zwei
drei
name phone address birthdate salary
At this time $1 = name and $4 = birthdate
```

In this script, the following output shows:

1. Initially when the set is not called, then `$1`, `$2`, `$3` do not contain any information.
2. Then, we set `$1` to `$3` as `GERMAN` numerals in words.
3. Then, set `$1` to `$5` as name, phone, address, birthdate, and salary, respectively.

Understanding shift

Using shift, we can change the parameter to which `$1` and `$2` are pointing to the next variable.

Create a script `shift_01.sh` as follows:

```
#!/bin/bash
echo "All Arguments Passed are as follow : "
echo $*
echo "Shift By one Position :"
shift
echo "Value of Positional Parameter $ 1 after shift :"
echo $1
echo "Shift by Two Positions :"
shift 2
echo "Value of Positional Parameter $ 1 After two Shifts :"
echo $1
```

Execute the command as follows:

```
$ chmod +x shift_01.sh
$ ./shift_01.sh One Two Three Four
```

Output:

`student@ubuntu$ ./shift_01.sh One Two Three Four`

All arguments passed are as follows:

`One Two Three Four`

Shift by one position.

Here, the value of the positional parameter `$1` after shift is:

`Two`

Shift by two positions.

The value of the positional parameter `$1` after two shifts:

`Four`

We observed that initially `$1` was `One`. After shift, `$1` will be pointing to `Two`. Once shift is done, the value in position `1` is always destroyed and is inaccessible.

Create a `shift_02.sh` script as follows:

```
#!/bin/bash

echo '$#: ' $#
echo '$@: ' $@
echo '$*: ' $*
echo
echo '$1 $2 $9 $10 are: ' $1 $2 $9 $10
echo

shift
echo '$#: ' $#
echo '$@: ' $@
echo '$*: ' $*
echo
echo '$1 $2 $9 are: ' $1 $2 $9

shift 2
echo '$#: ' $#
echo '$@: ' $@
echo '$*: ' $*
echo
echo '$1 $2 $9 are: ' $1 $2 $9

echo '${10}: ' ${10}
```

```
student@ubuntu:~/Desktop/work$ bash shift_02.sh 1 2 3 4 5 6 7 8 9 10 11 12 13
All parameters before shift
$#:  13
$@:  1 2 3 4 5 6 7 8 9 10 11 12 13
$*:  1 2 3 4 5 6 7 8 9 10 11 12 13

$1 $2 $9 $10 are:  1 2 9 10

All parameters after one shift
$#:  12
$@:  2 3 4 5 6 7 8 9 10 11 12 13
$*:  2 3 4 5 6 7 8 9 10 11 12 13

$1 $2 $9 are:  2 3 10
All parameters after shift 2
$#:  10
$@:  4 5 6 7 8 9 10 11 12 13
$*:  4 5 6 7 8 9 10 11 12 13

$1 $2 $9 are:  4 5 12
${10}:  13
```

In this script execution, the following output shows:

1. Initially, `$1` to `$13` were numerical values 1 to 13, respectively.
2. When we called the command shift, then `$1` shifted to number `2` and accordingly all $numbers are shifted.
3. When we called the command shift `2`, then `$1` shifted to number 4 and accordingly all $numbers are shifted.

Resetting positional parameters

In certain situations, we may need to reset original positional parameters.

Let's try the following:

`set Alan John Dennis`

This will reset the positional parameters.

Now `$1` is `Alan`, `$2` is `John`, and `$3` is `Dennis`.

Inside the scripts, we can save positional parameters in a variable as follows:

`oldargs=$*`

Then, we can set new positional parameters.

Later on, we can bring back our original positional parameters as follows:

`set $oldargs`

Understanding getopts

Command line parameters passed along with commands are also called as **positional parameters**. Many times, we need to pass options such as –f and -v along with positional parameter.

Let's learn the example for passing the `–x` or `–y` options along with commands. Write the Shell script `getopt.sh` as follows:

```
#!/bin/bash

USAGE="usage: $0 -x -y"

while getopts :xy: opt_char
do
```

```
      case $opt_char in
      x)
        echo "Option x was called."
        ;;
      y)
        echo "Option y was called. Argument called is $OPTARG"
        ;;
      \?)
        echo "$OPTARG is not a valid option."
        echo "$USAGE"
        ;;
      esac
    done
```

Execute this program:

$ ./getopt.sh

You will be learning switch and case statements in the next chapters. In this script, if option `-x` is passed, a case statement for `x` will be executed. If the `-y` option is passed, then a case statement for `-y` will be executed. Since no option is passed, there will not be any output on the screen.

$ ./getopt.sh -x

Output:

```
Option x was called."

$ ./getopt.sh -y my_file
Output:
Option y was called. Argument called is my_file.

$ ./getopt.sh -x -y my_file
Output:
Option x was called.
Option y was called. Argument called is my_file.

$ ./getopt.sh -y my_file -x
Output:
Option y was called. Argument called is my_file.
Option x was called.
```

Understanding default parameters

Many times we may pass certain parameters from the command line; sometimes, we may not pass any parameters at all. We may need to have certain default values to be initialized to certain variables.

We will understand this concept by the following script.

Create a `default_argument_1.sh` script as follows:

```
#!/bin/bash
MY_PARAM=${1:-default}
echo $MY_PARAM
```

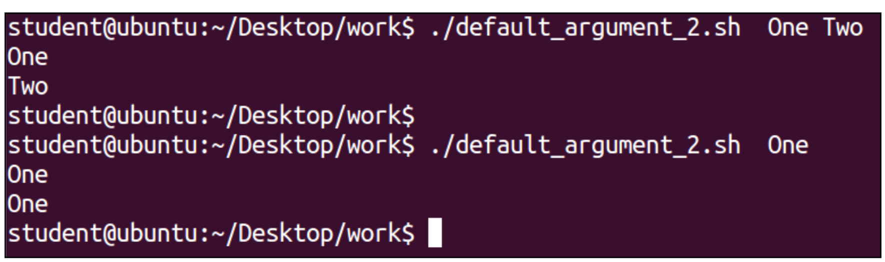
Execute the script and check:

```
$ chmod +x default_argument_1.sh One
$ ./default_argument_1.sh One
One
$ ./default_argument_1.sh
default
```

Create another `default_argument_2.sh` script:

```
#!/bin/bash
variable1=$1
variable2=${2:-$variable1}
echo $variable1
echo $variable2
```

Output:



We executed the script two times:

- When we passed two arguments, then `variable1` was `$1` and `variable2` was `$2`.
- In second case, when we passed only one argument, then `$1` was taken as a default argument for `$2`. Therefore, `variable1` was used as default `variable2`. If we do not give a second parameter, then the first parameter is taken as a default second parameter.

Working with arrays

An array is a list of variables. For example, we can create an array `FRUIT`, which will contain many fruit names. The array does not have a limit on how many variables it may contain. It can contain any type of data. The first element in an array will have the index value as 0:

```
student@ubuntu:~$ FRUITS=(Mango Banana Apple)
student@ubuntu:~$ echo ${FRUITS[*]}
Mango Banana Apple
student@ubuntu:~$ echo $FRUITS[*]
Mango[*]
student@ubuntu:~$ echo ${FRUITS[2]}
Apple
student@ubuntu:~$ FRUITS[3]=Orange
student@ubuntu:~$ echo ${FRUITS[*]}
Mango Banana Apple Orange
```

Creating an array and initializing it

You will learn about creating an array in the `Bash` shell.

If the array name is `FRUIT`, then we can create an array as follows:

```
FRUIT[index]=value
```

`Index` is the integer value. It should be 0 or any positive integer value.

We can also create an array as follows:

```
$ declare -a array_name
$ declare -a arrayname=(value1 value2 value3)
```

Example:

```
$ declare -a fruit=('Mango' 'Banana' 'Apple' 'Orange' 'Papaya')
$ declare -a array_name=(word1 word2 word3 ...)
$ declare -a fruit=( Pears Apple Mango Banana Papaya )
$ echo ${fruit[0]}
Pears
$ echo ${fruit[1]}
Apple
$ echo "All the fruits are ${fruit[*]}"
    All the fruits are Pears Apple Mango Banana Papaya
$ echo "The number of elements in the array are ${#fruit[*]}"
    The number of elements in the array are 3
$ unset fruit  or unset ${fruit[*]}
```

Accessing array values

Once we have initialized an array, we can access it as follows:

```
${array_name[index]}
```

We will create the script `array_01.sh` as follows:

```
#!/bin/bash

FRUIT[0]="Pears"
FRUIT[1]="Apple"
FRUIT[2]="Mango"
FRUIT[3]="Banana"
FRUIT[4]="Papaya"
echo "First Index: ${FRUIT[0]}"
echo "Second Index: ${FRUIT[1]}"
```

output:

```
$ chmod +x array_01.sh
$./array_01.sh
First Index: Pears
Second Index: Apple
```

To display all the items from the array, use the following commands:

```
${FRUIT[*]}
${FRUIT[@]}
```

Create an `array_02.sh` script as follows:

```
#!/bin/bash
FRUIT[0]="Pears"
FRUIT[1]="Apple"
FRUIT[2]="Mango"
FRUIT[3]="Banana"
FRUIT[4]="Papaya"
echo "Method One : ${FRUIT[*]}"
echo "Method Two : ${FRUIT[@]}"
```

Output:

```
$ chmod +x array_02.sh
$./ array_02.sh
Method One : Pears Apple Mango Banana Papaya
Method Two : Pears Apple Mango Banana Papaya
```

Let's see few more examples:

```
$ city[4]=Tokyo
```

The fourth member of the array, city, is being assigned `Tokyo`. Since it is the only element in the array, array the size will be 1.

```
$ echo ${city[*]}
Tokyo
```

The size of the array city is 1, since any other member of the array is not yet initialized.

`${city[*]}` will display the only element of the array city.

```
$ echo ${city[0]}
```

`city[0]` has no value, and neither does `city[1]` and `city[2]`.

```
$ echo ${city[4]}
Tokyo
```

`city[4]` has the name of city as `Tokyo`.

```
$ countries=(USA  [3]=UK  [2]=Spain)
```

The array countries are being assigned `USA` at index `0`, `UK` at index `3`, and `Spain` at index `2`. We can observe here that it does not matter in which sequence we are initializing the members of the array. They need not be in same sequence.

```
$ echo ${countries[*]}
USA Spain UK
$ echo ${countries[0]}
USA
```

The first element of the `countries` array is printed.

```
$ echo ${countries[1]}
```

There is nothing stored in `countries [1]`.

```
$ echo ${countries[2]}
Spain
```

The third element of the `countries` array, `countries [2]`, was assigned `Spain`.

```
$ echo ${countries[3]}
UK
```

The fourth element of the `countries` array, `countries [3]`, was assigned `UK`.

Summary

In this chapter, you learned about variables and environment variables. You also learned about how to export environment variables, set, shift, read-only variables, command line arguments, and about creating and handling arrays.

In the next chapter, you will learn about debugging, the `here` operator, interactive Shell scripts for taking input from keyboard, and file handling.

6
Neat Tricks with Shell Scripting

In the last chapter, you learned about shell and environment variables. You also learned about how to export environment variables, read-only variables, command-line arguments, and create/handle arrays.

In this chapter, we will cover following topics:

- Interactive Shell scripts and reading from the keyboard
- Using the `here` operator (`<<`) and `here` string (`<<<`)
- File handling
- Enabling debugging
- Syntax checking
- Shell tracing

Interactive Shell scripts – reading user input

The `read` command is a shell built-in command for reading data from a file or keyboard.

The `read` command receives the input from the keyboard or a file until it receives a newline character. Then, it converts the newline character into a null character:

1. Read a value and store it in the variable, shown as follows:

```
read variable
echo $variable
```

This will receive text from the keyboard. The received text will be stored in the variable.

2. Command read with prompt. Whenever we need to display the prompt with certain text, we use the `-p` option. The option `-p` displays the text that is placed after `-p` on the screen:

```
#!/bin/bash
# following line will print "Enter value: " and then read data
# The received text will be stored in variable value
read -p "Enter value :  " value
```

Output:

```
Enter value : abcd
```

3. If the variable name is not supplied next to the `read` command, then the received data or text will be stored in a special built-in variable called `REPLY`. Let's write a simple script `read_01.sh`, shown as follows:

```
#!/bin/bash
echo "Where do you stay ?"
read     # we have not supplied any option or variable
echo "You stay in $REPLY"
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x read_01.sh
$ ./read_01.sh
```

Output:

```
"Where do you stay?"
Mumbai
"You stay at Mumbai"
```

4. We will write the script `read_02.sh`. This script prompts the user to enter their first and last name to greet the user with their full name:

```
#!/bin/bash
echo "Enter first Name"
read FIRSTNAME
echo "Enter Last Name"
read LASTNAME
NAME="$FIRSTNAME $LASTNAME"
echo "Name is $NAME"
```

5. For reading text and storing in multiple variables, the syntax is as follows:

   ```
   $ read value1 value2 value3
   ```

   Let's write Shell script `read_03.sh`, shown as follows:

   ```
   #!/bin/bash
   echo "What is your name?"
   read fname mname lname
   echo "Your first name is : $fname"
   echo "Your middle name is : $mname"
   echo "Your last name is : $lname"
   ```

   Save the file, give the permission to execute, and run the script as follows:

   ```
   What is your name?
   Ganesh Sanjiv Naik
   "Your first name is : Ganesh"
   "Your middle name is : Sanjiv"
   "Your last name is : Naik"
   ```

6. Let's learn about reading a list of words and storing them in an array:

   ```
   #!/bin/bash
   echo -n "Name few cities? "
   read -a cities
   echo "Name of city is ${cities[2]}."
   ```

   Save the file, give the permission to execute, and run the script as follows:

   ```
   Name few cities? Delhi London Washington Tokyo
   Name of city is Washington.
   ```

   In this case, the list of cities is stored in the array of cities. The elements in the array are here:

   ```
   cities[0] = Delhi
   cities[1] = London
   cities[2] = Washington
   cities[3] = Tokyo
   ```

   The index of the array starts with `0`, and in this case, it ends at `3`. In this case, four elements are added in the `cities[]` array.

7. If we want the user to press the *Enter* key, then we can use the `read` command along with one unused variable, shown as follows:

   ```
   Echo "Please press enter to proceed further "
   read temp
   echo "Now backup operation will be started ! "
   ```

Summarizing the read command with options

The following table summarizes various read command-related options that you learned in the previous sections:

Format	Meaning
read	This command will read text from a keyboard and store the received text in a built-in variable `REPLY`.
read value	This reads a text from a keyboard or standard input and stores it into the variable value.
read first last	This will read the first word in variable first and the remaining text of the line in variable last. The first word is separated by white space from the remaining words in the line.
read –e	This is used in interactive shells for command-line editing. If vi editor is used, then vi commands can be used.
read –a array_name	This will store a list of words received in to an array.
read –r line	The text with backslash can be received here.
read –p prompt	This will print the prompt and wait for the user input. The received text will be stored in the variable REPLY.

The here document and the << operator

It is a special type of block of text or code. It is also a special form of I/O redirection. It can be used to feed the command list to an interactive program.

The syntax of the usage of the `here` document or the `<<` operator is as follows:

```
command << HERE
text1 …..
text 2….

HERE
```

This tells the shell that the command should receive the data from a current source, such as the `here` document, until the pattern is received. In this case, the pattern is `HERE`. We have used the delimiter as `HERE`. We can use any other word as the delimiter, such as quite or finish. All the text reads up to a pattern; or the `HERE` text is used as an input for command. The text or file received by the command is called as the `Here` document:

```
$ cat << QUIT
> first input line
> ...
> last input line
> QUIT
```

The block of text inserted after and before `QUIT` will be treated as a file. This content will be given as input to the command `cat`. We will also see more examples with various other commands, such as `sort`, `wc`, and similar.

Let's write the script `here_01.sh`:

```
#!/bin/bash
cat << quit
  Command is $0
  First Argument is $1
  Second Argument is $2
Quit
Save the file, give execute permission and run the script as follows:
$ chmod here_01.sh
$./here_01.sh Monday Tuesday
```

Output:

```
Command is here_01.sh
First Argument is Monday
Second Argument is Tuesday
```

The text block created in the preceding script between the `quit` words is called as the `here` document. We can treat this `here` document as a `separate` document. It can also be treated as multiple line input redirected to a Shell script.

Let's learn a few more sample programs.

The here operator with the sort command

Let's write script for using the `sort` command along with the `here` document:

1. Write the script `here_02.sh` as follows:

   ```
   #!/bin/bash
   sort << EOF
   > cherry
   > mango
   > apple
   > banana
   > EOF
   ```

2. Save the file, give the permission to execute, and run the script as follows:

   $ chmod u+x here_02.sh

   $ ./here_02.sh

3. The output is here:

   apple

   banana

   cherry

   mango

In this script, the `here` document is enclosed between the `EOF` pattern. We have used the `here` document to supply text to the `sort` command.

The here operator with the wc command

Let's write script for using the `wc` command along with the `here` document:

1. Create Shell script `here_03.sh`:

```
#!/bin/bash
wc -w << EOF
There was major earthquake
On April 25, 2015
in Nepal.
There was huge loss of human life in this tragic event.
EOF
```

2. Save the file, give the permission to execute, and run the script as follows:

   $ chmod u+x here_03.sh

   $ ./here_03.sh

3. The output is here:

   21

In this script, we have used the `here` document as an input for the `wc` command to calculate the number of words:

Tape backup using << here operator

Let's write a script for taking the tape backup by using the `tar` command and the `here` document:

1. Let's write the script `here_04.sh`:

```
#!/bin/bash
# We have used tar utility for archiving home folder on tape
tar -cvf /dev/st0 /home/student 2>/dev/null

# store status of tar operation in variable status
[ $? -eq 0 ] && status="Success" || status="Failed"

# Send email to administrator
mail -s 'Backup status' ganesh@levanatech.com << End_Of_Message
The backup job finished.
End date: $(date)
Status : $status
End_Of_Message
```

2. Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x here_04.sh
$ ./here_04.sh
```

This script uses the `tar` command to archive the `home` folder in the tape device, and then it sends mail to an administrator using the command `mail`. We have used the `here` document to feed data into the command `mail`.

The utility ed and here operator

The ed is a basic type of editor. We can edit text files using this editor:

1. Write the script `here_05.sh`:

```
#!/bin/bash
# flowers.txt contains the name of flowers
cat flowers.txt
ed flowers.txt << quit
,s/Rose/Lily/g
w
q
quit
cat flowers.txt
```

2. Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x here_05.sh
$ ./here_05.sh
```

3. The output is here:

```
Aster, Daffodil, Daisy, Jasmin, Lavender, Rose, Sunflower
59
59
Aster, Daffodil, Daisy, Jasmin, Lavender, Lily, Sunflower
```

In this script, we have used passed the `here` document to utility for editing the file `flowers.txt`. We replaced the `Rose` word with `Lily`.

A script for sending messages to all logged-in users

All the users who are logged in will receive the message using the `wall` command:

1. Write the script `here_06.sh`:

```
#!/bin/bash
# wall utility is used for sending message to all logged in users
wall << End_Of_Message
Tomorrow, on Friday evening, we will be celebrating
Birthday of few of our colleagues.
All are requested to be present in cafeteria by 3.30 PM.
    John
End_Of_Message
echo "Message sent"
```

2. Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x here_06.sh
$ ./here_06.sh
```

The command `wall` is used to send messages to the logged-in users. All the users that are logged in will receive the message.

Using the << here operator for FTP usage and data transfer

FTP is a commonly used protocol to transfer data on websites. FTP stands for **File Transfer Protocol**. The following steps show the usage of FTP and data transfer:

1. Write the script `here_07.sh`:

```
#!/bin/bash
# Checking number of arguments passed along with command
if [ $# -lt 2 ]
then
  echo "Error, usage is:"
  echo "ftpget hostname filename [directory]."
  exit -1
fi
hostname=$1
filename=$2
directory="." # Default value
if [ $# -ge 3 ]
then
  directory=$3
fi
ftp <<End_Of_Session
open $hostname
cd $directory
get $filename
quit
End_Of_Session
echo "FTP session ended."
```

2. Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x here_07.sh
$ ./here_07.sh ftp.somehost.com index.html WWW
```

For a successful execution of the script, we need to set up an autologin for the `ftp` command. The `here` operator does not work well when the `ftp` command asks for a username and password.

Turning off variable substitution

Enter the following script to see how to avoid a variable substitution in these files:

1. Save the script under the name `here_no.sh`, shown as follows:

```
filename="test1"
cat <<'Quoted_End_Marker'
When we add quotes before and after here
Document marker, we can include variables
Such as $USER, $PATH, $name and similar
Quoted_End_Marker
```

2. When you run this script, you will see the output like the following:
   ```
   $ bash here_no.sh
   With quotes around the here document marker,
   you can include variable references such
   as $HOME, $filename, and $USER.
   ```

This script uses an ordinary `here` file, but it turns off the variable substitution. Otherwise, you would see the values of `$HOME`, `$filename`, and `$USER` in the output instead of the literal text. All of this is done by magically enclosing the end marker, `Quoted_End_Marker`, in quotes at the original reference. Do not enclose the marker in quotes at the end of the `here` file.

The here string and the <<< operator

The `here` string is used for input redirection from text or a variable. Input is mentioned on the same line within single quotes (`''`).

The syntax is as follows:

```
$ command <<< 'string'
```

1. Let's see the following example `hereString_01.sh`:
   ```
   #!/bin/bash
   wc -w <<< 'Good Morning and have a nice day !'
   ```
2. Save the file, give the permission, and run the script as follows:
   ```
   $ chmod u+x hereString_01.sh
   $ ./hereString_01.sh
   ```
3. Here is the output:
   ```
   8
   ```

In this example, the string `Good Morning and have a nice day !` is called as the `here` string.

File handling

In this section, you will learn about handling files for reading and writing. In *Chapter 8, Automating Decision Making in Scripts*, you will learn about checking various attributes of files along with decision making constructs, such as if, case, and similar.

Introducing file handling

The exec command is very interesting. Whenever we run any command in shell, the new subshell or process gets created, and the command runs in this newly created process. When we run any command as argument to the exec command, exec will replace the current shell with the command to be executed. It does not create or spawn a new process to run the command.

Using exec to assign file descriptor (fd) to file

In the Bash shell environment, every process has three files opened by default. These are standard input, display, and error. The file descriptors associated with them are 0, 1, and 2 respectively. In the Bash shell, we can assign the file descriptor to any input or output file. These are called file descriptors.

The syntax for declaring output.txt as output is as follows:

```
exec fd > output.txt
```

This command will declare the number fd as an output file descriptor.

The syntax for closing the file is as follows:

```
exec fd<&-
```

To close fd, which is 5, enter the following:

```
exec 5<&-
```

We will try to understand these concepts by writing scripts.

Understanding the opening, writing, and closing of a file

Let's understand the opening, closing, and writing of a file.

Write a Shell script file_01.sh, shown as follows:

```
#!/bin/bash
# We will open file for writing purpose
# We are assigning descriptor number 3 for file sample_out.txt
exec 3> sample_out.txt

# We are sending output of command "echo" to sample_out.txt file
```

```
echo "This is a test message for sample_out.txt file" >&3

# Run command date & store output in file sample_out.txt
date >&3

# Closing file with file descriptor 3
exec 3<&-
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x file_01.sh
$ ./file_01.sh
$ cat sample_out.txt
```

Output:

```
This is a test message for sample_out.txt file
Tue Sep 29 23:19:22 IST 2015
```

Understanding reading from a file

Let's write script to read from a file:

Write the script `file_02.sh`, shown as follows:

```
#!/bin/bash
# We will open file sample_input.txt for reading purpose.
# We are assigning descriptor 3 to the file.
exec 3< sample_input.txt

cat <&3
# Closing file
exec 3<&-
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x file_02.sh
```

We will create the `sample_input.txt` file as follows:

```
$ echo "Hello to All" > sample_input.txt
```

Run the script and check the result:

```
$ ./file_02.sh
```

Output:

```
Hello to All
```

Understanding reading and writing to a file

In the earlier examples, we opened the file either for reading or writing. Now, we will see how to open the file for reading and writing purposes:

```
exec fd<> fileName
```

If the file descriptor number is not specified, then `0` will be used in its place. The file will be created if it does not exist. This procedure is useful to update files.

Let's understand following script.

Write the Shell script `file_03.sh` as follows:

```
#!/bin/bash
file_name="sample_out.txt"
# We are assing fd number 3 to file.
# We will be doing read and write operations on file
exec 3<> $file_name

# Writing to file
echo """
 Do not dwell in the past,
 do not dream of the future,
 concentrate the mind on the present moment. - Buddha
""" >&3
# closing file with fd number 3
exec 3>&-
```

Using command read on file descriptor (fd)

We can use command read to get data from a file to store it in variables.
The procedure for using the read command to get text from a file is as follows:

```
read -u fd variable1 variable2 ... variableN
```

Reading from one file and writing to another file

Now, we will see how to read from one file and write to another. Let's write script `file_04.sh` as follows:

```
#!/bin/bash
# We are assigning descriptor 3 to in_file.txt
exec 3< in_file.txt
```

