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
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
## Credits

**Author**
Ganesh Sanjiv Naik

**Copy Editor**
Charlotte Carneiro

**Reviewers**
Advait Deo
Eax Melanhovich
Shawn Solomon

**Project Coordinator**
Izzat Contractor

**Commissioning Editor**
Nadeem Bagban

**Proofreader**
Safis Editing

**Acquisition Editor**
Tushar Gupta

**Indexer**
Rekha Nair

**Content Development Editor**
Nikhil Potdukhe

**Production Coordinator**
Manu Joseph

**Technical Editor**
Rupali R. Shrawane

**Cover Work**
Manu Joseph
Ganesh Sanjiv Naik is an author, consultant, and corporate trainer for embedded Android, embedded Linux, and Internet of Things related product development.

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
I would like to thank my wife, Vishalakshi, for putting up with my late night writing sessions. Even though Vishalakshi is from microbiology background, on my request, she proofed all the chapters to spot language shortcomings. She patiently read my complete book, and even after not being a programmer, she gave me many valuable suggestions. Without her support and continuous motivation, this book would not have been possible. My professional friend, Kuldeep Vaity, has also read all chapters from a developer's perspective. His feedback was very valuable from technical angles, such as unclear code, insufficient explanation, and similar.

I feel proud to say that the book's cover picture was designed by my daughter, Roopali. She conceptualized the theme and took a lot of effort to properly convey the meaning of the book to readers.

My special thanks to the technical reviewers of the book. Their valuable suggestions have helped me add value to this book.

I would like to thank the entire Packt Publishing team. I would especially like to thank, Aditya Nair and Nikhil Potdukhe of Packt Publishing for the positive, motivating support given to me during the initial period to the end of the completion of this book. Nikhil was very helpful and patient in following up with me for chapters. Due to my busy schedule of consulting and training activities, I was not able to complete my chapters as per schedule; but Nikhil used to follow up very nicely, understandably, and patiently for the chapter's completion. Without his patient follow up, either I would have completed this book very late, or I would have left the writing work incomplete.
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).

Prior to this book, Advait has reviewed *Oracle Database 11g R2 Performance Tuning Cookbook*, Packt Publishing (ISBN 1849682607). He also publishes some of his work and learnings on his website at http://avdeo.com.

**Eax Melanhovich** is 27 and lives in Moscow, Russia. Most people don't know his real name or where he works since Eax is concerned about his privacy. Eax is an author of probably the most popular Russian standalone technical blog eax.me. He is also one of the co-hosts of the popular Russian IT podcast devzen.ru. Eax is an Ubuntu user and a functional programming enthusiast.

**Shawn Solomon** is a technology veteran with a broad background of experience from more than 20 years of pioneering in various technologies. While working in the ISP, VoIP, educational, open source development, and disaster recovery fields, his skillset has adapted and broadened over the years.
Support files, eBooks, discount offers, and more


Did you know that Packt offers eBook versions of every book published, with PDF and ePub files available? You can upgrade to the eBook version at www.PacktPub.com and as a print book customer, you are entitled to a discount on the eBook copy. Get in touch with us at service@packtpub.com for more details.

At www.PacktPub.com, you can also read a collection of free technical articles, sign up for a range of free newsletters and receive exclusive discounts and offers on Packt books and eBooks.

PACKTLib

https://www2.packtpub.com/books/subscription/packtlib

Do you need instant solutions to your IT questions? PacktLib is Packt's online digital book library. Here, you can search, access, and read Packt's entire library of books.

Why subscribe?

- Fully searchable across every book published by Packt
- Copy and paste, print, and bookmark content
- On demand and accessible via a web browser

Free access for Packt account holders

If you have an account with Packt at www.PacktPub.com, you can use this to access PacktLib today and view 9 entirely free books. Simply use your login credentials for immediate access.
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
Table of Contents

Preface ix

Chapter 1: Getting Started and Working with Shell Scripting 1
  Comparison of shells 2
  Tasks done by shell 3
  Working in shell 3
  Learning basic Linux commands 4
  Our first script – Hello World 5
  Compiler and interpreter – difference in process 7
  When not to use scripts 7
  Various directories 8
  Working more effectively with shell – basic commands 9
  Working with permissions 13
    Changing file permissions 13
    Command chmod 14
      Technique one – the symbolic method 14
      Technique two – the numeric method 14
    Setting umask 14
    Setuid 15
    Setgid 15
    Sticky bit 15
  Summary 16