```
# We are assigning descriptor 4 to out_file.txt
exec 4> out_file.txt

# We are reading first line of input.txt
read -u 3 line

echo $line

echo "Writing content of in_file.txt to out_file.txt"
echo  "Line 1 - $line " >&4

# Closing both the files
exec 3<&-
exec 4<&-
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x file_04.sh
$ echo "Sun is at the center of Solar System." > in_file.txt
$ cat in_file.txt
```

Output:

```
Sun is at the center of Solar System.
$ ./file_04.sh
```

Output:

```
Sun is at the center of Solar System.
Writing content of in_file.txt to out_file.txt
$ cat out_file.txt
```

Output:

```
Line 1 - Sun is at the center of Solar System.
```

In this example, we read the complete line in the variable `line` and we used the same variable to write it to another file.

Let's write one more script `file_05.sh` to get the hostname and addresses:

```
#!/bin/sh

cp /etc/hosts hosts2

grep -v '^#' hosts2 > hosts3
```

```
exec 3< hosts3    # opening hosts3 as input file

exec 4> hostsfinal  # opening hostsfinal as output file

read <& 3 address1 name_1 extra_info
read <& 3 address2 name_2 extra_info

echo $name_1 $address1 >& 4
echo $name_2 $address2 >& 4

exec 3<&-      # Closing hosts3
exec 4<&-      # Closing hostsfinal
```

In this script, we used the variables `address1`, `name_1`, `extra_info`, `address2`, and `name_2` to store useful information.

Displaying the file descriptor information from the /proc folder

We will write the script to display the actual file descriptors associated with the file.

Let's write the script `file_06.sh`, shown as follows:

```
#!/bin/bash
# we are assigning file descriptor 3 to input file test.txt
exec 3< test.txt
# we are assigning file descriptor 4 to output.txt
exec 4> output.txt
# we are using read command to read line from file
read -u 3 line
echo "Process id of current process is $$"
my_pid=$$
echo "Currently following files are opened by $0 script :"
ls -l /proc/$my_pid/fd

# We are closing both files test.txt and output.txt
exec 3<&-
exec 4>&-
```

File handling – reading line by line

You will learn how to use the `while` loop and the `read` command to read a file line by line. You will learn more about the `while` loop in the upcoming chapters.

Let's write the script `file_07.sh`, shown as follows:

```
#!/bin/bash
echo "Enter the name of file for reading"
read file_name
exec<$file_name
while read var_line
do
  echo $var_line
done
```

For executing the preceding script, we will need to create a file with some text in it. Then, we will pass this file name for reading purposes.

Executing the command and storing the results in a file

The following is the syntax for storing the output of a command in a file:

```
Command >& fd
./script >& fd
```

The following is the illustrative example script `file_08.sh`:

```
#!/bin/bash
exec 4> output.txt
cat /proc/cpuinfo  >&4
exec 3<&-
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x file_08.sh
$ ./file_08.sh
```

Output:

```
student@ubuntu:~/work$ ./file_08.sh
student@ubuntu:~/work$ cat output.txt
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 60
model name      : Intel(R) Core(TM) i7-4600M CPU @ 2.90GHz
stepping        : 3
microcode       : 0x17
cpu MHz         : 2893.510
cache size      : 4096 KB
physical id     : 0
siblings        : 1
core id         : 0
cpu cores       : 1
apicid          : 0
initial apicid  : 0
fdiv_bug        : no
f00f_bug        : no
coma_bug        : no
fpu             : yes
```

In this example, we have executed the command `cat /proc/cpuinfo` and we have stored the output in file `output.txt`.

Summarizing usage of the exec command

The following is the summary of the exec command for using various file handling-related operations:

Command	**What it does**
exec command	This command will replace shell and execute it. Therefore, it will not return to its original shell, which started it.
exec > data.txt	This opens `data.txt` for writing standard output.
exec < data.txt	This opens `data.txt` for reading standard input.
exec 3< data.txt	This opens `data.txt` for reading with descriptor 3.
sort <&3	This will sort `data.txt` file
exec 4>data.txt	This opens `data.txt` for writing with descriptor 4.
ll >&4	The output of `ll` is redirected to `data.txt`.
exec 6<&5	This makes fd 6 a copy of fd 5
exec 4<&-	This closes fd 4.

Debugging

In the very old days of computer technology, the initial problems with computers were due to real insects. Due to this, fault finding was later called as finding a bug. Therefore, the process of finding and fixing the problems in computers was called debugging.

The process of debugging involves the following:

- Finding out what has gone wrong
- Fixing the problem

In the actual debugging process, you will need to do the following:

- Understand the error message and find out what is the problem with the script.
- Find the error location in the script.
- Locate the line number from the error message. The following are a few error messages:
    - `debug_sp: line 11: [7: command not found]`
    - `file: line 6: unexpected EOF while looking for matching` `` `"' ``

  These messages inform the user about the line numbers of script which contain errors.
- Correct the issue or problematic part of code. We may have to read the line as well as look backward from this line number for any possible reason for the error.

Debugging mode – disabling the shell (option -n)

In the Bash shell, the `-n` option is a shortcut for **noexec** (as in no execution). This option tells the shell to not run the commands. Instead, the shell just checks for syntax errors.

We can test the script as follows:

```
$ bash -n hello.sh
```

The –n option will tell the Bash shell to check the syntax in the Shell script; but not to execute the Shell script.

Another way to do this is as follows:

```
#!/bin/bash  -n
We have modified shebang line.
```

In this case, we can test the Shell script as follows:

```
$ chmod u+x hello.sh
$ ./hello.sh
```

This option is safe, since the shell commands are not executed. We can catch incomplete if, for, while, case, and similar programming constructs as well as many more syntactical errors.

Let's write `debug_01.sh`:

```
#!/bin/bash
echo -n "Commands in bin directory are : $var"

for var in $(ls )
do
        echo -n -e "$var   "
do
# no error if "done" is typed instead of "do"
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod  u+x debug_01.sh
$ ./debug_01.sh
```

Output:

```
Commands in bin directory are : ./hello.sh: line 7: syntax error near
unexpected token `do'
./hello.sh: line 7: `do'


$ bash -n debug_01.sh
```

Output:

```
hello.sh: line 7: syntax error near unexpected token `do'
hello.sh: line 7: `do'
```

Debugging mode – displaying commands (option -v)

The `-v` option tells the shell to run in a **verbose** mode. In practice, this means that the shell will echo each command prior to executing the command. This will be useful in locating the line of script that has created an error.

We can enable the script execution with the -v option as follows:

```
$ bash -v hello.sh
```

Another way is by modifying the shebang line as follows:

```
#!/bin/bash  -v
```

In this case, we can run the script with the -v option as follows:

```
$ chmod u+x hello.sh
$ ./hello.sh
```

Let's write the script debug_02.sh, shown as follows:

```
#!/bin/bash
echo "Hello $LOGNAME"
echo "Today is `date`
echo "Your present working directory is $PWD
echo Good-bye $LOGNAME
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x debug_02.sh
$ ./debug_02.sh
```

Output:

```
Hello student
Today is Fri May 1 00:18:52 IST 2015
Your present working directory is /home/student/work
Good-bye student
```

Let's enable the -v option for debugging, and run the script again as follows:

```
$ bash -v debug_02.sh
```

Output:

```
#!/bin/bash
echo "Hello $LOGNAME"
"Hello student"
echo "Today is `date`
date
"Today is Fri May 1 00:18:52 IST 2015
echo "Your present working directory is $PWD
"Your present working directory is /home/student/work
echo Good-bye $LOGNAME
Good-bye student
```

Debugging mode – the tracing execution (option -x)

The `-x` option, short for **xtrace** or execution trace, tells the shell to echo each command after performing the substitution steps. Thus, we will see the value of variables and commands.

We can trace the execution of the Shell script as follows:

```
$ bash -x hello.sh
```

Instead of the previous way, we can modify the shebang line as follows:

```
#!/bin/bash  -x
```

Let's test the earlier script `debug_01.sh` as follows:

```
$ bash -x hello.sh
```

Output:

```
$ bash -x debug_02.sh
+ echo Hello student
Hello student
+ date
+ echo The date is Fri May 1 00:18:52 IST 2015
The date is Fri May 1 00:18:52 IST 2015
+ echo Your home shell is /bin/bash
Your home shell is /bin/bash
+ echo Good-bye student
Good-bye student
```

Let's try the following programs with the `-n` `-v` `-f` and `-x` options. Here's a sample program—`debug_03.sh`:

```
#!/bin/bash
echo "Total number of parameters are = $#"
echo "Script name = $0"
echo "First Parameter is $1"
echo "Second Parameter is $2"
echo "All parameters are = $*"
echo "File names starting with f* in current folder are :"
ls f*
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x debug_03.sh
$ ./debug_03.sh One Two
```

Output:

```
"Total number of parameters are = 2"
"Script name = ./debug_03.sh"
"First Parameter is India"
"Second Parameter is Delhi"
"All parameters are = India Delhi"
"File names starting with debug_02.sh debug_03.sh in current folder are:
"
debug_02.sh  debug_03.sh
```

Let's test the same script with the `-n` option, which will check for syntax errors:

```
$ bash -n debug_03.sh One Two
```

Let's test the same script with the `-v` option:

```
$ bash -v debug_03.sh One Two
```

Output:

```
#!/bin/bash
echo "Total number of parameters are = $#"
"Total number of parameters are = 2"
echo "Script name = $0"
"Script name = debug_03.sh"
echo "First Parameter is $1"
"First Parameter is India"
echo "Second Parameter is $2"
"Second Parameter is Delhi"
echo "All parameters are = $*"
"All parameters are = India Delhi"
echo "File names starting with d* in current folder are :"
"File names starting with debug_02.sh debug_03.sh in current folder are:
"
ls d*
debug_02.sh  debug_03.sh
```

Let us test the same script with the `-x` option:

```
$ bash -x debug_03.sh One Two
```

Output:

```
+ echo $'\342\200\234Total' number of parameters are = $'2\342\200\235'
"Total number of parameters are = 2"
+ echo $'\342\200\234Script' name = $'debug_03.sh\342\200\235'
"Script name = debug_03.sh"
+ echo $'\342\200\234First' Parameter is $'India\342\200\235'
"First Parameter is India"
+ echo $'\342\200\234Second' Parameter is $'Delhi\342\200\235'
"Second Parameter is Delhi"
+ echo $'\342\200\234All' parameters are = India $'Delhi\342\200\235'
"All parameters are = India Delhi"
+ echo $'\342\200\234File' names starting with debug_02.sh debug_03.sh in
current folder are $':\342\200\234'
"File names starting with debug_02.sh debug_03.sh in current folder are:
"
+ ls debug_02.sh debug_03.sh
debug_02.sh  debug_03.sh
```

Let's test one more program, which will give a syntax error during the `-n` and `-x` options debugging. Write the Shell script `debug_04.sh` as follows:

```
#!/bin/bash
echo "Commands in bin directory are : $var"

for var in $(ls )
do
        echo -n -e "$var   "
do
```

Save the file, give the permission to execute, and run the script as follows:

```
$ chmod u+x debug_04.sh
$ bash -n debug_04.sh
```

Output:

```
debug_04.sh: line 7: syntax error near unexpected token `do'
debug_04.sh: line 7: `do'
```

The preceding program has a syntax error on line number 7. The word `do` has an error. We need to change word "do" to "done".

Summarizing the debugging options for the Bash shell

The following is a summary of various debugging options used for debugging, such as `-x`, `-v`, and `-n` with their details:

```
$ bash -n script_name  // interpretation without execution
$ bash -v script_name  // Display commands in script
$ bash -x script_name  // Trace the execution of script

$ bash -xv script_name    // Enable options x and v for debugging
$ bash  +xv script_name    //Disable options x and v for debugging
```

Using the set command

Most of the time, we invoke the debugging mode from the first line of script. This debugging mode will remain active until the last line of code. But many times, we may need to enable debugging for a particular section of script. By using the set command, we can enable and disable debugging at any point in our Shell script:

```
set -x
section of script
set +x
```

Consider the following script:

```
#!/bin/bash

str1="USA"
str2="Canada";

[ $str1 = $str2 ]
echo $?

Set –x

[ $str1 != $str2 ]
echo $?

[ -z $str1 ]
echo $?
```

```
Set +x

[ -n $str2 ]
echo $?

Exit 0
```

In this case, the debugging will be enabled after the set `-x` and will be disabled immediately after the set `+x`.

Summary of debugging options for set command

The following table summarises the various options for the `set` command:

Short notation	**Result**
set -f	Disables globbing. In this case, the file name expansions using wildcards or metacharacters will be disabled.
set -v	This will print the Shell script lines as they are read by the shell.
set -x	This option will display each line after the variable substitution and command expansion, but before execution by the shell. This option is often called shell tracing.
set -n	This reads all commands and checks the syntax, but does not execute them.

The vi editor setting for debugging

For general debugging, we can use the vi editor along with certain options.

During debugging, many times we search for a pattern throughout the complete document. It is preferable to highlight the searched item. We will enable search pattern highlighting by using the following command in the vi editor when the document is opened:

```
:set hlsearch     :set ic  vi –b filename
```

We can even modify the vi editor configuration file— `.exrc` or `.vimrc` so that we need not give the previous command again and again.

Good practices for Shell scripts

If we follow certain good practices, then we will face errors. Even if errors are found, these will be easier to debug:

1. Clear and tidy the script. Try to properly indent the programming constructs, such as if, for, while, and other similar loops:

   ```
   if [ $rate -lt 3 ]
   then
     echo "Sales tax rate is too small."
   fi
   ```

2. Do not put multiple commands on the same line by using *;*.
3. Use descriptive variable names, such as *salary*, instead of *sa*. In very complex Shell scripts, non-descriptive variable names will make debugging very difficult.
4. Store the file and directory names in variables instead of typing them again and again. If any change is required in the directory path, then making the change in the variable at one place will be sufficient:

   ```
   WORKING_DIR=$HOME/work
   if [ -e $WORKING_DIR]
   then
     # Do something....
   fi
   ```

5. Use comments for an easier understating of script. This will make debugging easier to others. If it contains tricky or complex commands, then even after few months, we will need comments to understand our own script. A cute little trick today may become a challenge tomorrow.
6. Print informative error messages. Write simpler scripts. Use simpler if, case, for, and or functions. It is practically observed that if scripts are simpler, then these scripts are easy to maintain over a long period of time, such as few years.
7. Test the script again and again with various test scenarios and test cases. Check for all the possibilities of human error, such as bad input, insufficient arguments, nonexistent files, and similar possibilities.

Summary

In this chapter, you learned about debugging, the here operator, interactive Shell scripts for taking input from the keyboard, and file handling.

In the next chapter, you will learn about arithmetic and various operations, such as addition, subtraction, multiplication, division, and the extraction of the modulus of numerical variables.

7

Performing Arithmetic Operations in Shell Scripts

In the last chapter, you learned about debugging, the `here` operator, interactive Shell scripts for taking input from the keyboard, and file handling.

In this chapter, we will cover the following arithmetic operations topics:

- Addition
- Subtraction
- Multiplication
- Division
- Modulus

We can perform arithmetic operations in various ways, such as using `declare`, `let`, `expr`, and arithmetic expressions. You will also learn about representing numbers in different bases, such as binary, octal, and hex.

Using a command declare for arithmetic

Whenever we declare any variable, by default, this variable stores the string type of data. We cannot do arithmetic operations on them. We can declare a variable as an integer by using the `declare` command. Such variables are declared as integers; if we try to assign a string to them, then bash assigns 0 in these variables.

Bash will report an error if we try to assign fractional values (floating points) to integer variables.

We can create an integer variable called `value`, shown as follows:

```
$ declare -i value
```

We tell the shell that the variable value is of type integer. Otherwise, shell treats all variables as character strings:

- If we try to assign the `name` string to the integer variable `value`, then the `value` variable will be assigned the `0` value by Bash shell:

  ```
  $ value=name
  $ echo $value
  0
  ```

- We need to enclose numbers between double quotes, otherwise we should not use space in arithmetic expressions:

  ```
  $ value=4 + 4
  bash: +: command not found
  ```

- When we remove white spaces, the error also gets removed, and the arithmetic operation takes place.

  ```
  $ value=4+4
  $ echo $value
  8
  ```

- We can perform a multiplication operation as follows:

  ```
  $ value=4*3
  $ echo $value
  12
  $ value="4 * 5"
  $ echo $value
  20
  ```

- Since we have enclosed numbers in `""`, the multiplication operation is performed. Due to double quotes (`""`), the `*` operator was not used as a wildcard (`*`):

  ```
  $ value=5.6
  ```

  ```
  bash: num: 5.6: syntax error in expression (remainder of
  expression is ".5").
  ```

Since we have declared the variable `value` as an integer variable, when we initialize the variable with a floating point number, the error gets displayed by Bash shell.

Listing integers

If we want to see all declared integer variables along with their values, then we must give the following command:

```
$ declare -i
```

Output:

```
declare -ir BASHPID=""
declare -ir EUID="1001"
declare -i HISTCMD=""
declare -i LINENO=""
declare -i MAILCHECK="60"
declare -i OPTIND="1"
declare -ir PPID="1966"
declare -i RANDOM=""
declare -ir UID="1001"
```

Using the let command for arithmetic

We can use the bash built-in command `let` for performing arithmetic operations. To get more information about `let`, type the following:

```
$ help let
```

Output:

```
student@ubuntu:~$ help let
let: let arg [arg ...]
    Evaluate arithmetic expressions.

    Evaluate each ARG as an arithmetic expression.  Evaluation is done in
    fixed-width integers with no check for overflow, though division by 0
    is trapped and flagged as an error.  The following list of operators is
    grouped into levels of equal-precedence operators.  The levels are listed
    in order of decreasing precedence.

        id++, id--      variable post-increment, post-decrement
        ++id, --id      variable pre-increment, pre-decrement
        -, +            unary minus, plus
        !, ~            logical and bitwise negation
        **              exponentiation
        *, /, %         multiplication, division, remainder
        +, -            addition, subtraction
        <<, >>          left and right bitwise shifts
        <=, >=, <, >    comparison
        ==, !=          equality, inequality
        &               bitwise AND
        ^               bitwise XOR
        |               bitwise OR
        &&              logical AND
        ||              logical OR
        expr ? expr : expr
                        conditional operator
        =, *=, /=, %=,
        +=, -=, <<=, >>=,
        &=, ^=, |=      assignment

    Shell variables are allowed as operands.  The name of the variable
    is replaced by its value (coerced to a fixed-width integer) within
    an expression.  The variable need not have its integer attribute
    turned on to be used in an expression.

    Operators are evaluated in order of precedence.  Sub-expressions in
    parentheses are evaluated first and may override the precedence
    rules above.

    Exit Status:
```

Let's start using the `let` command:

```
$ value=6
$ let value=value+1
$ echo $value
7
$ let "value=value+4"
$ echo $value
11
$ let "value+=1"
#above expression evaluates as value=value+1
$ echo $value
12
```

A summary of operators available with the `let` command follows:

- Operation: Operator
- Unary minus: –
- Unary plus: +
- Logical NOT:!
- Bitwise NOT (negation):~
- Multiply: *
- Divide: /
- Remainder: %
- Subtract: –
- Add:+

Prior to bash 2.x, the following operators were not available:

- Bitwise left shift: <<
- Bitwise right shift: >>
- Equal to and not equal to: ==, !=
- Comparison operators: <=,>=,<,>

- Bitwise AND: &
- Bitwise: |
- Bitwise exclusive OR: ^
- Logical AND: &&
- Logical OR: ||
- Assignment and shortcut assignment: = *=/= %= -= += >>= <<= &= |= ^=

Using the expr command for arithmetic

We can use the `expr` command for arithmetic operations. The `expr` command is an external command; the binary of the `expr` command is stored in the folder called `/usr/bin/expr`.

Perform an addition operation as follows:

```
$ expr 40 + 2
42
```

Perform a subtraction operation as follows:

```
$ expr 42 - 2
40
```

Perform a division operation as follows:

```
$ expr 40 / 10
4
```

Perform a modulus (getting remainder) operation as follows:

```
$ expr 42 % 10
2
$ expr 4 * 10
expr: syntax error
```

With the `expr` command, we cannot use `*` for multiplication. We need to use `\*` for multiplication:

```
$ expr "4 * 10"
4 * 10
$ expr 4 \* 10
40
```

We will write a simple script to add two numbers. Write the Shell script called `arithmetic_01.sh` as follows:

```
#!/bin/bash
x=5
y=2
z=`expr $x + $y`
echo $z
Test the script as follows:
$ chmod +x arithmetic_01.sh
$ ./arithmetic_01.sh
```

The output is here:

```
7
```

Let's write a script to perform all the basic arithmetic operations. Write the Shell script called `arithmetic_02.sh` as follows:

```
#!/bin/bash
var1=30
var2=20
echo `expr $var1 + $var2`  # Arithmetic Addition
echo `expr $var1 - $var2`  # Arithmetic Subtraction
echo `expr $var1 \* $var2` # Arithmetic Multiplication
echo `expr $var1 / $var2`  # Arithmetic Division
echo `expr $var1 % $var2`  # Arithmetic Modular Division
                           # (Remainder)
Let us test the script
$ chmod +x arithmetic_02.sh
$ ./arithmetic_02.sh
```

The output is here:

```
50
10
600
1
10
```

Using an arithmetic expansion

We can use two different ways for evaluating arithmetic expressions:

```
$(( expression ))
$[ expression ]
```

Learn arithmetic operations using the preceding mentioned arithmetic expansion:

```
$ a=10
$ b=20
$ c=$((a + b))
$ echo $c
```

During arithmetic operations, we may need to find square or cube of any given number. These operations are called as exponent operations. We can perform exponent operations as follows:

```
$ a=5
$ b=3
$ expo=$[ $a ** $b ]# This is equivalent to ab
$ echo $expo
125
```

This is the result of the 5^3 operations.

Another way of arithmetic expansions is as follows:

```
$ B=10
$ A=$[B + 10]
$ echo $A
20
$ echo $[ 3 + 4 - 5 ]
2

$ echo $[ 3 + 4 * 5]
23
```

Arithmetic multiplication has more precedence over addition. Therefore, `4*5` was performed first, and the addition of `3+20` was performed later on:

```
$ echo $[(3 + 4) * 5]
35

$ echo $(( 3 + 4 ))
7

$ echo $(( 6 / 0 ))
bash: 6/0: division by 0 ( error token is "0")
```

We will use many of the preceding arithmetic techniques for doing the same addition operation and check the result.

Let's write an interactive script called `arithmetic_03.sh` as follows:

```
#!/bin/bash
echo "Enter  first value"
read number_1
echo "Enter  secondvalue"
read number_2
total=`expr $number_1 + $number_2`
echo $total
sum=$(($number_1 + $number_2))
echo "sum is "$sum
echo "Sum is $[ $number_1+$number_2 ]"
```

Let us test the script

```
$ chmod +x arithmetic_03.sh
$ ./arithmetic_03.sh
```

Output

```
Enter  first value
10
Enter  second  value
5
15
Sum is 15
Sum is 15
```

The preceding Shell script shows that even if we use any of the previous techniques, the result remains the same.

Let's write the shell called script `arithmetic_04.sh` as follows:

```
#!/bin/bash
# Interactive Shell Script Demonstrating Arithmetic Operators
echo "Enter First value"
read number_1
echo "Enter Second value"
read number_2
echo $(($number_1 + $number_2))
echo $(($number_1 / $number_2)) # Division of two numbers
```

Let's test the program as follows:

```
$ chmod +x arithmetic_04.sh
$ ./arithmetic_04.sh
```

Output:

```
Enter First value
10
Enter Second value
5
15
2
```

We will write one more script with a different technique. Let's write the Shell script `arithmetic_05.sh` as follows:

```
#!/bin/bash
# Script is For Demonstrating Arithmetic
var1=10
var2=20
echo $(($var1+$var2))  # Adding Two Values
echo $(($var1-$var2))  # Subtract Two Values
echo $(($var1*$var2))  # Multiply Two Values
echo $(($var1%$var2))  # Remainder
```

Let's test the program here:

```
$ chmod +x arithmetic_05.sh
$ ./arithmetic_05.sh
```

Output:

```
30
-10
200
10
```

We will write a script to add five numbers that are passed from a command line. Let's write the Shell script `arithmetic_06.sh` as follows:

```
#!/bin/bash
# Write a shell script which will receive 5 numbers from command line
# and print their sum.
echo "Sum of Five Numbers is:" $(($1 + $2 + $3 + $4 + $5))
```

Let's test the program:

```
$ chmod +x arithmetic_06.sh
$ ./arithmetic_06.sh 10 20 30 40 50
```

Output:

```
Sum of Five Numbers is: 150
```

Let's write the Shell script `arithmetic_07.sh` as follows for finding cube, quotient, and remainder:

```
#!/bin/bash

x=99

(( cube = x * x * x ))
(( quotient = x / 5 ))
(( remainder = x % 5 ))

echo "The cube of $x is $cube."
echo "The quotient of $x divided by 5 is $quotient."
echo "The remainder of $x divided by 5 is $remainder."