Chapter 2: Drilling Deep into Process Management,
  Job Control, and Automation 17
  Introducing process basics 17
  Monitoring processes using ps 19
  Process management 23
  Process monitoring tools – top, iostat, and vmstat 26
  Understanding "at" 29
Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Understanding &quot;crontab&quot;</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>Using Text Processing and Filters in Your Scripts</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Text filtering tools</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Head and tail</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>The diff command</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>The cut command</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>The paste command</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>The join command</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>The uniq command</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>The comm command</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>The tr command</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>IO redirection</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>File descriptors</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Redirection</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Brace expansion</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Pattern matching with the vi editor</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Pattern searching using grep</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>51</td>
</tr>
<tr>
<td>4</td>
<td>Working with Commands</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Learning shell interpretation of commands</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Checking and disabling shell internal commands</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>The exit status</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Command substitution</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Command separators</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Command1; command2</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Command grouping</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Logical operators</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Command1 &amp; command2</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Command1 &amp;&amp; command2</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Command1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipes</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>63</td>
</tr>
<tr>
<td>5</td>
<td>Exploring Expressions and Variables</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Understanding variables</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Working with environment variables</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>The local variable and its scope</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Exporting variables</td>
<td>71</td>
</tr>
</tbody>
</table>
Table of Contents

Working with read-only variables 74
Working with command line arguments (special variables, set and shift, getopt) 74
    Understanding set 76
    Understanding shift 79
        Resetting positional parameters 81
Understanding getopts 81
Understanding default parameters 83
Working with arrays 84
    Creating an array and initializing it 84
    Accessing array values 85
Summary 87

Chapter 6: Neat Tricks with Shell Scripting 89
Interactive Shell scripts – reading user input 89
    Summarizing the read command with options 92
The here document and the << operator 92
    The here operator with the sort command 93
    The here operator with the wc command 94
    The utility ed and here operator 95
    A script for sending messages to all logged-in users 96
    Using the << here operator for FTP usage and data transfer 96
Turning off variable substitution 97
The here string and the <<< operator 98
File handling 98
    Introducing file handling 99
        Using exec to assign file descriptor (fd) to file 99
    Understanding the opening, writing, and closing of a file 99
    Understanding reading from a file 100
    Understanding reading and writing to a file 101
    Using command read on file descriptor (fd) 101
    Reading from one file and writing to another file 101
        Displaying the file descriptor information from the /proc folder 103
        File handling – reading line by line 104
        Executing the command and storing the results in a file 104
    Summarizing usage of the exec command 105
Debugging 105
    Debugging mode – disabling the shell (option -n) 106
    Debugging mode – displaying commands (option -v) 107
    Debugging mode – the tracing execution (option -x) 109
        Summarizing the debugging options for the Bash shell 112
### Table of Contents

Using the set command 112  
Summary of debugging options for set command 113  
The vi editor setting for debugging 113  
Good practices for Shell scripts 114  
**Summary** 115  

**Chapter 7: Performing Arithmetic Operations in Shell Scripts** 117  
Using a command declare for arithmetic 117  
Listing integers 119  
Using the let command for arithmetic 120  
Using the expr command for arithmetic 122  
Using an arithmetic expansion 124  
Binary, octal, and hex arithmetic operations 128  
A floating-point arithmetic 129  
**Summary** 132  

**Chapter 8: Automating Decision Making in Scripts** 133  
Checking the exit status of commands 134  
Understanding the test command 135  
Using the test command with single brackets 135  
Using the test command with double brackets 136  
String comparison options for the test command 136  
Numerical comparison operators for the test command 138  
File test options for the test command 142  
File testing binary operators 143  
Logical test operators 144  
Conditional constructs – if else 145  
Numerical handling if constructs 147  
Using the command exit and the ? variable 148  
String handling with the if construct 149  
Checking for null values 151  
File handling with the if command 153  
Multiple test commands and if constructs 155  
The if/elif/else command 158  
The null command 160  
Switching case 161  
Implementing simple menus with select 167  
Looping with the for command 172  
Exiting from the current loop iteration with the continue command 177  
Exiting from a loop with a break 179  
Working with the do while loop 181
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using until</td>
<td>184</td>
</tr>
<tr>
<td>Piping the output of a loop to a Linux command</td>
<td>187</td>
</tr>
<tr>
<td>Running loops in the background</td>
<td>188</td>
</tr>
<tr>
<td>The IFS and loops</td>
<td>188</td>
</tr>
<tr>
<td>Summary</td>
<td>189</td>
</tr>
<tr>
<td>Chapter 9: Working with Functions</td>
<td>191</td>
</tr>
<tr>
<td>Understanding functions</td>
<td>191</td>
</tr>
<tr>
<td>Displaying functions</td>
<td>195</td>
</tr>
<tr>
<td>Removing functions</td>
<td>196</td>
</tr>
<tr>
<td>Passing arguments or parameters to functions</td>
<td>196</td>
</tr>
<tr>
<td>Sharing the data by many functions</td>
<td>200</td>
</tr>
<tr>
<td>Declaring local variables in functions</td>
<td>200</td>
</tr>
<tr>
<td>Returning information from functions</td>
<td>202</td>
</tr>
<tr>
<td>Returning a word or string from a function</td>
<td>204</td>
</tr>
<tr>
<td>Running functions in the background</td>
<td>204</td>
</tr>
<tr>
<td>Command source and period (.)</td>
<td>205</td>
</tr>
<tr>
<td>Creating a library of functions</td>
<td>205</td>
</tr>
<tr>
<td>Summary</td>
<td>206</td>
</tr>
<tr>
<td>Chapter 10: Using Advanced Functionality in Scripts</td>
<td>207</td>
</tr>
<tr>
<td>Understanding signals and traps</td>
<td>207</td>
</tr>
<tr>
<td>Using the trap command</td>
<td>209</td>
</tr>
<tr>
<td>Ignoring signals</td>
<td>210</td>
</tr>
<tr>
<td>Resetting signals</td>
<td>210</td>
</tr>
<tr>
<td>Listing traps</td>
<td>211</td>
</tr>
<tr>
<td>Using traps in function</td>
<td>211</td>
</tr>
<tr>
<td>Running scripts or processes even if the user logs out</td>
<td>212</td>
</tr>
<tr>
<td>Creating dialog boxes with the dialog utility</td>
<td>213</td>
</tr>
<tr>
<td>Creating a message box (msgbox)</td>
<td>214</td>
</tr>
<tr>
<td>Creating a message box (msgbox) with a title</td>
<td>214</td>
</tr>
<tr>
<td>The yes/no box (yesno)</td>
<td>215</td>
</tr>
<tr>
<td>The input box (inputbox)</td>
<td>216</td>
</tr>
<tr>
<td>The textbox (textbox)</td>
<td>218</td>
</tr>
<tr>
<td>A password box</td>
<td>218</td>
</tr>
<tr>
<td>The menu box (menu)</td>
<td>219</td>
</tr>
<tr>
<td>The checklist box (checklist)</td>
<td>221</td>
</tr>
<tr>
<td>The radiolist box (radiolist)</td>
<td>221</td>
</tr>
<tr>
<td>The progress meter box (gauge)</td>
<td>222</td>
</tr>
<tr>
<td>Summary</td>
<td>223</td>
</tr>
</tbody>
</table>
# Table of Contents

**Chapter 11: System Startup and Customizing a Linux System** 225

- **System startup, inittab, and run levels** 225
  - The kernel startup and init process 225
  - Understanding run levels 227
  - System initialization boot scripts 227

- **User initialization scripts** 229
  - Systemwide settings scripts 229
  - User level settings – default files 229

- **Summary** 231

**Chapter 12: Pattern Matching and Regular Expressions with sed and awk** 233

- **The basics of regular expressions** 233
- **sed – noninteractive stream editor** 234
  - Understanding sed 235
  - Understanding regular expression usage in sed 235
  - Addressing in sed 236
  - How to modify a file with sed 237
  - Printing – the p command 237
  - Deleting – the d command 238
  - Substitution – the s command 240
  - Range of selected lines: the comma 241
  - Multiple edits – the e command 243
  - Reading from files – the r command 244
  - Writing to files – the w command 244
  - Appending – the a command 245
  - Inserting – the i command 246
  - Changing – the c command 247
  - Transform – the y command 247
  - Quit – the q command 248
  - Holding and getting – the h and g commands 249
  - Holding and exchanging – the h and x commands 249
  - sed scripting 250

- **Using awk** 252
  - The meaning of awk 252
  - Using awk 252
  - Input from commands 254
  - How awk works 255
  - awk commands from within a file 256
Records and fields 257
  Records 257
  Fields 259
  Field separators 259
Patterns and actions 260
  Patterns 260
  Actions 261
Regular expressions 262
Writing the awk script file 263
Using variables in awk 264
Decision making using an if statement 264
Using the for loop 265
Using the while loop 266
Using the do while loop 266
Summary 267
Index 269
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, \texttt{4d3} tells us that line number 4 is deleted in \texttt{file2}. Similarly, the \texttt{change} command will show us changes in the file as well."