# Note the use of parenthesis to controlling arithmetic operator
# precedence evaluation.
(( y = 2 * (quotient * 5 + remainder) ))
echo "Two times $x is $y."
```

Let's test the program:

```
$ chmod +x arithmetic_07.sh
$ ./arithmetic_07.sh
```

Output:

```
The cube of 99 is 970299.
The quotient of 99 divided by 5 is 19.
The remainder of 99 divided by 5 is 4.
Two times 99 is 198.
```

Binary, octal, and hex arithmetic operations

Integer values can be represented in decimal, binary, octal, or hex numeric notations. By default, integer values are represented in decimal notation. Binary numbers have base 2. Octal numbers use base 8. Hexadecimals numbers use base 16. We will learn about various notations with examples in this section.

Syntax:

```
variable=base#number-in-that-base
```

Let's understand the preceding syntax with examples:

- Decimal representation:

  ```
  $ declare -i x=21
  $ echo $x
  21
  ```

- Binary representation:

  ```
  $ x=2#10101
  $ echo $x
  21
  ```

- Octal representation:

  ```
  $ declare -i x
  $ x=8#25
  $ echo $x
  21
  ```

- Hexadecimal representation:

```
$ declare -i x
$ x=16#15
$ echo $x
21
```

In the preceding examples, we displayed the, decimal `21` value in binary, octal, and hexadecimal representations.

A floating-point arithmetic

In Bash shell, we can only perform integer arithmetic. If we want to perform arithmetic involving a floating point or fractional values, then we will need to use various other utilities, such as `awk`, `bc`, and similar.

Let's see an example of using the utility called `bc`:

```
$ echo "scale=2; 15 / 2" | bc
7.50
```

For using the `bc` utility, we need to configure a scale parameter. Scale is the number of significant digits to the right of the decimal point. We have told the `bc` utility to calculate `15 / 2`, and then display the result with the scale of `2`.

Or:

```
$ bc
((83.12 + 32.13) * 37.3)
4298.82
```

Many things can be done with the `bc` utility, such as all types of arithmetic operations including binary and unary operations; it has many defined mathematical functions. It has its own programming syntax.

You can get more information about the utility `bc` at `http://www.gnu.org/software/bc/`.

Let's look at using `awk` for a floating-point arithmetic:

```
$ result=`awk -v a=3.1 -v b=5.2 'BEGIN{printf "%.2f\n",a*b}'`
$ echo $result
16.12
```

You will be learning more about the `awk` programming in the coming chapters. Therefore, we will not get into a detailed discussion of `awk` in this session.

Let's write few more Shell scripts using arithmetic programming skill in shell, which we have learned so far.

Let's write the Bash Shell script `arithmetic_08.sh` to find whether an input integer is even or odd:

```
#!/bin/bash
echo "Please enter a value"
read x
y=`expr $x%2`
if test $y -eq 0
then
echo "Entered number is even"
else
echo "Entered number is odd"
fi
```

Let's test the program:

```
$ chmod +x arithmetic_08.sh
$ ./arithmetic_08.sh
```

Output:

```
$ ./hello.sh
"Enter a number"
5
"Number is odd"
$ ./hello.sh
"Enter a number"
6
"Number is even"
```

Let's write the script `arithmetic_09.sh` to find the length of an input string:

```
#!/bin/bash
echo "Please Enter the String:"
read str
len=`echo $str | wc -c`
let len=len-1
echo "length of string = $len"
```

Let's test the script:

```
$ chmod +x arithmetic_09.sh
$ ./arithmetic_09.sh
```

Output:

```
Enter String:
Hello World
length of string = 11
```

Let's write a script to calculate the area and circumference of a rectangle and circle.

Write the Shell script `arithmetic_10.sh` as follows:

```
#!/bin/bash
echo "Please enter the length, width and radius"
read length width radius
areaRectangle=`expr $length \* $width `
temp=`expr $length + $width `
perimeterRect=`expr 2 \* $temp`
areaCircle=`echo 3.14 \* $radius \* $radius | bc`
circumferenceCircle=`echo 2 \* 3.14 \* $radius | bc`
echo "Area of rectangle = $areaRectangle"
echo "Perimeter of Rectangle = $perimeterRect."
echo "Area of circle = $areaCircle."
echo "Circumference of circle = $circumferenceCircle"
echo
```

Let's test the program:

```
$ chmod +x arithmetic_10.sh
$ ./arithmetic_10.sh
```

Output:

```
Enter the length, width and radius
5 10 5
Area of rectangle = 50
Perimeter of Rectangle = 30
Area of circle = 78.50
Circumference of circle = 31.40
```

Summary

In this chapter, you learned about performing arithmetic operations in various ways such as, using `declare, let`, `expr`, and arithmetic expressions. You also learned about representing numbers in different bases such as hex, octal, and binary. You learned about using the `bc` utility to perform floating point or fractional arithmetic.

In the next chapter, you will learn about automatic decision making by working with test and using `if-else`, `case`, `select`, `for`, `while`, and `dowhile`. You will also learn to control loops using `break` and `continue` statements.

8
Automating Decision Making in Scripts

In the last chapter, you learned about performing arithmetic operations in various ways such as using declare, let, expr, and arithmetic expressions. You also learned about representing numbers in different bases such as hex, octal, and binary, and using the `bc` utility for performing floating point or fractional arithmetic.

In real-world scripts, it is not just a sequential execution of commands, we need to check certain conditions or proceed as per certain logic and accordingly the script should continue executing. This is precisely what we do with automation. Automation refers to performing tasks, the sequence of which will change as per changes in the programming environment. A simple example would be to check if the directory is present; if present, then change to that directory, otherwise create a new directory and proceed. All these activities come under decision making in Shell scripts.

In this chapter, we will cover the following topics:

- Working with `test`
- Using `if-else`
- Switching `case`
- Using `select`
- Working with the `for` loop
- Working with the `while` loop
- Controlling loops:
    - The `continue` statement
    - The `break` statement

Checking the exit status of commands

Automation using Shell scripts involves checking if the earlier command executed successfully or failed, if the file is present or not, and so on. You will learn various constructs such as `if`, `case`, and so on, where we will need to check whether certain conditions are true or false. Accordingly, our script should conditionally execute various commands.

Let's enter the following command:

```
$ ls
```

Using the Bash shell, we can check if the preceding command executed successfully or failed as follows:

```
$ echo $?
```

The preceding command will return 0, if the `ls` command executed successfully. The result will be nonzero, such as 1 or 2 or any other nonzero number, if the command has failed. The Bash shell stores the status of the last command execution in a variable. If we need to check the status of the last command execution, then we should check the content of the variable.

Let's see the following example:

```
$ x=10
$ y=20
$ (( x < y ))
$ echo $?
0
```

This indicates that the `$(( x < y ))` expression has executed successfully.

Let's learn the same concept in the case of string handling:

```
$ name=Ganesh
$ grep "$name"  /etc/passwd
 Ganesh:9ZAC5G:6283:40:Ganesh Naik:/home/ganesh:/bin/sh
$ echo $?
0
```

Since the user `Ganesh` is already created on the computer, the string `Ganesh` was found in the `/etc/passwd` file.

```
$ name=John
$ grep "$name" /etc/passwd
```

```
$ echo $?
1       # non zero values means error
```

Since the user `John` was not found in the `/etc/passwd` file, the `grep` command returned a nonzero value. In scripts, we can use this during automation.

Understanding the test command

Let's now understand the `test` command.

Using the test command with single brackets

Let's learn the following example to check the content or value of expressions:

```
$ test $name = Ganesh
$ echo $?
0 if success and 1 if failure.
```

In the preceding example, we want to check if the content of the variable name is the same as `Ganesh` and `?` To check this, we have used the `test` command. The `test` will store the result of the comparison in the `?` variable.

We can use the following syntax for the preceding `test` command. In this case, we used `[ ]` instead of the `test` command. We've enclosed the expression to be evaluated in square brackets:

```
$ [[ $name = Ganesh ]]      # Brackets replace the test command
$ echo $?
0
```

During the evaluation of expressions by `test`, we can even use wildcard expressions:

```
$ [[ $name = [Gg]????? ]]
$ echo $?
0
```

Therefore, we can either use the `test` command or square brackets for checking or evaluating expressions. Since word splitting will be performed on variables, if we are using text with white spaces, then we will need to enclose the text inside double quotes such as `" "`.

Using the test command with double brackets

Let's consider the case where we want to check whether there is the name `Ganesh` and if his friend is `John`. In this case, we will have multiple expressions to be checked using the `AND` operator `&&`. In such a case, we can use following syntax:

```
$ [[ $name == Ganesh && $friend == "John" ]]
```

Another way to do this is as follows:

```
[ $name == Ganesh ] && [ $friend == "John" ]
```

We used double brackets in the preceding expressions.

Here, we want to evaluate multiple expressions on the same command line. We can use the preceding syntax with `AND` (`&&`) or `OR` (||) logical operators.

String comparison options for the test command

The following is a summary of various options for string comparison using test which is taken from the Bash reference manual available at `http://www.gnu.org/software/bash/`:

Test operator	**Tests true if**
-n string	True if the length of string is nonzero.
-z string	True if the length of string is zero.
string1 != string2	True if the strings are not equal.
string1 == string2 string1 = string2	True if the strings are equal.
string1 > string2	True if string1 sorts after string2 lexicographically.
string1 < string2	True if string1 sorts before string2 lexicographically.

Suppose we want to check if the length of a string is nonzero, then we can check it as follows:

```
test -n $string      or      [ -n $string ]
echo $?
```

If the result is `0`, then we can conclude that the string length is nonzero. If the content of `?` is nonzero, then the string is 0 in length.

Let's write Shell script `test01.sh` for learning various string operations:

```
#!/bin/bash

str1="Ganesh";
str2="Mumbai";
str3=

[ $str1 = $str2 ] # Will Check Two Strings Are Equal Or Not
echo $?

[ $str1 != $str2 ] # Will Check Two Strings Are Not Equal
echo $?

[ -n $str1 ] # Will confirm string length is greater than zero
echo $?

[ -z $str3 ] # Will Confirm length of String is Zero
echo $?
```

Let's test the following program:

```
$ chmod +x test01.sh
$ ./test01.sh
```

The following will be the output after executing the preceding commands:

```
1
0
0
0
```

Let's write an interactive Shell script `test02.sh` to get names from the user and then compare if both are the same:

```
#!/bin/bash
echo "Enter First name"
read name1
echo "Enter Second name"
read name2
[ $name1 = $name2 ] # Check equality of two names
echo $?
[ -n  $name2 ] # Check String Length is greater than Zero
echo $?
```

Let's test the following program:

```
$ chmod +x test02.sh
$ ./test02.sh
```

The following will be the output after executing the preceding commands:

```
Enter First name
LEVANA
Enter Second name
TECHNOLOGIES
1
0
```

Numerical comparison operators for the test command

The following is the summary of various options for numerical comparison using test:

Test Operator	Tests True If
`[ integer_1 -eq integer_2 ]`	`integer_1` is equal to `integer_2`
`[integer_1 -ne integer_2 ]`	`integer_1` is not equal to `integer_2`
`[integer_1 -gt integer_2 ]`	`integer_1` is greater than `integer_2`
`[integer_1 -ge integer_2 ]`	`integer_1` is greater than or equal to `integer_2`
`[integer_1 -ge integer_2 ]`	`integer_1` is less than `integer_2`
`[integer_1 -le integer_2 ]`	`integer_1` is less than or equal to `integer_2`

Let's write the Shell script `test03.sh` for learning various the numerical test operators' usage:

```
#!/bin/bash

num1=10
num2=30

echo $(($num1 < $num2))   # compare for less than
[ $num1 -lt $num2 ]       # compare for less than
echo $?
```

```
[ $num1 -ne $num2 ]      # compare for not equal
echo $?
[ $num1 -eq $num2 ]      # compare for equal to
echo $?
```

Let's test the following program:

```
$ chmod +x test03.sh
$ ./test03.sh
```

The following will be the output after executing the preceding commands:

```
1
0
0
1
```

Let's write the script `test04.sh` for interactively asking the user for three numbers and then testing those numbers for various comparisons:

```
#!/bin/bash
echo "Please enter 1st First Number"
read num1
echo "Please enter 2nd Number"
read num2
echo "Please enter 3rd Number"
read num3
[[ $num1 > $num2 ]]  # compare for greater than
echo $?
[[ $num1 != $num2 ]] # compare for not equal to
echo $?
[[ $num2 == $num3 ]] # compare for equal to
echo $?
[[ $num1 && $num2 ]] # Logical And Operation
echo $?
[[ $num2 || $num3 ]] # Logical OR Operation
echo $?
```

Let's test the following program:

```
$ chmod +x test04.sh
$ ./test04.sh
```

The following will be the output after executing the preceding commands:

```
Please enter 1st First Number
10
Please enter 2nd Number
20
Please enter 3rd Number
30
1
0
1
0
0
```

Let's write the script `test05.sh` for using string and numerical test operations:

```
#!/bin/bash
Var1=20
Var2=30
Str1="Accenture"
FileName="TestStringOperator"

test $Var1 -lt $Var2  # Test for Less Than
echo $?
test $Var1 -gt $Var2  # Test For Greater Than
echo $?
test -n $Str1         # Test for String Having Length Greater Than 0
echo $?
test -f $FileName     # Test for File Attributes
echo $?
```

Let's test the following program:

```
$ chmod +x test05.sh
$ ./test05.sh
```

The following will be the output after executing the preceding commands:

```
0
1
0
1
```

We used the test operation for the file in this script. It will check if the file is present. You will learn more about it in next section.

Now, we will write the script `test06.sh` using the test command interactively asking the user for data and then performing numerical as well as string comparison operations:

```
#!/bin/bash
echo "Please enter 1st Number"
read num1
echo "Please enter 2nd Number"
read num2
echo
test $num1 -eq $num2    # Test for Equal
echo $?
test $num1 -ne $num2    # Test for Not Equal
echo $?
test $num1 -ge $num2    # Test for Greater Than Equal
echo $?

echo "Please enter 1st String"
read Str1
echo "Please enter 2nd String"
read Str2

test $Str1 = $Str2    # Test for Two Strings Are Equal
echo $?
test -z $Str1        # Test for The Length Of The String Is > 0
echo $?
test $Str2        # Test for The String Is Not NULL
echo $?
```

Let's test the following program:

```
$ chmod +x test06.sh
$ ./test06.sh
```

The following will be the output after executing the preceding commands:

```
Please enter 1st Number
10
Please enter 2nd Number
20
1
```

```
0
1
Please enter 1st String
LEVANA
Please enter 2nd String
TECHNOLOGIES
1
1
0
```

Depending on the value of `$?` in the preceding output, we can decide whether the operation returned `true` or `false`. We will use this in `if`, `case`, and similar decision making, as well as in looping, activities.

File test options for the test command

The following are the various options for file handling operations using the test command:

Test Operator	Tests True If
`-b file_name`	Check if file is Block special file
`-c file_name`	Check if file is Character special file
`-d file_name`	Check if Directory is existing
`-e file_name`	Check if File existence
`-f file_name`	Check if file is Regular file and not a directory
`-G file_name`	Check if file is existing and is owned by the effective group ID
`-g file_name`	Check if file has Set-group-ID set
`-k file_name`	Check if file has Sticky bit set
`-L file_name`	Check if file is a symbolic link
`-p file_name`	Check if file is a named pipe
`-O file_name`	Check if file exists and is owned by the effective user ID
`-r file_name`	Check if file is readable
`-S file_name`	Check if file is a socket
`-s file_name`	Check if file has nonzero size
`-t fd`	Check if file has `fd` (file descriptor) and is opened on a terminal
`-u file_name`	Check if file has Set-user-ID bit set
`-w file_name`	Check if file is writable
`-x file_name`	Check if file is executable

File testing binary operators

The following are various options for binary file operations using test which is taken from the Bash reference manual available at `http://www.gnu.org/software/bash/`:

Test Operator	Tests True If
`[ file_1 -nt file_2 ]`	Check if file is newer than `file2`
`[ file_1 -ot file_2 ]`	Check if file is `file1` is older than `file2`
`[ file_1 -ef file_2 ]`	Check if `file1` and `file2` have the same device or inode numbers

Let's write the script `test07.sh` to test the basic file attributes such as whether it is a file or folder and whether it has a file size bigger than 0. The output will be different if the case file is present or not:

```
#!/bin/bash
# Check if file is Directory
[ -d work ]
echo $?
# Check that is it a File
[ -f test.txt ]
echo $?
# Check if File has size greater than 0
[ -s test.txt ]
echo $?
```

Let us test the program:

```
$ chmod +x test07.sh
$ ./test07.sh
```

The following will be the output after executing the preceding commands:

```
1
1
1
$ mkdir work
$ touch test.txt
$ ./test07.sh
0
0
1
```

We executed the script with and without the directory and `text.txt` file.

The following script `test08.sh` is checking the file permissions such as read, write, and execute permissions:

```
#!/bin/bash
# Check if File has Read Permission
[ -r File2 ]
echo $?
# Check if File Has Write Permission
[ -w File2 ]
echo $?
# Check if File Has Execute Permission
[ -x File2 ]
echo $?
```

Let's test the program:

```
$ touch File2
$ ls -l File2
-rw-rw-r-- 1 student student    0 Jun 23 22:37 File2
$ chmod +x test08.sh
$ ./test08.sh
```

The following will be the output after executing the preceding commands:

```
0
0
1
```

Logical test operators

The following are the various options for logical operations using test which is taken from the Bash reference manual available at `http://www.gnu.org/software/bash/`:

Test Operator	Tests True If
`[ string_1 -a string_1 ]`	Both `string_1` and `string_2` are true
`[ string_1 -o string_2 ]`	Either `string_1` or `string_2` is true
`[ ! string_1 ]`	Not a `string_1` match
`[[ pattern_1 && pattern_2 ]]`	Both `pattern_1` and `pattern_2` are true
`[[ pattern_1 || pattern_2 ]]`	Either `pattern_1` or `pattern_2` is true
`[[ ! pattern ]]`	Not a `pattern` match

We can use the test operator for strings along with pattern matching as follows:

```
$ name=Ganesh
$ [[ $name == [Gg]anesh ]]      # Wildcards allowed
$ echo $?
0
```

The following is the example for multiple strings with the `&&` logical operator:

```
$ name=Ganesh; friend=Anil
$ [[ $name == [Gg]anesh && $friend == "Lydia" ]]
$ echo $?
1
```

The following is the script with the test command along with the extended pattern matching enabled:

```
$ shopt -s extglob     # we are enabling extended pattern matching
$ city=Kannur
$ [[ $city == [Kk]a+(n)ur ]]
$ echo $?
0
```

In the given expressions, we are checking equality for strings. It tests if the city name starts with `K` or `k`, followed by `a`, one or more `n` characters, a `u`, and `r`.

Conditional constructs – if else

We use the `if` command to check the pattern or command status and accordingly we can make certain decisions to execute scripts or commands.

The syntax of the `if` conditional is as follows:

```
if     command
then
    command
    command
fi
```

From the preceding syntax, we can clearly understand the working of the `if` conditional construct. Initially, `if` will execute the command. If the result of command execution is true or 0, then all the commands that are enclosed between `then` and `fi` will be executed. If the status of command execution after `if` is false or nonzero, then all the commands after `then` will be ignored and the control of execution will directly go to `fi`.

Let's learn another variation of `if` constructs.

Syntax:

```
if command
then
     command
    command
else
    command
fi
```

In the preceding case if the command after `if` is successfully executed or the status variable `?` content is 0, then all the commands after `then` will be executed. If the result of the command is a failure or nonzero, then all the commands after `else` will be executed.

For numeric or string expression evaluations using `if`, the syntax is as follows:

```
if [ string/numeric expression ]
then
    command
fi
```

Alternatively, use the following syntax:

```
if [[ string expression ]]
then
    command
fi
```

Alternatively, use the following syntax:

```
if (( numeric expression ))
then
    command
fi
```

The simple example to check the status of the last command executed using the `if` construct is as follows:

```
#!/bin/bash
if [ $? -eq 0 ]
then
        echo "Command was successful."
else
        echo "Command was successful."
fi
```

Whenever we run any command, the exit status of command will be stored in the `?` variable. The preceding construct will be very useful in checking the status of the last command.

Numerical handling if constructs

Let's learn about using the `if` construct for numerical decision making.

We can use the `test` command for finding which variable contains the smaller value:

```
$ X=10
$ y=20
$ (( x < y ))
$ echo $?
0
The result 0 shows that x is smaller than y.
```

In the Shell script `if_01.sh`, we can use the `test` command along with the `if` construct for checking equality of variable with numerical value as follows:

```
#!/bin/bash
a=100
if [ $a -eq 100 ]
then
    echo "a is equal to $a"
else
        echo "a is not equal"
fi
```

Let's test the following program:

`$ chmod +x if_01.sh`

`$ ./if_01.sh`

The following will be the output after executing the preceding commands:

`a is equal to 100`

Use the script `if_02.sh` to check which product is costly. The script is as follows:

```
#!/bin/bash
echo "Enter the cost of product a"
read a
echo "Enter the cost of product b"
read b
```

```
if [ $a -gt $b ]
then
 echo " a is greater"
else
 echo " b is greater"
fi
```

Let's test the following program:

```
$ chmod +x if_02.sh
$ ./if_02.sh
```

The following will be the output after executing the preceding commands:

```
Enter the cost of product a
100
Enter the cost of product b
150
 b is greater
$
```

Using the command exit and the ? variable

If we need to terminate the Shell script and come back to command line, then we can use the exit command. The syntax is very simple:

```
exit 0
```

The given command will terminate the Shell script and return to the command line. It will store the 0 value in the status variable `?`. We can use any value between 0 and 255. Value 0 means success and any other nonzero value means an error. We can use these values to indicate error information.

The script to check the value of a parameter, which is passed along with command, either less than 0 or greater than 30 is as follows. This will save our efforts of using the nested `if` statement:

```
#!/bin/bash
if (( $1 <  0 || $1 > 30 ))
    then
        echo "mdays is out of range"
        exit 2
fi
```

The `test` command used in the preceding expression for `OR` can be written as follows:

```
[ $1 -lt 0 -o $1 -gt 30 ]
```

String handling with the if construct

Let's learn about using string-related checking using the `if` command.

The following script `if_03.sh` will check the equality of two strings:

```
echo "Enter the first string to compare"
read name1
echo "Enter the Second string to compare"
read name2

if [ $name1 == $name2 ]

then

    echo "First string is equal to Second string"

else

    echo "Strings are not same"

fi
```

Let's test the following program:

```
$ chmod +x if_03.sh
$ ./if_03.sh
```

The following will be the output after executing the preceding commands:

```
$ ./ if_03.sh
Enter the first string to compare
LEVANA
Enter the Second string to compare
TECHNOLOGIES
Strings are not same
$ ./ if_03.sh
```

The following will be the output after executing the preceding commands:

```
Enter the first string to compare
LEVANA
Enter the Second string to compare
LEVANA
First string is equal to Second string
$
```

We will write the script for performing various other string operations using a test. Let's write the script `if_04.sh` to compare two strings for various attributes:

```
#!/bin/bash

str1="Ganesh"
str2="Naik"

if [ $str1 = $str2 ]
then
    echo "Two Strings Are Equal"
fi

if [ $str1 != $str2 ]
then
    echo "Two Strings are not equal"
fi

if [ $str1 ]
then
    echo "String One Has Size Greater Than Zero"
fi

if [ $str2 ]
then
    echo "String Two Has Size Greater Than Zero"
fi
```

Let's test the following program:

```
$ chmod +x if_04.sh
$ ./if_04.sh
```

The following will be the output after executing the preceding commands:

```
Two Strings are not equal
String One Has Size Greater Than Zero
String Two Has Size Greater Than Zero
```

If we want to verify whether the entered password is valid then script `i_05.sh` will be as follows:

```
#!/bin/bash
stty -echo        # password will not be printed on screen
read -p "Please enter a password  :" password
if test "$password" == "Abrakadabra"
```

```
then
echo "Password is matching"
fi
stty echo
```

Let's test the following program:

```
$ chmod +x if_05.sh
$ ./if_05.sh
```

The following will be the output after executing the preceding commands:

```
$ ./ if_05.sh
Please enter a password  :  levana
$ ./ if_05.sh
Please enter a password  : Abrakadabra
Password is matching
$
```

Checking for null values

Many a time we need to check the value of variable, such as is it null? The null value means zero value. If we want to create the string with the null value, then we should use double quotes `""` while declaring it:

```
if [ "$string" = "" ]
then
echo "The string is null"
fi
```

We can even use `[ ! "$string" ]` or `[ -z "$string" ]` for null checking of strings.

Let's write the script `if_08.sh`, which will search if the entered person name is the user of the computer system:

```
#!/bin/bash
read -p "Enter a user name : " user_name

# try to locate username in in /etc/passwd
#
grep "^$user_name" /etc/passwd > /dev/null

status=$?