A block of code is set as follows:

```bash
#!/bin/bash
# This is comment line
echo "Hello World"
lsl
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:

```bash
$ expr 4 * 10
expr: syntax error
With command expr, we cannot use * for multiplication. We need to use \texttt{\*} 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.

Reader feedback
Feedback from our readers is always welcome. Let us know what you think about this book—what you liked or disliked. Reader feedback is important for us as it helps us develop titles that you will really get the most out of.

To send us general feedback, simply e-mail feedback@packtpub.com, and mention the book’s title in the subject of your message.

If there is a topic that you have expertise in and you are interested in either writing or contributing to a book, see our author guide at www.packtpub.com/authors.

Customer support
Now that you are the proud owner of a Packt book, we have a number of things to help you to get the most from your purchase.

Downloading the color images of this book
We also provide you with a PDF file that has color images of the screenshots/diagrams used in this book. The color images will help you better understand the changes in the output. You can download this file from https://www.packtpub.com/sites/default/files/downloads/LearningLinuxShellScripting_ColorImages.pdf.
Errata

Although we have taken every care to ensure the accuracy of our content, mistakes do happen. If you find a mistake in one of our books—maybe a mistake in the text or the code—we would be grateful if you could report this to us. By doing so, you can save other readers from frustration and help us improve subsequent versions of this book. If you find any errata, please report them by visiting http://www.packtpub.com/submit-errata, selecting your book, clicking on the Errata Submission Form link, and entering the details of your errata. Once your errata are verified, your submission will be accepted and the errata will be uploaded to our website or added to any list of existing errata under the Errata section of that title.

To view the previously submitted errata, go to https://www.packtpub.com/books/content/support and enter the name of the book in the search field. The required information will appear under the Errata section.

Piracy

Piracy of copyrighted material on the Internet is an ongoing problem across all media. At Packt, we take the protection of our copyright and licenses very seriously. If you come across any illegal copies of our works in any form on the Internet, please provide us with the location address or website name immediately so that we can pursue a remedy.

Please contact us at copyright@packtpub.com with a link to the suspected pirated material.

We appreciate your help in protecting our authors and our ability to bring you valuable content.

Questions

If you have a problem with any aspect of this book, you can contact us at questions@packtpub.com, and we will do our best to address the problem.
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:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Bourne</th>
<th>C</th>
<th>TC</th>
<th>Korn</th>
<th>Bash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aliases</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Command-line editing</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Advanced pattern matching</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Filename completion</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Directory stacks (pushd and popd)</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>History</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Functions</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Key binding</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Job control</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Spelling correction</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Prompt formatting</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

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:

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

   ```bash
   #!/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
     $ bash hello.sh
     ```
   - Technique two:
     ```bash
     $ 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.

```bash
$ ./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:

```bash
#!/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:
  ```bash
  $ man man
  ```

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

<table>
<thead>
<tr>
<th>Section number</th>
<th>Subject area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User commands</td>
</tr>
<tr>
<td>2</td>
<td>System calls</td>
</tr>
<tr>
<td>3</td>
<td>Library calls</td>
</tr>
<tr>
<td>4</td>
<td>Special files</td>
</tr>
<tr>
<td>5</td>
<td>File formats</td>
</tr>
<tr>
<td>6</td>
<td>Games</td>
</tr>
<tr>
<td>7</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>8</td>
<td>System admin</td>
</tr>
<tr>
<td>9</td>
<td>Kernel routines</td>
</tr>
</tbody>
</table>

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

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

To list all declared aliases, use the following command:

```bash
$ alias
```

To remove an alias, use the following command:

```bash
$ unalias copy
```

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

```bash
$ uname
```

**Output:**

```
Linux
```

This will display the basic OS information (UNIX name)

- Linux kernel version information will be displayed by the following:
  ```bash
  $ uname -r
  ```
  
  **Output:**
  
  ```
  3.13.0-32-generic
  ```

- To get all the information about a Linux machine, use the following command:
  ```bash
  $ 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:
  ```bash
  $ 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
    < Ctrl + 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-x. 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 drwxrwsrwx.

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.
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_kernel()`.

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
   dhsmasq
   2*[NetworkManager]
   - accounts-daemon {accounts-daemon}
   - acp id
   - anacron  sh  run-parts  apt  sleep
   - aptd
   - avahi-daemon avahi-daemon
   - bamfdaemon 2*[bamfdaemon]
   - bluetoothd
   - colord 2*[colord]
   - console-kit-daemon 64*[console-kit-daemon]
   - 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:
  
  ```bash
  $ ps
  ```
• To list processes along with the parent process ID associated with the current terminal, enter the following command:

```
$ ps -f
```

![Example output showing process ID and parent process ID](image1)

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
```

![Example output showing process state](image2)

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
```

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

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
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.

3. Now, use the following command:
   ```bash
   $ 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:
   ```bash
   $ sleep 20000 &
   $ sleep 30000 &
   $ sleep 40000 &
   ```

5. To check the presence of all the processes, enter the following command:
   ```bash
   $ jobs
   ```
Chapter 2

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.