if test $status -eq 0
```

```
then
    echo "User '$user_name' is found in /etc/passwd."
else
    echo "User '$user_name' is not found in /etc/passwd."
fi
```

Let's test the following program:

```
$ chmod +x if_08.sh
$ ./if_08.sh
```

The following will be the output after executing the preceding commands:

```
Enter a user name : ganesh
User 'ganesh' is not found in /etc/passwd.
```

In the preceding script, we are searching the username in the `/etc/passwd` file. If a person's name is not found in the `/etc/passwd` file, then we can conclude that the username is not created in the system.

Let's write a script to check the disk space being used. The script will print a warning if 90 percent or more of the disk space is used on one of the mounted partitions.

The Shell script `if_09.sh` for solving the disk filesystem usage warning will be as follows:

```
#!/bin/bash
df -h | grep /dev/sda1 | cut -c 35-36 > log.txt
read usage < log.txt
if [ $usage -gt 80 ]
then
    echo "Warning - Disk file system has exceeded 80% !"
    echo "Please move extra data to backup device.
else
    echo "Good - You have enough disk space to continue working !"
fi
```

Let's test the following program:

```
$ chmod +x if_09.sh
$ ./if_0.sh
```

Due to some hardware differences, if the preceding program does not work, then make the following changes in the script:

1. Check if your partition of storage is sda1, sda2, or any other by entering the `$df -h` command.
2. Check if the % disk utilization value is at character count 35 and 36, if different then make changes in the code accordingly.

Using the `df` command, we get the disk filesystem usage information. The `grep` command is filtering the hard disk partition, which contains our data. Then, we filter the disc % utilization number and store that value in the `log.txt` file. Using the read command, we read the % utilization and store it in the variable usage. Later on using the `if` command, we check and warn the user if the % utilization is greater than 80.

File handling with the if command

You have already learned about how to use the `test` command for checking various file operations such as checking the file's permissions and similar other attributes. A command's task in any script is to check if the file or folder is present or not. Then accordingly, we need to proceed. We will see how to use the `if` command along with the `test` command.

Use the simple script `if_10.sh` to check if the file exists or not in the current directory as follows:

```
#!/bin/bash
read filename
if test -e $filename
then
    echo "file exists"
else
    echo " file does not exist"
fi
```

Let's test the program as follows:

```
$ chmod +x if_10.sh
$ ./if_10.sh
```

The following will be the output after executing the preceding commands:

```
sample.txt
file does not exist
$ touch sample.txt
$ ./ if_10.sh
sample.txt
file exists
```

First, we checked without the file. Then, we created a file with the `touch` command. We can very easily check the presence of the file.

Let's learn how to use the `if` command to check various file attributes, such as whether it exists, does it have file permissions to read, write, executable, and similar by writing script `if_11.sh` as follows:

```
#!/bin/bash
echo "$1 is: "
if ! [ -e $1 ]
then
  echo "..Do not exists"
  exit
else
  echo "file is present"
fi

if [ -x $1 ]
then
  echo "..Executable"
fi

if [ -r $1 ]
then
  echo "..Readable"
fi

if [ -w $1 ]
then
  echo "..Writable"
fi
```

Let's test the following program:

```
$ chmod +x if_11.sh
$ ./if_11.sh
```

Output:

```
sample.txt is:
"file is present"
..Readable
..Writable
```

The Shell script `if_12.sh` for performing the file copy operation, and then checking if the copy operation was successful or not, will be as follows:

```
#!/bin/bash
file1="File1"
file2="File2"
if cp $file1 $file2
then
  echo "Copy Command Executed Successfully"
  echo "Content of file named Fil1 copied in another file named File2"
else
  echo "Some problem in command execution"
fi
```

Let's test the program:

```
$ chmod +x if_12.sh
$ ./if_12.sh
```

The following will be the output after executing the preceding commands:

```
$ touch File1
$ ./ if_12.sh
Copy Command Executed Successfully
Content of file named Fil1 copied in another file named File2
```

Multiple test commands and if constructs

These type of constructs enable us to execute the second command depending on the success or failure of the first command:

```
command1    &&    command2
command1    ||    command2
```

Let's write script `if_13.sh`. In this script, we will ask the user to input two numbers. Then, the `if` statement will evaluate two expressions. If both are true, then the command after `then` will be executed, otherwise commands after `else` will be called:

```
#!/bin/bash
echo "Enter the first number"
read val_a
echo "Enter the Second number"
read val_b

if [ $val_a == 1 ] && [ $val_b == 10 ]
then
  echo "testing is successful"
else
  echo "testing is not successful"
fi
```

Let's test the program:

```
$ chmod +x if_13.sh
$ ./if_13.sh
```

The following will be the output after executing the preceding commands:

```
Enter the first number
10
Enter the Second number
20
testing is not successful

$ ./if_13.sh
Enter the first number
1
Enter the Second number
10
testing is successful
```

Sometimes, we may need to enter a command to check if the file has the execute permission? If it is executable, then the file should be executed. The script for such a requirement will be as follows:

```
test -e file &&  .  file.
```

Let's learn one more example of `&&` and multiple expressions using the `test` command. In the next script `if_14.sh`, we will check if `file_one` is present, then we will print `Hello` and then immediately we will check if `file_two` is present, then we will print `there` on the screen:

```
#!/bin/bash

touch file_one
touch file_two

if [ -f "file_one" ] && echo "Hello" && [ -f file_two ] && echo
"there"
then
  echo  "in if"
else
  echo    "in else"
fi
exit 0
```

Let's test the program:

```
$ chmod +x if_14.sh.sh
$ ./if_14.sh
```

The following will be the output after executing the preceding commands:

```
Hello
there
in if
```

The following script `if_15.sh` will check file permissions such as read, write, and execute in the same `if` command using multiple `&&` with the `test` command:

```
#!/bin/bash
echo "Please enter file name for checking file permissions"
read file
if [[ -r $file && -w $file && -x $file ]]
then
     echo "The file has read, write, and execute permission"
fi
```

Let's test the program:

```
$ chmod +x if_15.sh
$ touch sample.txt
$ chmod +rwx sample.txt
$ ./if_15.sh
```

The following will be the output after executing the preceding commands:

```
The file has read, write, and execute permissions.
```

Till now, we have seen multiple expressions using the `&&` logical operator. Now we will see one example with the `OR` (`||`) logical operator. In the following script `if_16.sh`, we will check the existence of `file_one` and then we will print `Hello` on the screen. If the first expression of file checking fails, then the second expression of `echo` will be executed:

```
#!/bin/sh
if [ -f file_one ] || echo "Hello"
then
    echo "In if"
else
    echo "In else"
fi
```

Let's test the program:

```
$ chmod +x if_16.sh
$ ./if_16.sh
```

The following will be the output after executing the preceding commands:

```
hello
In if
$ touch file_one
$ ./if_16.sh
```

Output:

```
In if
```

We checked in the preceding script if `file_one` is absent or present.

The if/elif/else command

Whenever we need to take decision from multiple situations or options such as whether it a city is the capital of a country, the state capital, a major city, or a small town. In such situations where, depending on various options, we need to execute different commands, `if/else` or `if/elif/else` decision-making commands are useful.

Using the `if/elif/else` commands, we can have multiple decision-making processes. If the `if` command succeeds, the command after `then` will be executed. If it fails, the command after the `elif` statement will be tested. If that statement succeeds, then statements under the `elif` are executed. However, suppose none of the `elif` conditions are true, then statements after the `else` command are executed. Here, the `else` block is executed by default. The `fi` statement will close the `if/elif/else` command.

The syntax of decision making using the `if elif` construct is as follows:

```
If    expression_1
then
    Command

elif
     expression_2
then
    Command

elif
    expression_3
then
    Command

else
  Command

fi
```

Let's write script `if_18.sh` as follows. In this script, we are checking if the directory with a given name exists or not. If this fails, then we are checking whether the file with the given name exists. Even if this fails, then we will inform the user that neither the file nor the directory exists with the given name:

```
#!/bin/bash
echo "Kindly enter name of directory : "
read file

if [[ -d $file ]]
then
        echo "$file is a directory"
elif [[ -f $file ]]
    then
    echo "$file is a file."
 else
       echo "$file is neither a file nor a directory. "
fi
```

Let's test the program:

```
$ chmod +x if_18.sh
$ ./is_18.sh
```

The following will be the output after executing the preceding commands:

```
$ ./ if_18.sh
Kindly enter name of directory :
File1
File1 is a file.

$ mkdir dir1

$ ./ if_18.sh
Kindly enter name of directory :
dir1
dir1 is a directory

$ ./ if_18.sh
Kindly enter name of directory :
File007
File007 is neither a file nor a directory.
```

The null command

In many situations, we may need a command that does nothing and returns a success status such as 0. In such cases, we can use the `null` command. It is represented by a colon (`:`). For example, in the `if` loop, we do not want to put any command if it is successful, but we have certain commands to execute if it fails. In such situations, we can use the `null` command. This is illustrated in the following `if_19.sh` script. If we want to loop forever, then the `null` command can be used in the `for` loop:

```
#!/bin/bash
city=London
if grep "$city" city_database_file >& /dev/null
then
      :
else
      echo "City is not found in city_database_file "
      exit 1
fi
```

Let's test the program:

```
$ chmod +x if_19.sh
$ ./if_19.sh
```

The following will be the output after executing the preceding commands:

```
City is not found in city_database_file
```

We can observe from the preceding script that the colon is a `null` command and it does nothing.

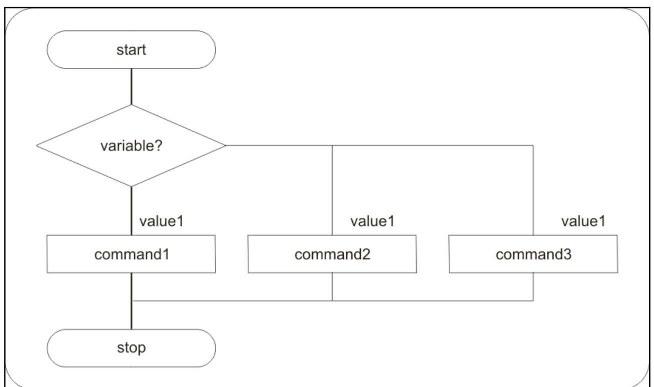
Switching case

Apart from simple branches with `if`, it is also possible to process multiple decision-making operations using the `case` command. In a `case` statement, the expression contained in a variable is compared with a number of expressions, and for each expression matched, a command is executed.

It is possible to have multiple branching using the `if/elif/else` commands. But if more than two or three `elif` commands are used, then code becomes very complex. When all the different conditions are depending on a single variable, in such `cases`, the `esac` statement is used. The interpreter checks the value of the `case` variable against `value1`, `value2`, `value3`, and so on, till the match is found. If the value is matched then all the statements after that `case` value are executed till the double semicolon is reached. If nothing is matched then statements after `esac` are executed. Wildcard characters and pipe (vertical bar for *ORing* two values) are allowed in the `case` statement.

A `case` statement has the following structure:

```
case variable in
  value1)
    command(s)
    ;;
  value2)
    command(s)
    ;;
  *)
    command(s)
          ;;
esac
```



Multiple Branching with `case`

For illustrating the switch `case` scripting example, we will write the `case_01.sh` script as follows. We will ask the user to enter any number from the range 1–9. We will check the entered number with the `case` command. If a user enters any other number, then we will display the error by displaying the `Invalid key` message:

```
#!/bin/bash

echo "Please enter any number from 1 to 9"
read number

case $number in
  1) echo "ONE"
    ;;
  2) echo "TWO"
    ;;
  3) echo "Three"
    ;;
```

```
    4) echo "FOUR"
        ;;
    5) echo "FIVE"
      ;;
    6) echo "SIX"
      ;;
    7) echo "SEVEN"
      ;;
    8) echo "EIGHT"
      ;;
    9) echo "NINE"
      ;;
    *) echo "SOME ANOTHER NUMBER"
      ;;
  esac
```

Let's test the program:

```
$ chmod +x case_01.sh
$ ./case_01.sh
```

The following will be the output after executing the preceding commands:

```
Please enter any number from 1 to 9
5
FIVE
```

Sometimes, in the Shell script we may need to ask for an e-mail address from the user. In such situations, we need to verify if the address is correct or not. We can use the `case` command to validate the correct e-mail address as follows:

```
#!/bin/bash
case $1  in

*@*.com)   echo "valid email address"

    ;;

*)    echo "invalid string"

    ;;

esac
```

Let's test the program:

```
$ chmod +x case_02..sh
$ ./ case_02.sh   abc@gmail.com
```

The following will be the output after executing the preceding commands, if the e-mail address is correct:

```
valid email address
$ ./ case_02.sh abc.com
```

The following will be the output after executing the preceding commands, if the e-mail address is not correct:

```
invalid string
```

If inside the script, we need to provide file operations such as copy, move, or delete, then we can use the `case` command for such scripts. The script `case_03.sh` for file operations is as follows:

```
#!/bin/bash
echo "Press 1 for copy or 2 for move or 3 for removing the file"
read num
case $num in
1)  echo "We are going to do copy operation"
echo " Enter Source file name"
read source
echo " Enter destination file name"
read destination
cp $source $destination
;;
2)   echo "We are going to do move operation"
echo " Enter Source file name"
read source
echo "Enter destination file name"
read destination
mv $source $destination   ;;
3)   echo "We are going to remove the file"
echo " Enter the name of file to remove"
read source
rm $source   ;;
*) echo "invalid key"
esac
```

Let's test the program:

```
$ chmod +x case_03.sh
$ ./case_03.sh
```

The following will be the output after executing the preceding commands:

```
Press 1 for copy or 2 for move or 3 for removing the file
1
We are going to do copy operation
 Enter Source file name
File1
 Enter destination file name
File4
```

In this Shell script `case_04.sh`, we will ask the user to enter the day of the week. Inside the script, we will detect the text entered and print a detailed description of the day such as `First Day is Monday` and similar on the screen. Note that we are able to perform pattern matching for the upper case and lower case in the `case` statement:

```
#!/bin/bash
echo "Enter Day Of The Week"
read day

case $day in
  [mM][oO][nN][dD][aA][yY])
        echo "First Day is Monday"
        ;;
  [tT][uU][eE][sS][dD][aA][yY])
        echo "Second Day Tuesday"
        ;;
  [wW][eE][dD][nN][eE][sS][dD][aA][yY])
        echo "Third Day Wednesday"
        ;;
  [tT][hH][uU][rR][sS][dD][aA][yY])
        echo " Fourth Day Thursday"
        ;;
  [fF][rR][iI][dD][aA][yY])
        echo "Fifth Day Friday"
        ;;
  [sS][aA][tT][uU][rR][dD][aA][yY])
        echo "Sixth Day Saturday"
        ;;
  [sS][uU][nN][dD][aA][yY])
        echo "Seventh Day Sunday"
        ;;
  *)
    echo "Invalid Day of Week"
    ;;
   esac
```

Let's test the program:

```
$ chmod +x case_04.sh
$ ./case_04.sh
```

The following will be the output after executing the preceding commands:

```
$ ./ case_04.sh
Enter Day Of The Week
Monday
First Day is Monday

$ ./ case_04.sh
Enter Day Of The Week
Thursday
Fourth Day Thursday
```

We write the script `case_05.sh` for printing days in the current month. We will use the `date` command in the script for finding the current month:

```
#!/bin/bash
mth=$(date +%m)

case $mth in
02)
  echo "February usually has 28 days."
  echo "If it is a leap year, it has 29 days."
  ;;

04|06|09|11)
  echo "The current month has 30 days."
  ;;

*)
  echo "The current month has 31 days."
  ;;
 esac
```

Let's test the program:

```
$ chmod +x case_05.sh
$ ./case_05.sh
```

The following will be the output after executing the preceding commands:

```
The current month has 30 days.
```

Implementing simple menus with select

With the Bash shell, it is possible to create simple menus with the help of the `select` built-in command.

The syntax of select is as follows:

```
PS3=prompting-text
select VARIABLE in item1 item2 item3
do
  commands
done
```

The advantage of a menu with `select` is that we can have an endless loop with it. We can have a condition in which we exit the loop.

In the following script `select_01.sh`, we show the menu with five options such as `a`, `bc`, `def`, `ghi`, and `jkl`. The script will execute the command inside `do` and `done`:

```
#!/bin/bash
select var1 in a  bc   def    ghi   jkl
do
echo "Present value of var1 is $var1
done
```

Let's test the program:

```
$ chmod +x select_01.sh
$ ./select_01.sh
```

The following will be the output after executing the preceding commands:

```
1) a
2) bc
3) def
4) ghi
5) jkl
#? 2
"Present value of var1 is bc
#? 4
```

```
"Present value of var1 is ghi
#? 5
"Present value of var1 is jkl
#?
Press     ^C    to quit
```

We can implement the `case` command inside the `do` and `done` part of the `select` menu. The syntax will be as follows:

```
PS3=prompting text
select   VARIABLE in  item1  item2 item3
do
  case VARIABLE in
  value1 ) command1 ; ;
  value2 ) command2 ; ;
esac
done
```

In the following script `select_02.sh`, we used the `case` command inside `do` and `done`. This gives us many convenient features. Due to select, we get endless such as continuous loop. In case the `if` option entered is quit, then it exits the continuous loop:

```
#!/bin/bash
PS3="please  select any one : "
select var in a b quit
do
case $var in
  a) echo option is a ;;
  b) echo option is b ;;
  quit) exit ;;
  *) echo option is default ;;
esac
done
```

Let's test the program:

```
$ chmod +x select_02.sh
$ ./select_02.sh
```

The following will be the output after executing the preceding commands:

```
1) a
2) b
3) quit
```

```
please  select any one : 1
option is a
please  select any one : 2
option is b
please  select any one : 3
```

In the following script `select_03.sh`, we used a case with numerical options 1, 2, 3, 4, and an option for an invalid choice:

```
#!/bin/bash
PS3="Please enter one of the option"
select var in 1 2 3 4
do
case $var in
    1) echo "One is selected";;
    2) echo "Two is selected;;
    3) echo "Two is selected;;
    4) echo "Two is selected;;
    *) echo "not a proper option";;
esac
done
```

Let's test the program:

```
$ chmod +x select_03.sh
$ ./select_03.sh
```

The following will be the output after executing the preceding commands:

```
1) 1
2) 2
3) 3
4) 4
Please enter one of the option : 1
"One is selected"
Please enter one of the option : 2
"Two is selected
Please enter one of the option : 3
"Two is selected
Please enter one of the option : 4
"Two is selected
```

Please enter one of the option : 8

"not a proper option"

Please enter one of the option :

In the case statement, we can put many choices to `select` the same command. Here is an example of the script `select_04.sh` as follows:

```
#!/bin/bash
PS3="Please select one of the above:"
select COMPONENT in comp1 comp2 comp3 all none
do
case $COMPONENT in
comp1|comp2|comp3) echo "comp1 or comp2 or comp3 selected" ;;
all) echo "selected all"
;;
none) break ;;
*) echo "ERROR: Invalid selection, $REPLY." ;;
esac
done
```

Let's test the program:

```
$ chmod +x select_04.sh
$ ./select_04.sh
```

The following will be the output after executing the preceding commands:

```
1) comp1
2) comp2
3) comp3
4) all
5) none
Please select one of the above:
```

The script `select_05.sh` is used to inform the user about the calorie information in fruits as follows:

```
#!/bin/bash
PS3="Enter the number for your fruit choice: "

select fruit in apple orange banana peach pear "Quit Menu"
do
  case $fruit in
    apple)
```

```
        echo "An apple has 80 calories."
        ;;

      orange)
        echo "An orange has 65 calories."
        ;;

      banana)
        echo "A banana has 100 calories."
        ;;

      peach)
        echo "A peach has 38 calories."
        ;;

      pear)
        echo "A pear has 100 calories."
        ;;

      "Quit Menu")
        break
        ;;

      *)
        echo "You did not enter a correct choice."
        ;;
    esac
  done
```

Let's test the program:

```
$ chmod +x select_05.sh
$ ./select_05.sh
```

The following will be the output after executing the preceding commands:

```
1) apple      3) banana      5) pear
2) orange     4) peach      6) Quit Menu
Enter the number for your fruit choice: 1
An apple has 80 calories.
Enter the number for your fruit choice: 2
An orange has 65 calories.
Enter the number for your fruit choice: 3
A banana has 100 calories.
```

```
Enter the number for your fruit choice: 4
A peach has 38 calories.
Enter the number for your fruit choice: 5
A pear has 100 calories.
Enter the number for your fruit choice: 6
```

Looping with the for command

For iterative operations, the `bash` shell uses three types of loops: `for`, `while`, and `until`. Using the `for` looping command, we can execute a set of commands for a finite number of times for every item in a list. In the `for` loop command, the user-defined variable is specified. After the `in` command, the keyword list of values can be specified. The user-defined variable will get the value from that list and all statements between `do` and `done` get executed until it reaches the end of the list.

The purpose of the `for` loop is to process a list of elements. It has the following syntax:

```
for variable in element1 element2 element3
do
commands
done
```

The simple script with the `for` loop could be as follows:

```
for command in clear date cal
do
  sleep 1
  $command
Done
```

In the preceding script, the commands `clear`, `date`, and `cal` will be called one after another. The sleep command will be called before every command for a second.

If we need to loop continuously or infinitely, then the following is the syntax:

```
for ((;;))
do
    command
done
```

Let's write a simple script for_01.sh. In this script, we will print the var variable 10 times:

```
#!/bin/bash
for var in {1..10}

do

  echo $var

done
```

Let's test the program:

```
$ chmod +x sor_01.sh
$ ./for_01.sh
```

The following will be the output after executing the preceding commands:

```
1
2
3
4
5
6
7
8
9
10
```

The following script for_02.sh uses the C programming style syntax:

```
#!/bin/bash
max=10
for  ((i=1; i<=max;  i++))
do
echo -n "$i     "    # one case with echo without -n option
done
```

Let's test the program:

```
$ chmod +x for_02.sh
$ ./for_02.sh
```

The following will be the output after executing the preceding commands:

```
$ ./for_02.sh      # OUTPUT with -n option
1    2    3    4    5    6    7    8    9    10
$ ./for_02.sh      # OUTPUT without -n option
1
2
3
4
5
6
7
8
9
10
```

In the next script `for_03.sh`, we will be processing a list of numbers, which are listed next to the `in` keyword:

```
#!/bin/bash
for var in 11 12 13 14 15 16 17 18 19 20
do
  echo $var
done
```

Let's test the program:

```
$ chmod +x for_03.sh
$ ./for_03.sh
```

The following will be the output after executing the preceding commands:

```
$ ./for_03.sh
11
12
13
14
15
16
17
```

```
18
19
20
```

In the following script `for_04.sh`, we create `users11` to `user20` along with their home directory:

```
#!/bin/bash
for var in user{11..20}
do
  useradd -m $var
  passwd -d $var
done
```

Let's test the program:

```
$ chmod +x for_04.sh.sh
$ sudo ./for_04.sh
```

The following will be the output after executing the preceding commands:

`user11` to `user20` will be created with their home folders in the `/home/` folder. You need to be a root user or administrator to run this script.

In the `for_05.sh` script, we will be passing command-line parameters. All the command-line parameters will be available as the `$*` inside script:

```
#!/bin/sh
for var in $*
do
  echo "command line contains: $var"
done
```

Let's test the program:

```
$ chmod +x for_05.sh
$ ./for_05.sh 1 2 3 4 5 6
```

The following will be the output after executing the preceding commands:

```
command line contains: 1
command line contains: 2
command line contains: 3
command line contains: 4
command line contains: 5
command line contains: 6
```

In the next script `for_06.sh`, we are passing a list of words such as name of fruits. Inside the script, we are printing the information of variable:

```
#!/bin/bash
# create fruits.txt => Apple Mango Grapes Pears Banana Orange
Pineapple
for var in `cat fruits.txt`
do
    echo "var contains: $var"
done
```

Let's test the program:

```
$ chmod +x for_06.sh
$ ./for_06.sh
```

The following will be the output after executing the preceding commands:

```
var contains: Apple
var contains: Mango
var contains: Grapes
var contains: Pears
var contains: Banana
var contains: Orange
var contains: Pineapple
```

Using the `for_07.sh` script, we generate a list of files with the `ls` shell command. This will be the list of filenames. In the `for` loop, the following list of files will be printed:

```
#!/bin/bash
echo -n "Commands in bin directory are : $var"
for var in $(ls /bin/*)
do
        echo -n -e "$var \t"
done
```

Let's test the program:

```
$ chmod +x for_07.sh
$ ./for_07
```

The following will be the output after executing the preceding commands:

```
This will print the content of /bin/ directory.
```

For taking a backup of files, we can write the `for_08.sh` script as follows:

```
#!/bin/bash
for filename in *.c
do
  echo "Copying $filename to $filename.bak"
  cp $filename $filename.bak
done
```

Let's test the program:

```
$ chmod +x for_08.sh
$ touch 1.c 2.c
$ ./for_08.sh
```

The following will be the output after executing the preceding commands:

```
"Copying 1.c to 1.c.bak"
"Copying 2.c to 2.c.bak"
```

Exiting from the current loop iteration with the continue command

With the help of the `continue` command, it is possible to exit from the current iteration of the loop and to resume the next iteration of the loop. We use the `for`, `while`, or `until` commands for loop iterations.

The following is the `for_09.sh` script for the loop with the `continue` command to skip a certain part of the loop commands:

```
#!/bin/bash
for x in 1 2 3
do
    echo before $x
    continue 1
    echo after $x
done
exit 0
```

Let's test the program:

```
$ chmod +x for_09.sh
$ ./for_09.sh
```

The following will be the output after executing the preceding commands:

```
before 1
before 2
before 3
```

The following is the `for_10.sh` script, in which we will check all files and directories. If the file is found, we will print the name. If the directory is found, we will skip further processing with the `continue` command. Take care that any of your useful files with the name `sample*` are not in the testing directory before testing this script:

```
#!/bin/bash
rm -rf sample*
echo > sample_1
echo > sample_2
mkdir sample_3
echo > sample_4

for file in sample*
do
  if [ -d "$file" ]
  then
    echo "skipping directory $file"
    continue
  fi
  echo file is $file
done
rm -rf sample*
exit 0
```

Let's test the program:

```
$ chmod +x for_10.sh
$ ./for_10.sh
```

The following will be the output after executing the preceding commands:

```
file is sample_1
file is sample_2
skipping directory sample_3
file is sample_4
```

In the following script `for_11.sh`, we are checking the backup of files in the `/MP3/` folder. If the file is not found in the folder, we are copying it into the folder for backup purposes. We can implement incremental backup scripts using this functionality:

```
#!/bin/bash
for   FILE in 'ls *.mp3'
do
  if  test -e /MP3/$FILE
  then
    echo "The file $FILE exists."
    continue
  fi
  cp $FILE /MP3
done
```

Let's test the program:

```
$ chmod +x for_11.sh
$ ./for_11.sh
```

If the file exists in the MP3 folder, then the loop will continue to check the next file. If the file backup is not present in the MP3 folder, then the file will be copied to it.

Exiting from a loop with a break

In the previous section, we discussed about how `continue` can be used to exit from the current iteration of a loop. The `break` command is another way to introduce a new condition within a loop. Unlike `continue`, however, it causes the loop to be terminated altogether if the condition is met.

In the `for_12.sh` script, we check the directory's content. If the directory is found, then we are exiting the loop and displaying the message that the first directory is found:

```
#!/bin/bash
rm -rf sample*
echo > sample_1
echo > sample_2
mkdir sample_3
echo > sample_4

for file in sample*
do
  if [ -d "$file" ]; then
```

```
      break;
    fi
  done

  echo The first directory is $file
  rm -rf sample*
  exit 0
```

Let's test the program:

```
$ chmod +x for_12.sh
$ ./for_12.sh
```

The following will be the output after executing the preceding commands:

```
The first directory is sample_3
```

In the `for_13.sh` script, we ask the user to enter any number. We print the square of numbers in the `while` loop. If a user enters the number 0, then we use the `break` command to exit the loop:

```
#!/bin/bash
typeset -i  num=0
while true
do
  echo -n "Enter any number (0 to exit): "
  read num junk

  if (( num == 0 ))
  then
    break
  else
    echo "Square of $num is $(( num * num ))."
  fi
done

echo "script has ended"
```

Let's test the program:

```
$ chmod +x for_13.sh
$ ./for_13.sh
```

The following will be the output after executing the preceding commands:

```
Enter any number (0 to exit): 1
Square of 1 is 1.
Enter any number (0 to exit): 5
Square of 5 is 25.
Enter any number (0 to exit): 0
```

Working with the do while loop

Similar to the `for` command, `while` is also the command for loop operations. The command next to `while` is evaluated. If it is successful or 0 then the commands inside `do` and `done` are executed.

The purpose of a loop is to test a certain condition or expression and execute a given command `while` the condition is true (`while` loop) or `until` the condition becomes true (`until` loop):

while condition
do
  commands
done
	until condition
	do
	  commands
	done

The following is the `while_01.sh` script, in which we read a file and display its it's content:

```
#!/bin/bash
file=/etc/resolv.conf
while IFS= read -r line    # IFS : inter field separator
do
   # echo line is stored in $line
  echo $line
done < "$file"
```

Let's test the program:

```
$ chmod +x while_01.sh
$ ./while_01.sh
```

The following will be the output after executing the preceding commands:

```
nameserver 192.168.168.2
search localdomain
```

In the following script while_02.sh, we are printing number 1–10 on the screen using the while loop:

```
#!/bin/bash
declare -i x
x=0
while [ $x -le 10 ]
do
  echo $x
  x=$((x+1))
done
```

Let's test the program:

```
$ chmod +x while_02.sh
$ ./while_02.sh
```

The following will be the output after executing the preceding commands:

```
0
1
2
3
4
5
6
7
8
9
10
```

In the following script while_03.sh, we ask the user to input the test. If the input of the text is quit, then we terminate the loop; otherwise, we print the text on the screen:

```
#!/bin/bash
INPUT=""
while [ "$INPUT" != quit ]
do
   echo ""
```

```
    echo 'Enter a word (quit to exit) : '
    read INPUT
    echo "You typed : $INPUT"
done
```

Let's test the program:

```
$ chmod +x while_03.sh
$ ./while_03.sh
```

The following will be the output after executing the preceding commands:

```
Enter a word (quit to exit) :
GANESH
You typed : GANESH
Enter a word (quit to exit) :
Naik
You typed : Naik

Enter a word (quit to exit) :
quit
You typed : quit
```

In the following `while_04.sh` script, we print the content of variable `num` on screen. We are starting with value 1. In the loop, we increment the value of the `num` variable by 1. When the value of the variable `num` reaches 6, then the `while` loop is terminated:

```
#!/bin/bash
num=1
while (( num < 6 ))
do
  echo "The value of num is: $num"
  (( num = num + 1 ))              # let num=num+1
done
echo "Done."
```

Let's test the program:

```
$ chmod +x while_04.sh
$ ./while_04.sh
```

The following will be the output after executing the preceding commands:

```
The value of num is: 1
The value of num is: 2
The value of num is: 3
The value of num is: 4
The value of num is: 5
Done.
```

The `while_05.sh` script prints a series of odd numbers on the screen. We are passing a total number of odd numbers required as command-line parameter:

```
#!/bin/bash
count=1
num=1
while [ $count -le $1 ]
do
  echo $num
  num=`expr $num + 2`
  count=`expr $count + 1`
done
```

Let's test the program:

```
$ chmod +x while_05.sh
$ ./while_05.sh 5
```

The following will be the output after executing the preceding commands:

```
1
3
5
7
9
```

Using until

The `until` command is similar to the `while` command. The given statements in the loop are executed as long as they evaluate the condition as true. As soon as the condition becomes false, then the loop is exited.

The syntax is as follows:

```
until command
do
    command(s)
done
```

In the following script `until_01.sh`, we are printing numbers 0-9 on screen. When the value of variable `x` becomes 10, then the `until` loop stops executing:

```
#!/bin/bash
x=0
until [ $x -eq 10 ]
do
  echo $x
  x=`expr $x + 1`
done
```

Let's test the program:

```
$ chmod +x until_01.sh
$ ./until_01.sh
```

The following will be the output after executing the preceding commands:

```
0
1
2
3
4
5
6
7
8
9
```

In the following script `until_02.sh`, we ask the user to input text. We are printing entered text on the screen. When the user enters the text `quit`, the `until` loop ends the iterations:

```
#!/bin/bash
INPUT=""
until [ "$INPUT" = quit ]
do
   echo ""
```

```
    echo 'Enter a word (quit to exit) : '
    read INPUT
    echo "You typed : $INPUT"
done
```

Let's test the program:

```
$ chmod +x until_02.sh
$ ./until_02.sh
```

The following will be the output after executing the preceding commands:

```
Enter a word (quit to exit) :
Ganesh
You typed : Ganesh

Enter a word (quit to exit) :
Naik
You typed : Naik

Enter a word (quit to exit) :
quit
You typed : quit
```

In the following script `until_03.sh`, we are passing the username as a command-line parameter to the script. When required, the user logs in the `grep` command and will find it from the output of the `who` command. Then, the `until` loop will stop iterations and inform on screen about the user login:

```
#!/bin/bash
until who | grep "$1" > /dev/null
do
  sleep 60
done
echo -e \\a
echo "***** $1 has just logged in *****"
exit 0
```

Let's test the program:

```
$ chmod +x until_03.sh
$ ./until_03.sh User10
```

The following will be the output after executing the preceding commands:

```
"***** User10 has just logged in *****"
```

This message will be displayed when `user10` has logged into the server.

Piping the output of a loop to a Linux command

If we need to redirect the output of a loop to any other Linux command such as `sort`, we can even redirect the loop output to be stored in the file:

The following is an example of source code `for_14.sh`:

```
#!/bin/bash
for value in 10 5 27 33 14  25
do
      echo  $value
done | sort -n
```

Let's test the program:

```
$ chmod +x for_14.sh
$ ./for_14.sh
```

The following will be the output after executing the preceding commands:

```
5
10
14
25
27
33
```

In the preceding script, the `for` loop iterates through a list of numbers which is unsorted. The numbers are printed in the body of the loop, which are enclosed between `do` and `done` commands. Once the loop is complete, the output is piped to the `sort` command, which in turn is performing a numerical sort and printing the result on the screen.

Running loops in the background

In certain situations, the script with loops may take lot of time to complete. In such situations, we may decide to run the script containing loops in the background so that we can continue other activities in the same terminals. The advantage of this will be that the terminal will be free for giving the next commands.

The following `for_15.sh` script is the technique to run a script with loops in the background:

```
#!/bin/bash
for animal in Tiger Lion Cat Dog
do
     echo $animal
    sleep 1
done &
```

Let's test the program:

```
$ chmod +x for_15.sh
$ ./for_15.sh
```

The following will be the output after executing the preceding commands:

```
Tiger
Lion
Cat
Dog
```

In the preceding script, the `for` loop will process animals `Tiger`, `Lion`, `Cat`, and `Dog` sequentially. The variable animal will be assigned the animal names one after another. In the `for` loop, the commands to be executed are enclosed between `do` and `done`. The ampersand after the done keyword will make the `for` loop run in the background. The script will run in the background till the `for` loop is complete.

The IFS and loops

The shell has one environment variable, which is called the **Internal Field Separator** (**IFS**). This variable indicates how the words are separated on the command line. The `IFS` variable is, normally or by default, a white space (' '). The `IFS` variable is used as a word separator (token) for the `for` command. In many documents, IFS can be any one of the white space, ':', '|', ': ' or any other desired character. This will be useful while using commands such as `read`, `set`, `for`, and so on. If we are going to change the default `IFS`, then it is a good practice to store the original IFS in a variable.

Later on, when we have done our required tasks, then we can assign the original character back to IFS.

In the following script `for_16.sh`, we are using ":" as the IFS character:

```
#/bin/bash
cities=Delhi:Chennai:Bangaluru:Kolkata
old_ifs="$IFS"           # Saving original value of IFS
IFS=":"
for place in $cities
do
      echo  The name of city is $place
done
```

Let's test the program:

```
$ chmod +x for_16.sh
$ ./for_16.sh
```

The following will be the output after executing the preceding commands:

```
The name of city is Delhi
The name of city is Chennai
The name of city is Bangaluru
The name of city is Kolkata
```

By default the original inter field separator is a whitespace. We have saved the original IFS in the `old_ifs` variable. We assigned colon ':' and an IFS in the script. Therefore, we can use ':' as an inter field separator in our test file or text string.

Summary

In this chapter, you learned about using decision making in scripts by working with `Test`, `if-else`, and switching `case`. We also used select for a loop with menu. For repeating tasks, such as processing lists, you learned about using the `for` loop, `while` loop and `do while`. You also learned how to control loops using the `break` statement and `continue` statement.

In the next chapter, you will learn about writing new functions and calling them, sharing data between functions, passing parameters to functions, and creating a library of functions.

9
Working with Functions

In the last chapter, you learned about using decision making in scripts by working with `test`, `if-else`, and `switch case`. We also used select `for` loop with menu. For repeated tasks, such as processing lists, you learned to use the `for` and `while` loops and the `do` while. You also learned about how to control loops using the `break` and `continue` statements.

In this chapter, you will learn the following topics:

- Writing a new function and calling
- Sharing data between functions
- Passing parameters to functions
- Creating a library of functions

Understanding functions

We, human beings, in our day-to day lives, take help from people, who are specialized in certain knowledge or skills, such as doctors, lawyers, and barbers. This helps our lives to be more organized and comfortable so that we need not learn every skill in this world. We take advantage of skills that have already been acquired by other people. The same thing applies to software development as well. If we use whatever code or scripts that have already been developed, then this will save our time and energy.

In real-world scripts, we break down big tasks or scripts into smaller logical tasks. This modularization of scripts helps in the better development and understanding of code. The smaller logical blocks of script are be called functions.

The advantages of functions are as follows:

- If the script is very big, then understanding it becomes very difficult. Using functions, we can easily understand complex script through logical blocks or functions.
- When a big and complex script is divided into functions, then it becomes easy to develop and test the script.
- If a certain part of code is repeated again and again in the big script, then using functions to replace repetitive code is very practical, such as checking whether the file or directory is present or not.
- We define functions for specific tasks or activities. Such functions can be called as commands in scripts.

Functions can be defined on a command line or inside scripts. The syntax for defining functions on a command line is as follows:

```
functionName { command_1; command_2; . . . }
```

Or:

```
functionName() { command_1; command_2; . . }
```

In single-line functions, every command should end with a semicolon.

Let's write a very simple function to illustrate the preceding syntax:

```
$ hello() {echo 'Hello world!';}
```

We can use the previously defined function as follows:

```
$ hello
```

Output:

```
Hello world!
```

The syntax of the function declaration inside the Shell script is as follows:

```
function_name() {
   block of code
}
```

An alternate function syntax is mentioned here:

```
function function_name
{
   block of code
}
```

Functions should be defined at the beginning of a script.

We can add this function in the Shell script `function_01.sh` as follows:

```
#!/bin/bash
hello()
{echo "Executing function hello"
}
echo "Script has started now"
hello
echo "Script will end"
```

Test the script as follows:

```
$ chmod +x function_01.sh
$ ./function_01.sh
```

Output:

```
Script has started now
Executing function hello
Script will end
```

We can modify the preceding script into `function_02.sh` with some more functionality, shown as follows:

```
#!/bin/bash
function greet()
{ echo "Hello $LOGNAME, today is $(date)"; }
greet
```

Test the script as follows:

```
$ chmod +x function_02.sh
$ ./function_02.sh
```

Output:

```
Hello ganesh, today is Sun Jul  5 22:47:23 PDT 2015
```

The system `init` functions are placed in the `/lib/lsb/init-functions` folder in the Linux operating system:

The script `function_03.sh` with a function for listing the present working directory and listing all the files in the current directory is as follows:

```
#!/bin/bash
function_lister ()
{
   echo Your present working directory is `pwd`
   echo Your files are:
   ls
}
function_lister
```

Test the script as follows:

```
$ chmod +x function_03.sh
$ ./function_03.sh
```

Output:

```
Your present working directory is /home/student/Desktop/test
Your files are:
01.sh  02.sh  03.sh
```

The script `function_04.sh` with a function to pause the script until users press any key is as follows:

```
#!/bin/bash
# pause: causes a script to take a break
pause()
{
echo "To continue, hit RETURN."
read q
}
pause
```

Test the script as follows:

```
$ chmod +x function_04.sh
$ ./function_04.sh
```

Output:

```
To continue,   hit  RETURN.
(after hitting any key it resumes)
```

The script `function_05.sh` with a function to print the previous day is as follows:

```
#!/bin/bash
yesterday()
{
date --date='1 day ago'
}
yesterday
```

Test the script as follows:

```
$ chmod +x function_05.sh
$ ./function_05.sh
```

Output:

```
Sat Jul  4 22:52:24 PDT 2015
```

The function to convert lowercase letters into uppercase letters is shown in `function_06.sh` as follows:

```
#!/bin/bash
function Convert_Upper()
{
echo $1 | tr 'abcdefghijklmnopqrstuvwxyz' \
               'ABCDEFGHIJKLMNOPQRSTUVWXYZ'
}
Convert_Upper "ganesh naik - embedded android and linux training"
```

Test the script as follows:

```
$ chmod +x function_06.sh
$ ./function_06.sh
```

Output:

```
GANESH NAIK - EMBEDDED ANDROID AND LINUX TRAINING
```

Displaying functions

If you want to see all the declared functions in the shell environment, then enter the following command:

```
$ declare -f
```

If you want to see a particular function, then here is the command:

```
$ declare -f hello
```

Output:

```
hello ()
{
    echo 'Hello world!'
}
```

Removing functions

If we no longer need the function in shell, then we use following command:

```
$ unset -f hello
$ declare -f# Check the function in shell environment.
```

Output:

Nothing will be displayed on the screen, as the function `hello` is removed from the shell environment with the `unset` command.

Passing arguments or parameters to functions

In certain situations, we may need to pass arguments or parameters to functions. In such situations, we can pass arguments as follows.

Calling the script with command-line parameters is as follows:

```
$ name arg1 arg2 arg3 . . .
```

Let's type a function as follows:

```
$  hello() { echo "Hello $1, let us be a friend."; }
```

Call the function in the command line as follows:

```
$ hello Ganesh
```

Output:

```
Hello Ganesh, let us be a friend
```

Let's write the script `function_07.sh`. In this script, we pass command-line parameters to the script as well as the function:

```
#!/bin/bash
quit()
{
   exit
}
ex()
{
      echo $1 $2 $3
}
ex Hello hi bye# Function ex with three arguments
ex World# Function ex with one argument
echo $1# First argument passed to script
echo $2# Second argument passed to script
echo $3# Third argument passed to script
quit
echo foo
```

Test the script as follows:

```
$ chmod +x function_07.sh
$ ./function_07.sh One Two Three
```

Output:

```
Hello hi bye
World
One
Two
Three
```

We can observe from the output that the parameters passed to the function are local to the function. In global scope, the command-line parameters to script are available as `$1`, `$2`, `$3`, and more.

Another example script called `function_08.sh` to pass multiple arguments to the function is as follows:

```
#!/bin/bash
countries()
{
# let us store first argument $1 in variable temp
temp=$1
```

```
    echo "countries(): \$0 = $0"  # print command
    echo "countries(): \$1 = $1"  # print first argument
    echo "countries(): total number of args passed = $#"
    echo "countries(): all arguments (\$*) passed = -\"$*\""
    }

    # Call function with one argument
    echo "Calling countries() for first time"
    countriesUSA

    # Call function with three arguments
    echo "Calling countries() second time "
    countriesUSA India Japan
```

Test the script as follows:

```
$ chmod +x function_08.sh
$ ./function_08.sh
```

Output:

```
Calling countries() for first time
countries(): $0 = ./hello.sh
countries(): $1 = USA
countries(): total number of args passed = 1
countries(): all arguments ($*) passed = -"USA"
Calling countries() second time
countries(): $0 = ./hello.sh
countries(): $1 = USA
countries(): total number of args passed = 3
countries(): all arguments ($*) passed = -"USA India Japan"
```

We can create a function that could create a new directory and change to it during the execution of the program. The script `function_09.sh` is as follows:

```
#!/bin/bash
# mcd: mkdir + cd; creates a new directory and
# changes into that new directory
mcd ()
{
mkdir $1
cd $1
}
mcd test1
```

The preceding script will create the `test1` folder in the current folder and change the path to the `test1` folder.

A common task in many scripts is to ask users to input an answer as either `Yes` or `No`. In such situations, the following script `function_10.sh` would be very useful:

```
#!/bin/bash
yesno ( )
{
while  true .
do
echo "$*"
echo "Please answer by entering yes or no : "
read reply
case $reply in
yes)
echo "You answered Yes"
return 0
;;
no)
echo "You answered No"
return 1
;;
*  )
echo "Invalid input"
;;
esac
done
}
Yesno
```

Test the script as follows:

```
$ chmod +x function_10.sh
$ ./function_10.sh
```

Output:

```
Please answer by entering yes or no:
yes
"You answered Yes"
$ ./function_10.sh
Please answer by entering yes or no:
no
"You answered No"
```

Sharing the data by many functions

We can create variables that may contain strings or numerical values. These global variables can be accessed by all the functions inside a script.

A simple script called `function_11.sh` with functions is as follows:

```
#!/bin/bash
# We will define variable temp for sharing data with function
temp="/temp/filename"

remove_file()
{
  echo "removing file $temp..."
}
remove_file
```

Test the script as follows:

```
$ chmod +x function_11.sh
$ ./function_11.sh
```

Output:

```
removing file /temp/filename...
```

Declaring local variables in functions

Whenever we declare a variable in a script, it is accessible to all functions. The variable is global by default. If the variable is modified by any line of script or any function, it will be modified in global scope. This may create problems in certain situations. We will see this problem in the following script `function_12.sh`:

```
#!/bin/bash
name="John"
hello()
{name="Maya"
   echo $name
}
echo $name# name contains John
hello# name contains Maya
echo $name# name contains Maya
```

Test the script as follows:

```
$ chmod +x function_12.sh
$ ./function_12.sh
```

Output:

```
John
Maya
Maya
```

To make a variable local, we declare it as follows:

```
local var=value
local varName
```

Let's write the script `function_13.sh` as follows:

```
#!/bin/bash
name="John"
hello()
{local name="Mary"
echo $name
}
echo $name# name contains John
hello# name contains Mary
echo $name# name contains John
```

Test the script as follows:

```
$ chmod +x function_13.sh
$ ./function_13.sh
```

Output:

```
John
Mary
John
```

The command `local` can only be used within a function. The keyword `local` limits the scope of the variable to the function. In the previous script, we initially declared the variable `name`; it has global scope. This variable `name` has the content `John`. Then, we have declared the `local` variable `name` in the function `hello`. This local variable `name` is initialized to `Mary`. Then, outside of the function `hello`, we again access the global variable `name`, which has the content `John`.

Returning information from functions

You have learned to pass command-line parameters to functions. Similarly, the function can return integers as a return value. Normally, functions return either *TRUE* or *FALSE*. In certain cases, the function can return integer values, such as 5 or 10, as well.

The syntax is:

```
return N
```

When the function calls the command return, the function exits with the value specified by `N`.

If the function does not call the command return, then the exit status returned is that of the last command executed in the function. If what we need is the status of the last command executed in the function, then we need not return any value from the function. This is illustrated in the following script `function_14.sh`:

```
#!/bin/bash
is_user_root() { [ $(id -u) -eq 0 ]; }
is_user_root && echo "You are root user, you can go ahead."\
|| echo "You need to be administrator to run this script"
```

Test the script as follows:

```
$ chmod +x function_14.sh
$ ./function_14.sh
```

If you are a root user, then the output will be as follows:

```
You are root user, you can go ahead.
```

If you are a normal user, then the output will be as follows:

```
You need to be administrator to run this script
```

A modified version of the previous script is `function_15.sh`:

```
#!/bin/bash
declare -r TRUE=0
declare -r FALSE=1

is_user_root()
{
[ $(id -u)-eq 0 ]&&return$TRUE||return$FALSE
}
```

```
is_user_root && echo "You can continue" || echo "You need to be root
to run this script."
```

Test the script as follows:

```
$ chmod +x function_15.sh
$ ./function_15.sh
```

Output:

```
You need to run this script as a root user.
```

Let's see the script in which the function returns a value:

```
#!/bin/bash
yes_or_no()
{
echo "Is your name $*?"
while true
do
echo -n "Please reply yes or no :"
readreply
case$reply in
Y | y | yes) return 0;;
N | n | no ) return 1;;
*) echo "Invalid answer"
esac
done
}

if yes_or_no $1
then
echo "Hello $1"
else
echo "name not provided"
fi
```

Test the script as follows:

```
$ chmod +x function_16.sh
$ ./function_16.sh Ganesh
```

Output:

```
Is your name Ganesh?
Please reply yes or no   :yes
Hello Ganesh
```

Returning a word or string from a function

In Shell scripts, functions cannot return a word or string from a function. If we need to pass data to script, then we will have to store it in a global variable. We can even use echo or print to send data to pipe or redirect it to the log file.

Running functions in the background

We have already seen in previous chapters that to run any command in the background, we have to terminate the command using `&`:

```
$ command &
```

Similarly, we can make the function run in the background by appending `&` after the function call. This will make the function run in the background so that the terminal will be free:

```
#!/bin/bash
dobackup()
{
    echo "Started backup"
    tar -zcvf /dev/st0 /home >/dev/null 2>&1
    echo "Completed backup"
}
dobackup &
echo -n "Task...done."
echo
```

Test the script as follows:

```
$ chmod +x function_17.sh
$ ./function_17.sh
```

Output:

```
Task...done.
Started backup
Completed backup
```

Command source and period (.)

Normally, whenever we enter a command, the new process gets created. If we want to make functions from the script to be made available in the current shell, then we need a technique that will run the script in the current shell instead of creating a new shell environment. The solution to this problem is using either the `source` or "`.`"commands.

The commands source and "." can be used to run the Shell script in the current shell instead of creating a new process. This helps with declaring functions and variables in the current shell.

The syntax is as follows:

```
$ source filename [arguments]
```

Or:

```
$ . filename [arguments]
```

$ source functions.sh

Or:

```
$ . functions.sh
```

If we pass command-line arguments, these will be handled inside a script as `$1`, `$2`, and more:

```
$ source functions.sh arg1 arg2
```

Or:

```
$ ./path/to/functions.sh arg1 arg2
```

The `source` command does not create a new shell; but runs the Shell scripts in the current shell, so that all the variables and functions will be available in the current shell for usage.

Creating a library of functions

If we want to create our own library of functions, then we can create a script and add all the functions into this script. We can make all the functions from our script `functions.sh` available in the current shell by calling `source` or the period `.` command.

The procedure to load all functions into the current shell is as follows:

```
$ countryUSA
```

Since the function `country` is not a part of the shell environment, this command will give an error:

```
$ . functions.sh
```

Or:

```
$ source functions.sh
$ country USA India Japan
```

This will execute the function `country` along with the parameter `USAIndia Japan`.

We can even load a script containing library functions inside another script as follows:

```
#!/bin/bash
. /../my-library.sh
call_library_functions();
```

We have called the library function script `my-library.sh` inside another script. This will define all the functions within the script `my-library.sh` available in the current script environment.

Summary

In this chapter, we understood the functions in Shell scripts. You learned about defining and displaying functions and removing the functions the from shell. You also learned about passing arguments to functions, sharing data between functions, declaring local variables in functions, returning results from functions, and running functions in background. You finally learned about using the `source` and `.` commands. We used these commands to use the library of functions.

In the next chapter, you will learn about using `traps` and `signals`. You will also learn about creating menus with the help of the utility `dialog`.

10

Using Advanced Functionality in Scripts

In the last chapter, you learned about using functions in Shell scripts and defining, displaying, and removing functions from the shell. You also learned about passing arguments to functions, sharing data between functions, declaring local variables in functions, returning results from functions, and running functions in the background. In the end, you learned about using `source` and `.` commands. You used these commands for using a library of functions.

In this chapter, you will learn the following topics:

- Understanding signals and traps
- Graphical menu development using the `dialog` utility

Understanding signals and traps

Two types of interrupts exist in the Linux operating system: the hardware interrupt and the software interrupt. Software interrupts are called signals or traps. Software interrupts are used for interprocess synchronizations.

Signals are used to notify about a certain event occurrence or to initiate a certain activity.

We use software signals many times, for example, if any command is not responding after it is typed, then you might have entered *Ctrl* + *C*. This sends a `SIGINT` signal to the process, and the process is terminated. In certain situations, we may want the program to perform a certain activity instead of terminating it using the *Ctrl* + *C* command. In such cases, we can use the `trap` command to ignore a signal or to associate our desired function with that signal.

In operating systems, software interrupts or signals are generated when the process attempts to divide a number by zero or due to power failure, system hang up, illegal instruction execution, or invalid memory access.

The action performed by a few signals is to terminate the process. We can configure the shell to do the following responses:

- Catch the signal and execute user defined programs
- Ignore the signal
- Suspend the process (similar to *Ctrl* + *Z*)
- Continue the process, which was suspended earlier

Enter either of following commands to get the full list of all signals:

$ kill -l

$ trap -l

Output:

```
student@ubuntu:~/work$ kill -l
 1) SIGHUP       2) SIGINT       3) SIGQUIT      4) SIGILL       5) SIGTRAP
 6) SIGABRT      7) SIGBUS       8) SIGFPE       9) SIGKILL     10) SIGUSR1
11) SIGSEGV     12) SIGUSR2     13) SIGPIPE     14) SIGALRM     15) SIGTERM
16) SIGSTKFLT   17) SIGCHLD     18) SIGCONT     19) SIGSTOP     20) SIGTSTP
21) SIGTTIN     22) SIGTTOU     23) SIGURG      24) SIGXCPU     25) SIGXFSZ
26) SIGVTALRM   27) SIGPROF     28) SIGWINCH    29) SIGIO       30) SIGPWR
31) SIGSYS      34) SIGRTMIN    35) SIGRTMIN+1  36) SIGRTMIN+2  37) SIGRTMIN+3
38) SIGRTMIN+4  39) SIGRTMIN+5  40) SIGRTMIN+6  41) SIGRTMIN+7  42) SIGRTMIN+8
43) SIGRTMIN+9  44) SIGRTMIN+10 45) SIGRTMIN+11 46) SIGRTMIN+12 47) SIGRTMIN+13
48) SIGRTMIN+14 49) SIGRTMIN+15 50) SIGRTMAX-14 51) SIGRTMAX-13 52) SIGRTMAX-12
53) SIGRTMAX-11 54) SIGRTMAX-10 55) SIGRTMAX-9  56) SIGRTMAX-8  57) SIGRTMAX-7
58) SIGRTMAX-6  59) SIGRTMAX-5  60) SIGRTMAX-4  61) SIGRTMAX-3  62) SIGRTMAX-2
63) SIGRTMAX-1  64) SIGRTMAX
```

If we want to know which keys are used for particular signals, then we enter the following command:

$ stty -a

The following is a list of a few of the standard signals that a process can use:

Number	Name	Description	Action
0	`EXIT`	The shell exits.	Termination
1	`SIGHUP`	The terminal has been disconnected.	Termination
2	`SIGINT`	The user presses *Ctrl* + *C*	Termination
3	`SIGQUIT`	The user presses *Ctrl* + \	Termination

Number	Name	Description	Action
4	SIGILL	This gives an illegal hardware instruction.	Program error
5	SIGTRAP	This is produced by debugger.	Program error
8	SIGFPE	This gives an arithmetic error, such as division by zero.	Program error
9	SIGKILL	This cannot be caught or ignored.	Termination

We can send either of the kill signals to a process with PID # `1234` as follows:

```
kill -9 1234
kill -KILL 1234
kill -SIGKILL 1234
```

As we can see, we can use a signal number or a signal name along with the process ID. By default, the `kill` command sends signal number 15 to process. Using the `kill` command, we can send the desired signal to any specific process.

We can stop a process using the *Ctrl* + *Z* signal as follows:

```
$ kill -19 pid
```

Ctrl + *Z* or `SIGTSTP` will stop the process.

We can run the stopped process by sending the `SIGCONT` signal.

```
$ kill -18 pid
```

The signal number of `SIGCONT` is 18.

Using the trap command

If a signal or software interrupt is generated while the script is running, then we can define what action is performed by that interrupt handler using the `trap` command. The `trap` command helps us in reassigning the system response to a particular signal through the user defined function or commands.

The syntax to use the `trap` command is either of the following:

```
$ trap 'command; command' signal-name
$ trap 'command; command' signal-number
```

The usage as per the preceding syntax is as follows:

```
trap 'echo "You pressed Control key"; exit 1'  0 1 2 15
```

This will print the message `You pressed Control Key`, any `SIGINT`, `SIGHUP`, or `SIGTERM` received by the process:

```
trap 'rm file.tmp; exit 1'  EXIT INT TERM HUP
```

When any of the `SIGINT`, `SIGTERM`, or `SIGHUP` signals arrives, then it will delete the `file.tmp` file and exit with status 1.

While using the `trap` command, if the command string is surrounded by double quotes, then the command substitution and variable substitution will be done during the `trap` command execution. If the command string is enclosed in single quotes then the command substitution and variable substitution will be done when the signal is detected.

Ignoring signals

If we want the shell to ignore certain signals, then we can call the `trap` command followed by a pair of empty quotes as a command. Those signals will be ignored by the shell process shown by either of the following commands:

```
$ trap " " 2 3 20
$ trap "" INT QUIT TSTP
```

The signals `2 (SIGINT)`, `3 (SIGQUIT)`, and `20 (SIGTSTP)` will be ignored by the shell process.

Resetting signals

If we want to reset the signal behavior to the original default action, then we need to call the `trap` command followed by the signal name or number as shown in the following examples, respectively:

```
$ trap TSTP
$ trap 20
```

This will reset the default action of signal `20 (SIGTSTP)`. The default action is to suspend the process (*Ctrl* + *Z*).

Listing traps

Let's reassign our function to signals by the `trap` command:

```
$ trap 'echo "You pressed Control key"; exit 1' 0 1 2 15
```

If we do not pass any arguments after the trap command, then it lists all reassigned signals along with their functions.

We can list all the assigned signal lists by the following command:

```
$ trap
```

Output:

```
trap -- 'echo "You pressed Control key"; exit 1' EXIT
trap -- 'echo "You pressed Control key"; exit 1' SIGHUP
trap -- 'echo "You pressed Control key"; exit 1' SIGINT
trap -- 'echo "You pressed Control key"; exit 1' SIGTERM
```

Using traps in function

If we use the `trap` command inside a function in script, then the reassigned signal behavior will become global inside a script. We can check this effect in the following script example.

Let's write Shell script `trap_01.sh` as follows:

```
#!/bin/bash
trap "echo  caught signal SIGINT" SIGINT
trap "echo  caught signal SIGQUIT" 3
trap "echo  caught signal SIGTERM" 15
while :
do
    sleep 50
done
```

Let's test the program as follows:

```
$ chmod +x trap_01.sh
$ ./ trap_01.sh
```

Output:

```
^Ccaught signal SIGINT
^\Quit (core dumped)
caught signal SIGQUIT
```

Let's write one more Shell script `trap_02.sh` as follows:

```
#!/bin/bash

trap "echo  caught signal SIGINT" SIGINT
trap "echo  caught signal SIGQUIT" 3
trap "echo  caught signal SIGTERM" 15
trap "echo caught signal SIGTSTP" TSTP

echo "Enter any string (type 'dough' to exit)."
while true
do
    echo "Rolling...\c"
    read string
    if [ "$string" = "dough" ]
    then
        break
    fi
done
echo "Exiting normally"
```

Let's test the program as follows:

```
$ chmod +x trap_02.sh
$ ./ trap_02.sh
```

Output:

```
Enter any string (type 'dough' to exit).
Rolling...\c
^Ccaught signal SIGINT
dough
Exiting normally
```

Running scripts or processes even if the user logs out

Sometimes we may need our script to run even after we log out, such as when taking a back up and similar activities. In this case, even if we log out, the system is powered on and running. In such situations, we can use the `nohup` command. The `nohup` command prevents the process from terminating using the SIGHUP signal.

The nohup command makes our script run without attaching it to a terminal. Therefore, if we use the echo command to print text on the terminal. It will not be printed in a terminal, since the script is not attached to a terminal. In such cases, we need to redirect the output to the file, or nohup will automatically redirect the output to a nohup.out file.

Therefore, if we need to run a process, even if we log out, we need to use the nohup command as follows:

```
$ nohup command &
```

The example is as follows:

```
$ nohup sort emp.lst &
```

This will run a program to sort the emp.lst file in the background.

```
$ nohup date &
```

Creating dialog boxes with the dialog utility

The dialog utility is used to create a basic level graphical user interface. We can use this in Shell script to create very useful programs.

To install the dialog utility in Debian or Ubuntu Linux, enter following command:

```
$ sudo apt-get update
$ sudo apt-get install l dialog
```

Similarly, enter the following command to install the utility dialog in CentOS or Red Hat Linux:

```
$ sudo yum install dialog
```

The typical syntax of the dialog command is as follows:

```
$ dialog --common-options --boxType "Text" Height Width \
                                    --box-specific-option
```

The common-options utility is used to set the background color, title, and so on in dialog boxes.

The option details are as follows:

- Text: The caption or contents of the box
- Height: The height of the dialog box
- Width: The width of the dialog box

Creating a message box (msgbox)

To create a simple message box, we can use the following command:

```
$ dialog --msgbox "This is a message." 10 50
```

Creating a message box (msgbox) with a title

Enter the following command to create a message box with the following title:

```
$ dialog --title "Hello" --msgbox 'Hello world!' 6 20
```

The option details are as follows:

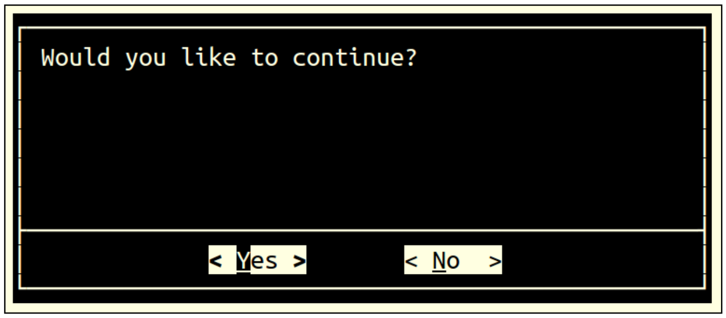
- `--title "Hello"`: This will set the title of the message box as `"Hello"`
- `--msgbox 'Hello world!'`: This will set the content of the message box as `"Hello world!"`
- `6`: This will set the height of the message box
- `20`: This will set the width of message box:

The message box has a **Hello** title with content **Hello World**! It has a single **OK** button. We can use this message box to inform the user about any events or information. The user will have to press *Enter* to close this message box. If the content is large for a message box, then the dialog utility will provide the scrolling of the message.

The yes/no box (yesno)

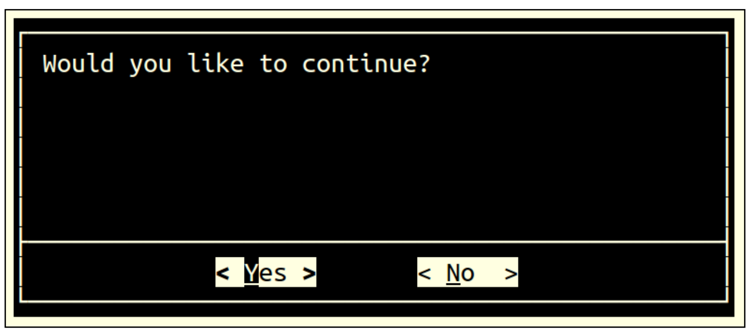
If we need to obtain a yes or no answer from the user, we can use the following options along with the dialog command:

```
$ dialog --yesno "Would you like to continue?" 10 50
```



We can have the same yes/no dialog box with a title as follows:

```
$  dialog --title "yesno box" --yesno "Would you like to continue?" 10 50
```



Let's write the Shell script `dialog_01.sh` as follows:

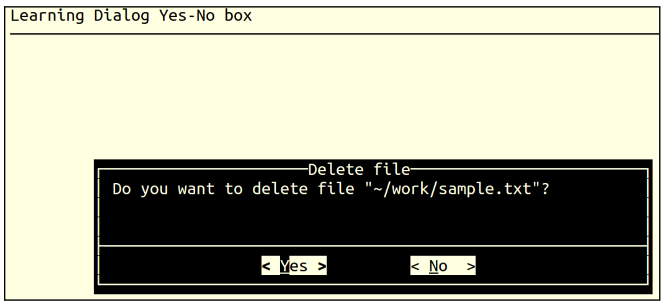
```
#!/bin/bash
dialog --title "Delete file" \
--backtitle "Learning Dialog Yes-No box" \
--yesno "Do you want to delete file \"~/work/sample.txt\"?" 7 60

# Selecting "Yes" button will return 0.
# Selecting "No" button will return 1.
# Selecting [Esc] will return 255.
result=$?
case $result in
   0)     rm ~/work/sample.txt
```

```
        echo "File deleted.";;
       1)      echo "File could not be deleted.";;
       255)    echo "Action Cancelled – Presssed [ESC] key.";;
   esac
```

Let's test the following program:

```
$ chmod +x dialog_01.sh
$ ./dialog_01.sh
```

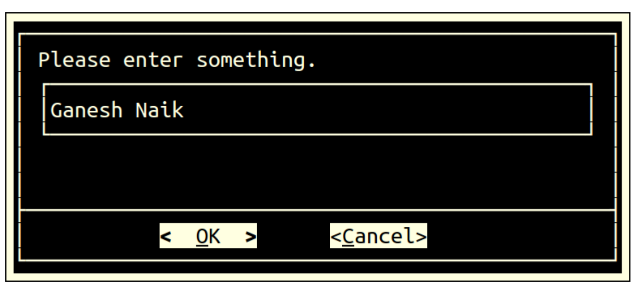
Output:



The input box (inputbox)

Whenever we want to ask a user for an input text via the keyboard, in such situations, the inputbox option is useful. While entering text via keyboard, we can use keys such as delete, backspace, and the arrow cursor keys for editing. If the input text is larger than the input box, the input field will be scrolled. Once the `OK` button is pressed, the input text can be redirected to a text file:

```
# dialog  --inputbox  "Please enter something."   10  50 \
2> /tmp/tempfile
VAR=`cat ~/work/output.txt
```

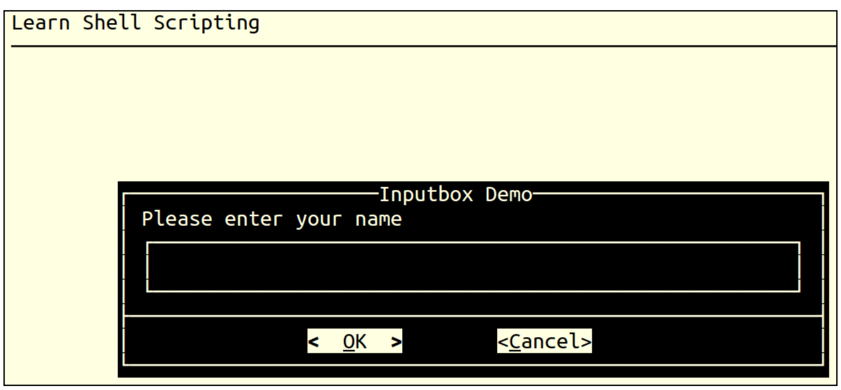


Let's write the Shell script `dialog_02.sh` to create an input box as follows:

```
#!/bin/bash
result="output.txt"
>$ $result    #  Create empty file

dialog --title "Inputbox Demo" \
--backtitle "Learn Shell Scripting" \
--inputbox "Please enter your name " 8 60 2>$result

response=$?
name=$(<$result)
case $response in
0)   echo "Hello $name"
      ;;
1)   echo "Cancelled."
      ;;
255)     echo "Escape key pressed."
esac
rm $result
```

Let's test the following program:

```
$ chmod +x dialog_02.sh
$ ./dialog_02.sh
```



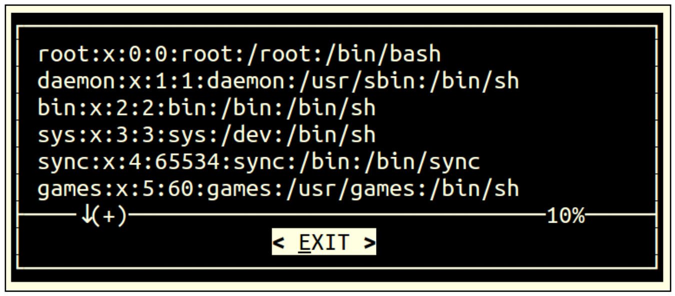
Output:

```
"Hello Ganesh Naik"
```

The textbox (textbox)

If we want to display the contents of the file in a textbox inside the menu created by dialog, then enter the following command:

```
$ dialog  --textbox /etc/passwd 10  50
```



We are displaying the `/etc/passwd` file in the textbox with the previous command.

A password box

Many a time, we need to get the password from the user. In this case, the password should not be visible on the screen. The password box option is perfectly useful for this purpose.

If we want to display an entered password as a string of ****, then we will need to add the`--insecure` option.

We will need to redirect the inserted password in a file.

Let's write Shell script `dialog_03.sh` to receive the password as follows:

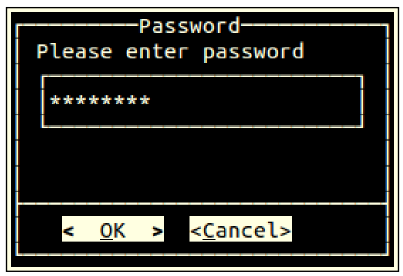
```
#!/bin/bash
# creating the file to store password
result="output.txt 2>/dev/null"

# delete the password stored file, if program is exited pre-maturely.
trap "rm -f output.txt" 2 15

dialog --title "Password" \
--insecure \
--clear \
--passwordbox "Please enter password" 10 30 2> $result

reply=$?
```

```
case $reply in
  0)    echo "You have entered Password :  $(cat $result)";;
  1)    echo "You have pressed Cancel";;
  255)    cat $data && [ -s $data ] || echo "Escape key is pressed.";;
esac
```

Let's test the following program:

```
$ chmod +x dialog_03.sh
$ ./dialog_03.sh
```

Output:



Output:

```
You have entered Password :  adcd1234
```

The menu box (menu)

Usually, any program or Shell script may be required to perform multiple types of tasks. In such cases, the menu box option is very useful. This option will display the list of choices for the user. Then, the user may select any of his or her desired choice. Our script should execute the desired option.

Each menu has two fields, a tag and an item string. In the next example menu demo, we have tags such as date, calendar, and editor. The description of tags is called as an item string.

Let's write the Shell script `dialog_04.sh` to create a menu as follows:

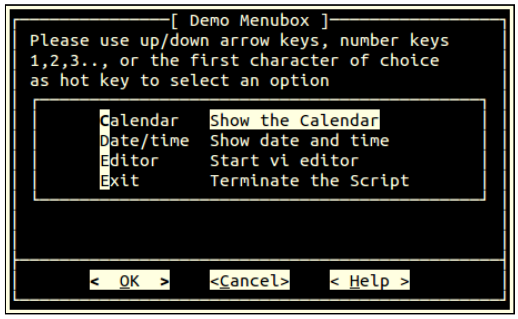
```
#!/bin/bash
# Declare file to store selected menu option
RESPONSE=menu.txt
# Declare file to store content to display date and cal output
TEMP_DATA=output.txt
```

```
vi_editor=vi
# trap and delete temp files
trap "rm $TEMP_DATA; rm $RESPONSE; exit" SIGHUP SIGINT SIGTERM

function display_output(){
    dialog --backtitle "Learning Shell Scripting" --title "Output"
--clear --msgbox "$(<$TEMP_DATA)" 10 41
}

function display_date(){
    echo "Today is `date` @ $(hostname -f)." >$TEMP_DATA
    display_output 6 60 "Date and Time"
}

function display_calendar(){
    cal >$TEMP_DATA
    display_output 13 25 "Calendar"
}

# We are calling infinite loop here
while true
do

# Show main menu
dialog --help-button --clear --backtitle "Learn Shell Scripting" \
--title "[ Demo Menubox ]" \
--menu "Please use up/down arrow keys, number keys\n\
1,2,3.., or the first character of choice\n\
as hot key to select an option" 15 50 4 \
Calendar "Show the Calendar" \
Date/time "Show date and time" \
Editor "Start vi editor" \
Exit "Terminate the Script" 2>"${RESPONSE}"

menuitem=$(<"${RESPONSE}")

# Start activity as per selected choice
case $menuitem in
    Calendar) display_calendar;;
    Date/time) display_date;;
    Editor) $vi_editor;;
    Exit) echo "Thank you !"; break;;
esac
done
# Delete temporary files
[ -f $TEMP_DATA ] && rm $TEMP_DATA
[ -f $RESPONSE ] && rm $RESPONSE
```

Let's test the following program:

```
$ chmod +x dialog_04.sh
$ ./dialog_04.sh
```

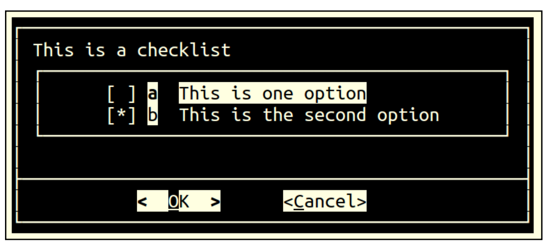
Output:



The checklist box (checklist)

In this case, we can present the user with a choice to select one or multiple options from a list:'

```
# dialog --checklist "This is a checklist" 10 50 2 \
"a"  "This is one option" "off" \
"b" "This is the second option" "on"
```

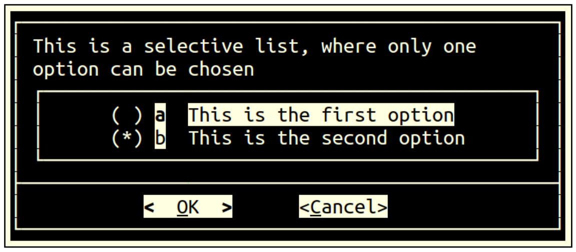


The radiolist box (radiolist)

If you want the user to select only one option out of many choices, then `radiolist` is a suitable option:

```
# dialog --radiolist  "This is a selective list, where only one \
option can be chosen" 10 50 2 \
"a" "This is the first option" "off" \
"b" "This is the second option" "on"
```

Radio buttons are not square but round, as can be seen in the following screenshot:



The progress meter box (gauge)

The progress meter displays a meter at the bottom of the box. This meter indicates the percentage of the process completed. New percentages are read from standard input, one integer per line. This meter is updated to reflect each new percentage.

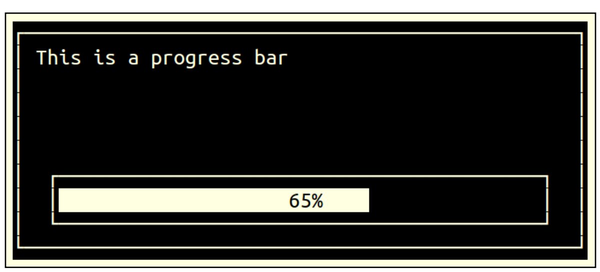
Let's write the Shell script `dialog_05.sh` to create a progress meter as follows:

```
#!/bin/bash
declare -i COUNTER=1
{
    while test $COUNTER -le 100
        do
            echo $COUNTER
            COUNTER=COUNTER+1
            sleep 1
    done
    } |  dialog --gauge  "This is a progress bar"  10 50 0
```

Let's test the following program:

```
$ chmod +x dialog_05.sh
$ ./dialog_05.sh
```

Output:



Customization of dialog with the configuration file We can customize dialog using the `~/.dialogrc` configuration file. The default file location is `$HOME/.dialogrc`.

To create the `.dialogrc` configuration file, enter the following command:

```
$ dialog --create-rc ~/.dialogrc
```

We can customize the output of the `dialog` utility by changing any of the configuration parameters defined in the `.dialogrc` file.

Summary

In this chapter, you learned about using `traps` and `signals`. You also learned about creating menus with the help of the `dialog` utility.

In the next chapter, you will learn about Linux system startup, from power on till the login-logout of the user and how to customize a Linux system environment.

11

System Startup and Customizing a Linux System

In the last chapter, you learned about using **traps** and **signals**. You also learned about creating menus with the help of **dialog** utility.

In this chapter, you will learn about Linux system startup, from power on to the user login and how to customize a Linux system environment.

System startup, inittab, and run levels

When we power on the Linux system, the Shell scripts are run one after another and the Linux system is initialized. These scripts start various services, daemons, start databases, mount discs, and many more applications. Even during the shutting down of the system, certain Shell scripts are executed so that important system data and information can be saved to the disk and the applications are properly shut down. These are called boot, startup, and shutdown scripts. These scripts are copied during installation of the Linux operating system in your computer. As a developer or administrator, understanding these scripts may help you in understating and debugging the Linux system. If required, you can customize these scripts if the need arises.

The kernel startup and init process

In our computers, there is one EPROM chip called **BIOS**, which is situated on the motherboard or main board of our computers. When we power on, the processor starts executing a program from BIOS. The program from BIOS, does a power on self-test such as checking memory and other peripherals. Then the BIOS program initializes the basic hardware required for PC operation, such as initializing the PCI bus, video devices, and similar.

Finally, BIOS checks the boot device sequence and queries the first boot device. This BIOS program then reads the master boot record of the first boot device, which is normally a hard disk, USB device, or DVD. Once BIOS reads the master boot record of the first boot device, then the boot loader is started. The boot loader reads kernel binary and copies it in the RAM memory. The boot loader checks if the kernel binary is clean and not corrupt. If the integrity check is good then it uncompresses the kernel in the RAM. The bootloader then calls the `start_kernel()` function, which is a part of kernel. Once the `start_kernel()` function is called, the kernel is started.

The kernel then initializes the subsystems of kernel such as process management, filesystem, device drivers, memory management, network management, and similar other modules of the kernel. Then, it mounts the root file system, and kernel creates the first process called **init**. This init process reads the `/etc/inittab` file. In inittab, the run level information is stored. As per this information, the operating system is initialized process init.

The typical `/etc/inittab` content will be as follows:

```
$ cat /etc/inittab
```

Output:

```
# Default runlevel. The runlevels used are:
#   0 - halt (Do NOT set initdefault to this)
#   1 - Single user mode
#   2 - Multiuser, without NFS (The same as 3, if you do not have
networking)
#   3 - Full multiuser mode
#   4 - unused
#   5 - X11
#   6 - reboot (Do NOT set initdefault to this)
#
id:5:initdefault:
```

In the preceding line, the number 5 after ID specifies that the system should be started in run level 5. It means that the system should be started in `X11`, such as a graphical user interface. We will study more about run levels in the next section.

Nowadays, many distributions have modified the boot-up sequence. They have removed the `/etc/inittab` file and used different applications to customize the boot-up process.

Understanding run levels

There are seven run levels. The system will be started in run level 1 to 5. Run level 0 is used for shutting down the system. Run level 6 is used for rebooting the system. The graphical user interface is started in run level 5. The following is the summary of different run levels:

Sr. No.	Run level number	Description
1	0	Halting the system
2	1	Single-user mode
3	2	Multi-user mode
4	3	Multi-user with network support
5	4	Not used
6	5	Graphical user interface with multi-user and networking support
7	6	Rebooting the system

We need to be in the root-user mode to use the `init` command.

If we give the following command, then the system will shutdown:

```
# init 0
```

To reboot the system use the following command:

```
# init 6
```

If the system is running in the command-line mode, and if you want to start your server in the graphical user mode, then use the following command:

```
# init 5
```

System initialization boot scripts

In the Linux system, the following folders will be present in the `/etc/` folder:

Sr. No.	Folder name	Description
1	`rc0.d/`	The scripts called during shutting down
2	`rc1.d/`	The run level 1 scripts
3	`rc2.d/`	The run level 2 scripts
4	`rc3.d/`	The run level 3 scripts
5	`rc4.d/`	The run level 4 scripts

Sr. No.	Folder name	Description
6	`rc5.d/`	The run level 5 scripts
7	`rc6.d/`	The run level 6 scripts
8	`rcS.d/`	The scripts called before every run level
9	`rc.local`	The final script called after run level initialization

Every run level folder will have script names starting either with S or K. When starting the system, the scripts with names starting with S are called one after another. When shutting down, all the script names starting with K are called one after another.

For example, if the system has to be started in run level 5, then initially all the scripts from the `rcS.d` folder will be called, then all the scripts from `rc5.d` will be called. Finally, the `rc.local` script will be called.

The content of `/etc/rc.local` is as follows:

```
$ cat /etc/rc.local
```

Output:

```
#!/bin/sh -e
#
# rc.local
#
# This script is executed at the end of each multiuser runlevel.
# Make sure that the script will "exit 0" on success or any other
# value on error.
#
# In order to enable or disable this script just change
# the execution bits.
#
# By default this script does nothing.
exit 0
```

We can add our customization commands before the `exit 0` line in the preceding `rc.local` script.

Before any user is logged in, the mentioned scripts will be called. After this, user login initialization will be started. This is explained in the following sessions.

User initialization scripts

Till now, we have seen different scripts, these scripts initialize the operating system, prior to the login of any user. Once the basic operating system in initialized, the user login process starts. This process is explained in the following topics.

Systemwide settings scripts

In the `/etc/` folder, the following files are related to the user level initialization:

- `/etc/profile`: Few distributions will have additional folder `/etc/profile.d/`. All the scripts from the `profile.d` folder will be executed.
- `/etc/bash.bashrc`

The preceding scripts are called by all the users, including root and normal users. Initially, the `/etc/profile` script will be called. This script creates system-wide environment settings. Few distributions will have the `/etc/profile.d/` folder. SuSE Linux has additional `/etc/profile.local` script. The scripts in this folder will also be called. Then, the `/etc/bash.bachrc` script will be executed.

User level settings – default files

Scripts in the `/etc/` folder will be called for all the users. Particular user-specific initialization scripts are located in the `HOME` folder of each user. These are as follows:

- `$HOME/.bash_profile`: This contains user-specific bash environment default settings. This script is called during the login process.
- `$HOME/.bash_login`: This contains the second user environment initialization script called during login process.
- `$HOME/.profile`: If present, this script internally calls the `.bashrc` script file.
- `$HOME/.bashrc`: This is an interactive shell or terminal initialization script.

All the preceding script's names start with dot. These are hidden files. We will need to give the `ls -a` command to view these files.

- Non - login shells.

Whenever we create a new shell terminal, such as, if we pressed the *Ctrl* + *Alt* + *T* key combination or we start a terminal from the applications tab then the terminal which is created is called the interactive shell terminal. We use this terminal to interact with the operating system. This is not the login shell, which is created during the boot-up process. But this interactive shell terminal gives us the CLI prompt for entering the command to execute.

Whenever we create an interactive bash terminal, Shell scripts from `/etc/profile` and similar are not called, only the `~/.bashrc` script is called every time we create a new interactive shell terminal. If we want any environment customization for every newly created interactive shell terminal, we need to customize the `.bashrc` script from the home folder of the user.

If you check the content of `$HOME/.bashrc`, you will observe the following:

- The `.bashrc` script is the setting prompt
- It initializes the environmental variables, HISTCONTROL, HISTSIZE, and HISTFILESIZE
- It customizes the output of the `less` command
- It creates various alias commands such as `grep`, `fgrep`, `egrep`, `ll`, `la`, `l`, and similar

If we customize `.bashrc` such as adding new alias commands or declaring a new function or environment variables, then we should execute `.bashrc` to take its effect. The following are the two ways to run the `.bashrc` script so that the environment of the current shell will also be updated as per the customization done in the `.bashrc` script:

- `$ source .bashrc`
- `$ . bashrc`

In these two techniques, the child shell is not created but the new function is. Environment and similar variables will become a part of the current shell environment.

Every user's home folder has one more script called `.bash_logout`. This script is called or executed when the user exits from the login shell.

If the system user is an embedded system developer, who is interested in adding or modifying the device's driver-related command, then he or she will have to make changes in the `/etc/rc*.d` folder scripts, or they may have to modify the `/etc/rc.local` script.

If the administrator wants to modify the environment for all the users, then they will have to modify the `/etc/profile` and `/etc/bash_bashrc` scripts.

If we want to customize the environment related to a particular user, then the scripts located in the user's home folder, such as `$HOME/.profile`, `$HOME/bash_profile`, and `$HOME/bash_login` scripts, should be modified.

If the user wants to customize only the interactive shell terminal environment, then they will have to customize the `$HOME/.bashrc` script.

If you are working in system administration, then I would suggest you learn about the `/etc/fstab` file and it's editing. This file is used for configuring mount points and how file systems are mounted.

Summary

In this chapter, you learned about the Linux system start up, from power on till user login and how to customize a Linux system environment.

In the next chapter, you will learn about using stream editor (sed) and awk for text processing.

12
Pattern Matching and Regular Expressions with sed and awk

In the previous chapter, you learned about Linux system's startup, from power-on till user login, and how to customize a Linux system environment.

In this chapter, we will cover the following topics:

- Understanding regular expressions
- Stream editor (sed) for text processing
- Using awk for text processing

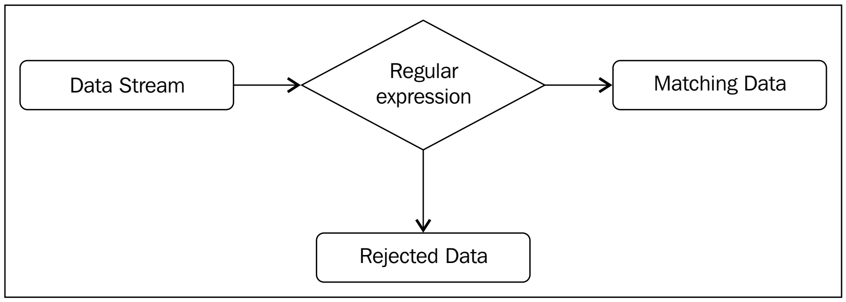
The basics of regular expressions

A sequence of characters that have certain patterns of text (with meta-characters), which will be searched from in a larger text or file is called **regular expressions**:

```
$ ll /proc | grep cpuinfo
```

In the preceding command, the `grep` utility will search for the `cpuinfo` text in all lines of input text and will print lines that have the `cpuinfo` text.

The utilities such as `grep`, `sed`, or `awk` use regular expressions for filtering text and then apply various processing commands as required by the user. The lines which do not match the pattern will be rejected. The following diagram explains the same concept:



In *Chapter 3*, *Using Test Processing and Filters in Your Scripts*, you learned about the basics of regular expressions and pattern matching using the **vi** editor and the `grep` utility.

sed – noninteractive stream editor

The **stream editor** (**sed**) is a very popular noninteractive stream editor. Normally, whenever we edit files using the vi editor, we need to open the file using the `vi` command, then we interact with the file, such as to see the content of the file on screen, then, edit it, and save the file. Using sed, we can type commands on the command line and sed will make the changes to the text file. The sed is a nondestructive editor. The sed makes the changes to the file and displays the content on screen. If we want to save the changed file, then we need to redirect the output of the sed to the file.

The procedure to install sed is shown here.

For Ubuntu or any Debian-based distributions enter the following command:

```
$ apt-get install sed
```

For Red Hat or any rpm-based distribution enter the following command:

```
$ yum install sed
```

To check the version of sed, enter the following command:

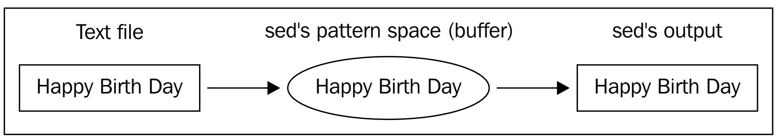
```
$ sed –V
```

Otherwise, enter this command:

```
$ sed --version
GNU sed version 3.02
```

Understanding sed

Whenever you use `sed` commands on a text file, sed reads the first line of the file and stores it in a temporary buffer called **pattern space**. The sed processes this pattern space buffer as per commands given by the user. Then, it prints the output on screen. This line from the pattern space is then removed and the next line of the file is loaded in the pattern space. In this way, it processes all the lines one by one. This line-by-line processing is continued till the last line of the file. As the `sed` commands are processed on the temporary buffer or pattern space, the original line is not modified. Therefore, we say sed is a nondestructive buffer.



Understanding regular expression usage in sed

While using `sed`, regular expressions are enclosed in forward slashes. As `grep` and `sed` use regular expressions and metacharacters for searching patterns in the file. For example:

```
sed -n '/Regular_Expression/p' filename
sed -n '/Mango/p' filename
```

This will print lines matching the `Mango` pattern:

```
sed -n 's/RE/replacement string/' filename
sed -n 's/Mango/Apple/' filename
```

This will find the line containing the `Mango` pattern and then the `Mango` pattern will be replaced by the `Apple` text. This modified line will be shown on screen and the original file will be unchanged.

The following is a summary of various metacharacters and it's usage in sed:

Metacharacter	**Function**
^	This is the beginning-of-line anchor
$	This is the end-of-line anchor
.	This matches one character, but not the newline character
*	This matches zero or more characters
[ ]	This matches one character in the set
[^]	This matches one character not in the set
\(..\)	This saves matched characters
&	This saves the search string so it can be remembered in the replacement string
\<	This is the beginning-of-word anchor
\>	This is the end-of-word anchor
x\{m\}	This is the repetition of the character `x`:`m` times
x\{m,\}	This means at least `m` times
x\{m,n\}	This means between `m` and `n` times

Addressing in sed

We can specify which line or number of lines the pattern search and commands are to be applied on while using the `sed` commands. If line numbers are not specified, then the pattern search and commands will be applied on all lines of the input file.

The line numbers on which commands are to be applied are called **address**. Address can be a single line number or range of lines in which the starting number of the line and the ending number of the range will be separated by commas. Ranges can be composed of numbers, regular expressions or a combination of both.

The `sed` commands specify actions such as printing, removing, replacing, and so on.

The syntax is as follows:

```
sed 'command' filename(s)
```

Example:

```
$ cat myfile |  sed '1,3d'
```

Otherwise it can be:

```
sed '1,3d' myfile
```

This will delete lines 1 to 3:

```
sed -n '/[Aa]pple/p' item.list
```

If the `Apple` or `apple` pattern is found in the `item.list` file, then those lines will be printed on screen and the original file `myfile` will be unchanged.

To negate the command, the exclamation character (`!`) can be used.

Example:

```
sed '/Apple/d' item.list
```

This tells sed to delete all the lines containing the `Apple` pattern.

Consider the following example:

```
sed '/Apple/!d' item.list
```

This will delete all the lines except the line containing the `Apple` pattern.

How to modify a file with sed

The sed is a nondestructive editor. This means the output of sed is displayed on screen; but the original file is unchanged. If we want to modify the file, then we can redirect the output of the `sed` command to the file. Deleting lines is illustrated in the following examples:

```
$ sed '1,3d' datafile >  tempfile
$ mv tempfile newfile
```

In this example, we have deleted lines 1 to 3 and stored the output in `tempfile`. Then, we have to rename `tempfile` to `newfile`.

Printing – the p command

By default, the action of the `sed` command is to print the pattern space, such as every line which is copied in buffer, and then print the result of processing on it. Therefore, the sed output will consist of all lines along with the processed line by sed. If we do not want the default pattern space line to be printed, then we need to give the `-n` option. Therefore, we should use the `-n` option and the `p` command together to see the result of the sed processed output.

Here is an example:

```
$ cat country.txt
```

The output is as follows:

```
Country  Capital     ISD Code
USA      Washington  1
China    Beijing     86
Japan    Tokyo       81
India    Delhi       91
$ sed '/USA/p'country.txt
```

The output is as follows:

```
Country  Capital     ISD Code
USA      Washington   1
USA      Washington   1
China    Beijing     86
Japan    Tokyo       81
India    Delhi       91
```

All the lines from the file are printed by default and the lines with the `USA` pattern are also printed:

```
$ sed -n '/USA/p' country.txt
```

The output is as follows:

```
USA  Washington  1
```

As we have given the `-n` option, sed has suppressed default printing of all lines from the `country` file; but has printed the line that contains the text pattern `USA`.

Deleting – the d command

The `d` command is used to delete lines. After `sed` copies a line from a file and puts it into a pattern buffer, it processes commands on that line, and finally, displays the contents of the pattern buffer on screen. When the `d` command is issued, the line currently in the pattern buffer is removed, not displayed which is shown as follows:

```
$ cat country.txt
Country  Capital     ISD Code
USA      Washington   1
China    Beijing     86
Japan    Tokyo       81
India    Delhi       91
$ sed '3d' country.txt
```

The output is as follows:

```
Country      Capital     ISD Code
USA          Washington   1
Japan        Tokyo       81
India        Delhi       91
```

Here is the explanation.

The output will contain all the lines except the third line. The third line is deleted by the following command:

```
$ sed '3,$d' country.txt
```

The output is as follows:

```
Country       Capital     ISD Code
USA           Washington  1
```

This will delete third line to the last line. The dollar sign in the address indicates the last line. The comma is called **range operator**.

```
$ sed '$d' country.txt
```

The output is as follows:

```
Country       Capital     ISD Code
USA           Washington   1
China         Beijing     86
Japan         Tokyo       81
```

Here is the explanation.

This deletes the last line. All lines except lines will be displayed.

`Here is an example:` **`$ sed '/Japan/d' country.txt`**

The output is as follows:

```
Country       Capital     ISD Code
USA           Washington    1
China         Beijing      86
India         Delhi        91
```

The line containing the `Japan` pattern is deleted. All other lines are printed:

```
$ sed '/Japan/!d' country.txt
```

The output is as follows:

```
Japan       Tokyo        81
```

This has deleted all the lines that do not contain `Japan`.

Let's see a few more examples with the `delete` command.

This will delete line 4 and the next five lines:

```
$ sed '4,+5d'
```

This will keep lines 1 to 5 and delete all the other lines:

```
$ sed '1,5!d'
```

This will delete lines 1, 4, 7, and so on:

```
$ sed '1~3d'
```

Starting from 1, every third line step increments. The number that follows the tilde is what is called the **step increment**. The step increment indicates the following:

```
$ sed '2~2d'
```

This will delete every other line starting with line 2 to be deleted.

Substitution – the s command

If we want to substitute the text by new text, then we can use commands. After the forward slash, the regular expression is enclosed and then the text to be substituted is placed. If the `g` option is used, then substitution will happen globally, meaning that it will be applied in the full document. Otherwise, only the first instance will be substituted:

```
$ cat shopping.txt
```

The output is as follows:

```
Product     Quantity   Unit_Price  Total_Cost
Apple        2           3           6
Orange       2           .8          1.6
Papaya       2           1.5         3
Chicken      3           5          15
Cashew       1          10          10
$ sed 's/Cashew/Almonds/g' shopping.txt
```

The output is as follows:

```
Product      Quantity   Unit_Price  Total_Cost
Apple        2           3           6
Orange       2            .8         1.6
Papaya       2           1.5         3
Chicken      3           5          15
Almonds      1          10          10
```

The `s` command has replaced `Cashew` by `Almonds`. The `g` flag at the end indicates that the substitution is to be applied globally. Otherwise, it will be applied to the first pattern match only.

The following substitution command will replace two digit numbers at the end of the line with `.5` appended to them:

```
$ sed 's/[0-9][0-9]$/&.5/' shopping.txt
```

The output is as follows:

```
Product      Quantity  Unit_Price  Total_Cost
Apple        2          3            6
Orange       2           .8          1.6
Papaya       2          1.5          3
Chicken      3          5           15.5
Cashew       1         10           10.5
```

The ampersand in the search pattern represents the exact pattern found. This will be replaced by the exact pattern with `.5` appended to it.

Range of selected lines: the comma

To use the sed effectively, we should be clear about how to define range. **Range** is typically two addresses in a file as follows:

- Range with numbers:

  ```
  '6d': range of line 6
  '3,6d': range from line 3 to 6
  ```

- Range with pattern:

  ```
  '/pattern1/,/pattern2/
  ```

This will specify the range of all the lines between the `pattern1` and `pattern2` patterns. We can even specify th range with a combination of both, that is, `'/pattern/,6'`. This will specify the range of lines between the pattern and line 6.

As mentioned, we can specify the range as numbers, pattern, or a combination of both.

For example:

```
$ cat country.txt
Country  Capital     ISD Code
USA      Washington    1
China    Beijing      86
Japan    Tokyo        81
India    Delhi        91
$ sed -n '/USA/,/Japan/p' country.txt
```

The output is as follows:

```
USA     Washington     1
China   Beijing       86
Japan   Tokyo         81
```

In this example, all the lines between addresses starting from `USA` and until the pattern `Japan` will be printed on screen.

For example:

```
$ sed -n '2,/India/p' country.txt
```

The output is as follows:

```
USA      Washington    1
China    Beijing      86
Japan    Tokyo        81
India    Delhi        91
```

In this example, line 2 to the pattern `India`, are printed on screen.

For example:

```
$ sed '/Apple/,/Papaya/s/$/**   Out of Stock   **/' shopping.txt
```

The output is as follows:

```
Product  Quantity  Unit_Price  Total_Cost
Apple    2          3             6**       Out of Stock    **
Orange   2           .8           1.6**     Out of Stock    **
Papaya   2          1.5           3**       Out of Stock    **
Chicken  3          5            15
Cashew  1          10            10
```

In this example. for all the lines between the `Apple` and `Papaya` patterns, the end of line will be replaced by the `**      Out of Stock    **` string.

Multiple edits – the e command

If we need to perform multiple editing by the same command, then we can use the `-e` command. Each edit command should be separated by the `-e` command. The sed will apply each editing command separated by `-e` on the pattern space before loading the next line in the pattern space:

```
$ cat shopping.txt
```

The output is as follows:

```
Product     Quantity  Unit_Price  Total_Cost
Apple       2          3             6
Orange      2           .8           1.6
Papaya      2          1.5           3
Chicken     3          5            15
Cashew      1         10            10
```

For example:

```
sed -e '5d' -e 's/Cashew/Almonds/' shopping.txt
```

The output is as follows:

```
Product  Quantity  Unit_Price  Total_Cost
Apple    2          3           6
Orange   2           .8          1.6
Papaya   2          1.5          3
Almonds  1         10           10
```

Initially, the command for deleting the fifth line is called, then, the next substitution command to replace `Cashew` by `Almonds` is processed.

Reading from files – the r command

If we need to insert text from another file into the file, which is processed by sed, then we can use the `r` command. We can insert text from another file to the specified location:

For example:

```
$ cat new.txt
```

The output will be:

```
*********************************
    Apples are out of stock

$ sed '/Apple/r new.txt' shopping.txt
```

The output is as follows:

```
Product     Quantity  Unit_Price  Total_Cost
Apple       2         3           6
*********************************
    Apples are out of stock
*********************************
Orange      2          .8         1.6
Papaya      2         1.5         3
Chicken     3         5          15
Cashew      1        10          10
```

The explanation is that, this command has added the content of the `new.txt` file after the line containing the `Apple` pattern.

Writing to files – the w command

The `sed` command for write is `w`. Using this command, we can write lines from one file to another file.

For example:

```
$ cat new.txt
```

The output is as follows:

```
new is a empty file


$ sed -n '/Chicken/w new.txt' shopping.txt
$ cat new.txt
Chicken    3    5    15
```

After the `w` command, we specify the file to which we will perform the write operation. In this example, the line containing the `Chicken` pattern is written to the `new.txt` file.

Appending – the a command

The `a` command is used for **appending**. When the `append` command is used, it appends the text after the line in the pattern space, in which the pattern is matched. The backslash should be placed immediately after the `a` command. On the next line, the text to be appended is to be placed.

For example:

```
$ cat shopping.txt
```

The output is as follows:

```
Product      Quantity  Unit_Price  Total_Cost
Apple        2          3           6
Orange       2           .8         1.6
Papaya       2          1.5         3
Chicken      3          5          15
Cashew       1         10          10


$ sed '/Orange/a\
**** Buy one get one free offer on this item ! ****' shopping.txt
```

The output is as follows:

```
Product    Quantity  Unit_Price  Total_Cost
Apple      2          3           6
Orange     2           .8         1.6
**** Buy one get one free offer on this item ! ****
```

```
Papaya    2          1.5          3
Chicken   3           5          15
Cashew    1          10          10
```

The new text `**** Buy one get one free offer on this item ! ****` is appended after the line containing the `Orange` pattern.

Inserting – the i command

The `i` command is used for **inserting** text above the current pattern space line. When we use the `append` command, new text is inserted after the current line which is in the pattern buffer. In this similar-to-append command, the backslash is inserted after the `i` command.

For example:

```
$ cat shopping.txt
Product     Quantity  Unit_Price  Total_Cost
Apple       2          3            6
Orange      2           .8          1.6
Papaya      2          1.5          3
Chicken     3          5           15
Cashew      1         10           10
$ sed '/Apple/i\
       New Prices will apply from Next month ! ' shopping.txt
```

The output is as follows:

```
Product     Quantity  Unit_Price  Total_Cost
       New Prices will apply from Next month !
Apple           2      3            6
Orange          2       .8          1.6
Papaya          2      1.5          3
Chicken         3      5           15
Cashew          1     10           10
```

In this example, the new text `New Prices will be applied from next month!` is inserted before the line containing the `Apple` pattern. Please check the `i` command and the backslash following it.

Changing – the c command

The `c` command is the **change** command. It allows the sed to modify or change existing text with new text. The old text is overwritten with the new:

```
$ cat shopping.txt
```

The output is as follows:

```
Product     Quantity  Unit_Price  Total_Cost
Apple        2         3           6
Orange       2          .8         1.6
Papaya       2         1.5         3
Chicken      3         5          15
Cashew       1        10          10
```

For example:

```
$ sed '/Papaya/c\
  Papaya is out of stock today !' shopping.txt
```

The output is as follows:

```
Product  Quantity  Unit_Price  Total_Cost
Apple     2         3           6
Orange    2          .8         1.6
  Papaya is out of stock today !
Chicken   3         5          15
Cashew    1        10          10
```

In this example, the line containing the expression `Papaya` is changed by the new line `Papaya is out of stock today!`.

Transform – the y command

The command **transform** is similar to the Linux `tr` command. The characters are translated as per character sequence given. For example, `y/ABC/abc/` will convert lowercase abc into uppercase ABC.

For example:

```
$ cat shopping.txt
```

The output will be:

```
Product     Quantity  Unit_Price  Total_Cost
Apple        2         3           6
Orange       2          .8         1.6
Papaya       2         1.5         3
Chicken      3         5          15
Cashew       1        10          10
$ sed '2,4y/abcdefghijklmnopqrstuvwxyz/ABCDEFGHIJKLMNOPQRS
TUVWXYZ/' shopping.txt
```

The output will be:

```
Product  Quantity  Unit_Price  Total_Cost
APPLE       2        3           6
ORANGE      2        .8          1.6
PAPAYA      2       1.5          3
Chicken     3       5           15
Cashew      1      10           10
```

In this example, on lines 2, 3 and 4, all the lowercase letters are converted to uppercase letters.

Quit – the q command

The q command is used for **quitting** the sed processing without proceeding to the next lines:

```
$ cat shopping.txt
```

The output will be:

```
Product     Quantity  Unit_Price  Total_Cost
Apple         2        3           6
Orange        2         .8         1.6
Papaya        2       1.5          3
Chicken       3       5           15
Cashew        1      10           10
```

For example:

```
$ sed '3q' shopping.txt
```

The output will be:

```
Product  Quantity  Unit_Price  Total_Cost
Apple     2         3           6
Orange    2         .8          1.6
```

In this example, after printing the first to third lines, sed quits further processing.

Holding and getting – the h and g commands

We have already seen that the sed has pattern buffer. The sed has one more type of buffer called **holding buffer**. By the `h` command, we can inform sed to store the pattern buffer in the holding buffer. And whenever we need the line that is stored in the pattern buffer, we can **get** it by the `g` command, that is, get the buffer.

For example:

```
$ sed -e '/Product/h' -e '$g' shopping.txt
```

The output is as follows:

```
Product  Quantity  Unit_Price  Total_Cost
Apple     2          3           6
Orange    2          .8          1.6
Papaya    2         1.5          3
Chicken   3         5            15
Cashew    1        10            10
Product  Quantity  Unit_Price  Total_Cost
```

In this example, the line containing the `Product` pattern is stored in the holding buffer by the `h` command. Then, the next editing command indicates to the `sed` to get the line from the holding buffer when the last line of the file is reached and appends the line from the holding buffer after the last line of the file.

Holding and exchanging – the h and x commands

The `x` is an **exchange** command. By using this command, we can exchange the holding buffer with the current line in the pattern buffer.

For example:

```
$ sed -e '/Apple/h'  -e '/Cashew/x' shopping.txt
```

The output is as follows:

```
Product  Quantity  Unit_Price  Total_Cost
Apple      2         3          6
Orange     2         .8         1.6
Papaya     2       1.5          3
Chicken    3       5           15
Apple      2       3            6
```

In this example, the line with the `Apple` pattern is stored in the holding buffer. When the pattern with `Cashew` is found, that line will be exchanged by the holding buffer.

sed scripting

The sed script file contains a list of sed commands in a file. To inform the sed about our script file, we should use the `-f` option before the script file name. If the `sed` commands are not separated by a new line, then every command should be separated by a colon "`:`". We have to take care that there should not be any training white space after every command in the sed script file; otherwise, the sed will give an error. sed takes each line in the pattern buffer and then, it will process all commands on that line. After this line is processed, the next line will be loaded in the pattern buffer. For the continuation of any `sed` command, which cannot be fitted in one line, we need to add one backslash at the end of the line to inform about continuation.

For example:

```
$ cat shopping1.txt
```

The output is as follows:

```
Product   Quantity  Unit_Price
Apple      200       3
Orange     200        .8
Papaya     100       1.5
Chicken     65       5
Cashew      50      10
April, third week
$ cat stock
```

The output is as follows:

```
# This is my first sed script by :
1i\
Stock status report
/Orange/a\
Fresh Oranges are not available in this season. \
Fresh Oranges will be available from next month
/Chicken/c\
**********************************************************\
We will not be stocking this item for next few weeks.\
**********************************************************
$d
```

Enter the next command as follows:

```
$ sed -f stock shopping1.txt
```

The output is as follows:

```
Stock status report
Product   Quantity  Unit_Price
Apple       200       3
Orange      200        .8
Fresh Oranges are not available in this season.
Fresh Oranges will be available from next month
Papaya      100       1.5
**********************************************************
We will not be stocking this item for next few weeks.
**********************************************************
Cashew       50     10
```

In this script, the following processing has taken place:

1. The comment line starts with the pound (`#`) sign.
2. The command `1i\` informs sed to insert the next text before line number 1.
3. The command `/Orange/a\` informs sed to append the next text after the line containing the `Orange` pattern.
4. The command `/Chicken/c\` informs sed to replace the line containing the `Chicken` pattern by the next line.
5. The last command, `$d`, tells sed to delete the last line of the input file.

Using awk

awk is a program, which has its own programming language for performing data processing and to generate reports.

The GNU version of awk is **gawk**.

awk processes data, which can be received from a standard input, input file, or as the output of any other command or process.

awk processes data similar to sed, such as lines by line. It processes every line for the specified pattern and performs specified actions. If pattern is specified, then all the lines containing specified patterns will be displayed. If `pattern` is not specified, then the specified actions will be performed on all the lines.

The meaning of awk

The name of the program awk is made from the initials of three authors of the language, namely Alfred **A**ho, Peter **W**einberger and Brian **K**ernighan. It is not very clear why they selected the name awk instead of kaw or wak!

Using awk

The following are different ways to use awk:

- Syntax while using only `pattern`:

  ```
  $ awk 'pattern' filename
  ```

  In this case, all the lines containing `pattern` will be printed.

- Syntax using only `action`:

  ```
  $ awk '{action}' filename
  ```

  In this case, `action` will be applied on all lines

- Syntax using `pattern` and `action`:

  ```
  $ awk 'pattern {action}' filename
  ```

  In this case, `action` will be applied on all the lines containing `pattern`.

As seen previously, the `awk` instruction consists of patterns, actions, or a combination of both.

Actions will be enclosed in curly brackets. Actions can contain many statements separated by a semicolon or a newline.

`awk` commands can be on the command line or in the awk script file. The input lines could be received from keyboard, pipe, or a file.

Input from files

Let's see a few examples by using the preceding syntax using input from files:

```
$ cat people.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

Enter the next command as follows:

```
$ awk '/Martin/' people.txt
```

The output is as follows:

```
Fred Martin  6500  22/7/1982
```

This prints a line containing the `Martin` pattern.

For example:

```
$ cat people.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

Enter the next command as follows:

```
$ awk '{print $1}' people.txt
```

The output is as follows:

```
Bill
Fred
Julie
Marie
Tom
```

This `awk` command prints the first field of all the lines from the `people.txt` file:

```
$ cat people.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

For example:

```
$ awk '/Martin/{print $1, $2}' people.txt
Fred Martin
```

This prints the first and second field of the line that contains the `Martin` pattern.

Input from commands

We can use the output of any other Linux command as an input to the awk program. We need to use the pipe to send an output of other command as the input to the awk program.

The syntax is as follows:

```
$ command | awk 'pattern'
$ command | awk '{action}'
$ command | awk 'pattern {action}'
```

For example:

```
$ cat people.txt | awk '$3 > 6500'
```

The output is as follows:

```
Bill Thomas   8000  08/9/1968
Tom Walker    7000  14/1/1977
```

This prints all lines, in which field 3 is greater than `6500`.

For example:

```
$ cat people.txt | awk '/1972$/{print $1, $2}'
```

The output is as follows:

```
Marie Jones
```

This prints fields 1 and 2 of the lines, which ends with the `1972` pattern:

```
$ cat people.txt | awk '$3 > 6500 {print $1, $2}'
```

This prints fields 1 and 2 of the line, in which the third field is greater than `6500`.

How awk works

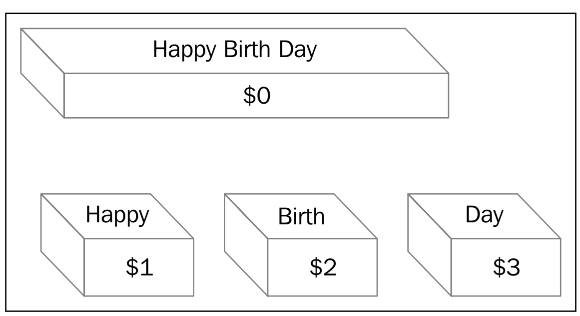
Let's understand how the awk program processes every line. We will consider a simple file, `sample.txt`:

```
$ cat sample.txt
Happy Birth Day
We should live every day.
```

Let's consider the following `awk` command:

```
$ awk '{print $1, $3}' sample.txt
```

The following diagram shows, how the awk will process every line in memory:



The explanation about the preceding diagram is as follows:

- awk reads a line from the file and puts it into an internal variable called `$0`. Each line is called record. By default, every line is terminated by a newline.
- Then, every record or line is divided into separate words or fields. Every word is stored in numbered variables `$1`, `$2`, and so on. There can be as many as 100 fields per record.
- awk has an internal variable called **IFS** (**Internal Field Separator**). IFS is normally whitespace. Whitespace includes tabs and spaces. The fields will be separated by IFS. If we want to specify any other IFS, such as colon `:` in the `/etc/passwd` file, then we will need to specify it in the awk command line.

When awk checks an action as `'{print $1, $3}'`, it tells awk to print the first and third fields. Fields will be separated by space. The command will be as follows:

```
$ awk '{print $1, $3}' sample.txt
```

The output will be as follows:

```
Happy Day
We live
```

the explanation of the output is as follows:

- There is one more internal variable called **Output Field Separator** (**OFS**). This is normally space. This will be used for separating fields, while printing as output.
- Once the first line is processed, awk loads the next line in `$0` and it continues as discussed earlier.

awk commands from within a file

We can put `awk` commands in a file. We will need to use the `-f` option before using the awk script file name to inform about using the awk script file for all processing instructions. awk will copy the first line from the data file to be processed in `$0`, and then, it will apply all processing instructions on that record. Then, it will discard that record and load the next line from the data file. This way, it will proceed till the last line of the data file. If the action is not specified, the pattern matching lines will be printed on screen. If the pattern is not specified, then the specified action will be performed on all lines of the data file.

For example:

```
$ cat people.txt
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ cat awk_script
/Martin/{print $1, $2}
```

Enter the next command as follows:

```
$ awk -f awk_script people.txt
```

The output is as follows:

```
Fred Martin
```

The `awk` command file contains the `Martin` pattern and it specifies the action of printing fields 1 and 2 of the line, matching the pattern. Therefore, it has printed the first and second fields of the line, containing the `Martin` pattern.

Records and fields

Every line terminated by the newline is called **record** and every word separated by white space is called **field**. We will learn more about them in this section.

Records

awk does not see the file as one continuous stream of data; but it processes the file line by line. Each line is terminated by a new line character. It copies each line in the internal buffer called record.

The record separator

By default, a newline or carriage return is an input record separator and output record separator. The input record separator is stored in the built-in variable RS, and the output record separator is stored in ORS. We can modify the ORS and RS, if required.

The $0 variable

The entire line that is copied in buffer, such as record, is called `$0`.

Take the following command for example:

```
$ cat people.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ awk '{print $0}' people.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

This has printed all the lines of the text file. Similar results can be seen by the following command:

```
$ awk '{print}' people.txt
```

The NR variable

awk has a built-in variable called **NR**. It stores the record number. Initially, the value stored in NR is `1`. Then, it will be incremented by one for each new record.

Take, for example, the following command:

```
$ cat people.txt
```

The output will be:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ awk '{print NR, $0}'  people.txt
```

The output will be:

```
1 Bill Thomas  8000  08/9/1968
2 Fred Martin  6500  22/7/1982
```

```
3 Julie Moore  4500  25/2/1978
4 Marie Jones  6000  05/8/1972
5 Tom Walker   7000  14/1/1977
```

This has printed every record, such as `$0` with record number, which is stored in NR. That is why we see 1, 2, 3, and so on before every line of output.

Fields

Every line is called record and every word in record is called **field**. By default, words or fields are separated by whitespace, that is, space or tab. awk has an internal built-in variable called NF, which will keep track of field numbers. Typically, the maximum field number will be 100, which will depend on implementation. The following example has five records and four fields.

For example:

```
$1    $2         $3       $4
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ awk '{print NR, $1, $2, $4}' people.txt
```

The output will be:

```
1 Bill Thomas 08/9/1968
2 Fred Martin 22/7/1982
3 Julie Moore 25/2/1978
4 Marie Jones 05/8/1972
5 Tom Walker  14/1/1977
```

This has printed record number and field numbers 1, 2, and so on, on the screen.

Field separators

Every word is separated by white space. We will learn more about them in this section.

The input field separator

We have already discussed that input field separator is whitespace, by default. We can change this IFS to other values on the command line or by using the `BEGIN` statement. We need to use the `-F` option to change IFS.

For example:

```
$ cat people.txt
```

The output will be:

```
Bill Thomas:8000:08/9/1968
Fred Martin:6500:22/7/1982
Julie Moore:4500:25/2/1978
Marie Jones:6000:05/8/1972
Tom Walker:7000:14/1/1977
$ awk -F: '/Marie/{print $1, $2}' people.txt
```

The output will be:

```
Marie Jones 6000
```

We have used the `-F` option to specify colon (`:`) as IFS instead of the default, IFS. Therefore, it has printed field 1 and 2 of the records in which the `Marie` pattern was matched. We can even specify more than one IFS on the command line as follows:

```
$ awk –F'[ :\t]'  '{print $1, $2, $3}' people.txt
```

This will use space, colon, and tab characters as the inter field separator or IFS.

Patterns and actions

While executing commands using awk, we need to define patterns and actions. Let's learn more about them in this section.

Patterns

awk uses the patterns to control the processing of actions. When pattern or regular expression is found in the record, then action is performed, or if no action is defined then awk simply prints the line on screen.

For example:

```
$ cat people.txt
```

The output will be:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ awk '/Bill/' people.txt
```

The output will be:

```
Bill Thomas  8000  08/9/1968
```

In this example, when the `Bill` pattern is found in the record, that record is printed on screen:

```
$ awk '$3 > 5000' people.txt
```

The output will be:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

In this example, when field 3 is greater than `5000`, that record is printed on screen.

Actions

Actions are performed when the required pattern is found in record. Actions are enclosed in curly brackets such as '`{`' and '`}`'. We can specify different commands in the same curly brackets; but those should be separated by a semicolon.

The syntax is as follows:

```
pattern{ action statement; action statement; .. }
     or
pattern
{    action statement
       action statement
}
```

The following example gives a better idea:

```
$ awk '/Bill/{print $1, $2 ", Happy Birth Day !"}' people.txt
```

Output:

```
Bill Thomas, Happy Birth Day !
```

Whenever a record contains the `Bill` pattern, awk performs the action of printing field 1, field 2 and prints the message `Happy Birth Day`.

Regular expressions

The regular expressions is a pattern enclosed in forward slashes. Regular expression can contain metacharacters. If the pattern matches any string in the record, then the condition is true and any associated action, if mentioned, will be executed. If no action is specified, then simply the record is printed on screen.

Metacharacters used in awk regular expressions are as follows:

Metacharacter	What it does
.	A single character is matched
*	Zero or more characters are matched
^	The beginning of the string is matched
$	The end of the string is matched
+	One or more of the characters are matched
?	Zero or one of the characters are matched
[ABC]	Any one character in the set of characters A, B, or C is matched
[^ABC]	Any one character not in the set of characters A, B, or C is matched
[A–Z]	Any one character in the range from A to Z is matched
a|b	Either a or b is matched
(AB)+	One or more sets of AB; such as AB, ABAB, and so on is matched
*	A literal asterisk is matched
&	This is used to represent the replacement string when it is found in the search string

In the following example, all lines containing regular expression "`Moore`" will be searched and matching record's field 1 and 2 will be displayed on screen:

```
$ awk  '/Moore/{print $1, $2}' people.txt
```

The output is as follows:

```
Julie Moore
```

Writing the awk script file

Whenever we need to write multiple patterns and actions in a statement, then it is more convenient to write a script file. The script file will contain patterns and actions. If multiple commands are on the same line, then those should be separated by a semicolon; otherwise, we need to write them on separate lines. The comment line will start by using the pound (#) sign.

For example:

```
$ cat people.txt
```

The output is as folllows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
```

(The awk script)

```
$ cat report
```

The output is as follows:

```
/Bill/{print "Birth date of " $1, $2 " is " $4}
/^Julie/{print $1, $2 " has a salary of  $" $3 "."}
/Marie/{print NR, $0}
```

Enter the next command as follows:

```
$ awk -f report people.txt
```

The output will be:

```
Birth date of Bill Thomas is 08/9/1968
Julie Moore has a salary of $4500.
4 Marie Jones  6000  05/8/1972
```

In this example, the awk command is followed by the `-f` option, which specifies the script file as `record` and then processes all the commands on the text file `people.txt`.

In this script, regular expression `Bill` is matched, then print text, field 1, field 2, and then print the birth date information. If the regular expression `Julie` is matched at the start of the line, then print her salary information. If regular expression `Marie` is matched, then print the record number NR and print the complete record.

Using variables in awk

We can simply declare a variable in the awk script, without even any initialization. Variables can be of type string, number, or floating type and so on. There is no type declaration required like in C programming. awk will find out the type of variable by its right-hand side data type during initialization or its usage in the script.

Uninitialized variables will have the value `0` or strings will have a value `null` such as "", depending on how it is used inside scripts:

```
name = "Ganesh"
```

The variable `name` is of the string type:

```
j++
```

The variable `j` is a number. Variable `j` is initialized to zero and it is incremented by one:

```
value = 50
```

The variable `value` is a number with initial value `50`.

The technique to modify the string type variable to the number type is as follows:

```
name + 0
```

The technique to modify the number type variable to the string type is as follows:

```
value " "
```

User-defined variables can be made up of letters, digits, and underscores.
The variable cannot start with a digit.

Decision making using an if statement

In awk programming, the `if` statement is used for decision making. The syntax is as follows:

```
if (conditional-expression)
  action1
else
  action2
```

If the condition is true, then `action1` will be performed, else `action2` will be performed. This is very similar to C programming `if` constructs.

An example of using the `if` statement in the `awk` command is as follows:

```
$ cat person.txt
```

The output is as follows:

```
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Julie Moore  4500  25/2/1978
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
$ awk '{
if ($3 > 7000) { print "person with salary more than 7000 is \n", $1, " "
, $2;}
}' people.txt
```

The output is as follows:

```
person with salary more than 7000 is
Bill Thomas
```

In this example, field 3 is checked for `greater than 7000` in every record. If field 3 is greater than `7000` for any record, then the action of printing the name of the person and value of third record will be done.

Using the for loop

The `for` loop is used for doing certain actions repetitively. The syntax is as follows:

```
for(initialization; condition; increment/decrement)
actions
```

Initially, a variable is initialized. Then, the condition is checked, if it is true, then action or actions enclosed in curly brackets are performed. Then, the variable is incremented or decremented. Again, the condition is checked. If the condition is true, then actions are performed, otherwise, the loop is terminated.

An example of the `awk` command with the `for` loop is as follows:

```
$ awk '{ for( i = 1; i <= NF; i++) print NF, $i }' people.txt
```

Initially, the `i` variable is initialized to 1. Then, the condition is checked to see whether `i` is less than NF. If true, then the action of printing NF and the field is performed. Then `i` is incremented by one. Again, the condition is checked if it is true or false. If true, then it will perform actions again; otherwise, it will terminate the looping activity.

Using the while loop

Similar to C programming, awk has a `while` loop for doing the tasks repeatedly. `while` will check for the condition. If the condition is true, then actions will be performed. If condition is false, then it will terminate the loop.

The syntax is as follows:

```
  while(condition)
    actions
```

An example of using the `while` construct in `awk` is as follows:

```
$ cat people.txt
$ awk '{ i  = 1; while ( i <= NF ) { print NF, $i ; i++ } }' people.txt
```

NF is the number of fields in the record. The variable `i` is initialized to 1. Then, while `i` is smaller or equal to NF, the print action will be performed. The `print` command will print fields from the record from the file `people.txt`. In the action block, `i` is incremented by one. The `while` construct will perform the action repeatedly until `i` is less than or equal to NF.

Using the do while loop

The `do while` loop is similar to `while` loop; but the difference is, even if the condition is true, at least once the action will be performed unlike the `while` loop.

The syntax is as follows:

```
do
action
while (condition)
```

After the action or actions are performed, the condition is checked again. If the condition is true, then the action will be performed again, otherwise, the loop will be terminated.

The following is an example of using the `do while` loop:

```
$ cat awk_script
BEGIN {
  do {
    ++x
    print x
  } while ( x <= 4 )
}
$ awk -f awk_script
1
2
3
4
5
```

In this example, `x` is incremented to 1 and value of `x` is printed. Then the condition is checked to see whether `x` is less than or equal to 4. If the condition is true, then the action is performed again.

Summary

In this chapter, you learned about regular expressions and about using sed and awk for text processing. You learned various commands and usage of options along with a lot of examples for using sed and awk. In this example, the value of x is set in the body of the loop using the auto-increment operator. The body of the loop is executed once and the expression is evaluated.

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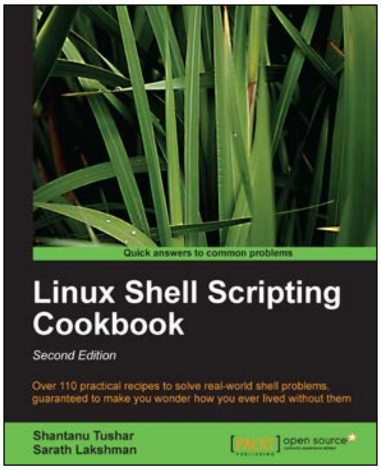

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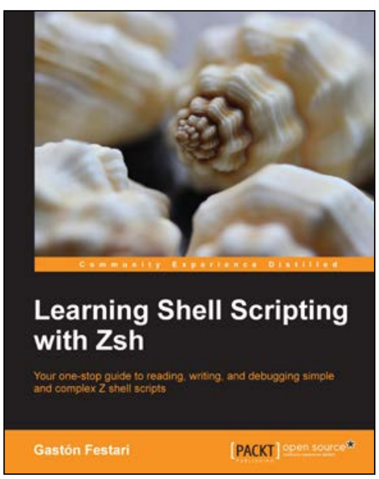

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