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
```

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: 2963524k total, 942860k used, 1120664k free, 98244k buffers
Swap: 2894876k total, 0k used, 2894876k 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:
  
  ```bash
  $ iostat
  ```

  ```bash
  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 0.08 98.62
  Device: tps  kb_read/s  kb_wrtt/s  kb_read  kb_wrtt
  sda  3.05  38.06  10.34  478399 129968
  ```

  ```bash
  $ iostat -c
  ```

  Shows only CPU statistics

  ```bash
  $ iostat -d
  ```

  Shows only disk statistics

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

  ```bash
  $ vmstat
  ```
$ 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:

---

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

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

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

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

  ```bash
  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:

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

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
<th>Equivalent To</th>
</tr>
</thead>
<tbody>
<tr>
<td>@reboot</td>
<td>Run once at startup</td>
<td>None</td>
</tr>
<tr>
<td>@weekly</td>
<td>Run once a week</td>
<td>0 0 ** 0</td>
</tr>
<tr>
<td>@daily</td>
<td>Run once a day</td>
<td>0 0 ***</td>
</tr>
<tr>
<td>@midnight</td>
<td>(same as @daily)</td>
<td>0 0 ***</td>
</tr>
<tr>
<td>@hourly</td>
<td>Run once an hour</td>
<td>0 ****</td>
</tr>
</tbody>
</table>

**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.
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. Let's 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
```
Using Text Processing and Filters in Your Scripts

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 contain the login name, encrypted password, user ID, group ID, and user name:
  
  $ cut -d: -f1-5 /etc/passwd
• 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
c
bb
yy
zz
```

- The next command prints only duplicate lines:

```
$ uniq -d test
```

Output:

```
aa
c
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:

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

This will translate the lower case characters to upper case:

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

This will squeeze multiple spaces into a single space:

```bash
$ 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

<table>
<thead>
<tr>
<th>Sr</th>
<th>Examples of command usage</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>sort sample.txt</td>
<td>Alphabetically sorting of lines</td>
</tr>
<tr>
<td>2</td>
<td>sort -u sample.txt</td>
<td>Duplicate entries are sorted</td>
</tr>
<tr>
<td>3</td>
<td>sort -r sample.txt</td>
<td>Reverse sort</td>
</tr>
<tr>
<td>4</td>
<td>sort-n -k3 sample.txt</td>
<td>Numerical sorting of the 3rd field</td>
</tr>
</tbody>
</table>

**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.txt` 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

[42]
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.txt 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:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt; sample.txt</code></td>
<td>The command will take input from <code>sample.txt</code></td>
</tr>
<tr>
<td><code>&gt; sample.txt</code></td>
<td>The success result will be stored in <code>sample.txt</code></td>
</tr>
<tr>
<td><code>&gt;&gt; sample.txt</code></td>
<td>The successive outputs will be appended to <code>sample.txt</code></td>
</tr>
<tr>
<td><code>2&gt; sample.txt</code></td>
<td>The error results will be stored in <code>sample.txt</code></td>
</tr>
<tr>
<td><code>2&gt;&gt; sample.txt</code></td>
<td>The successive error output will be appended to <code>sample.txt</code></td>
</tr>
<tr>
<td><code>&amp;&gt; sample.txt</code></td>
<td>This will store success and errors, such as in <code>sample.txt</code></td>
</tr>
<tr>
<td><code>&gt;&amp; sample.txt</code></td>
<td>This will store success and errors, such as in <code>sample.txt</code> (same as above)</td>
</tr>
<tr>
<td><code>2&gt;&amp;1</code></td>
<td>This will redirect an error to where output is going</td>
</tr>
<tr>
<td><code>1&gt;&amp;2</code></td>
<td>This will redirects output to where error is going</td>
</tr>
<tr>
<td>`&gt;</td>
<td>`</td>
</tr>
<tr>
<td><code>&lt; filename</code></td>
<td>This uses the file as both standard input and output if a device file (from <code>/dev</code>)</td>
</tr>
<tr>
<td><code>cat xyz &gt; success_file</code></td>
<td>This stores success and failure in different files</td>
</tr>
</tbody>
</table>
The following is the summary of various metacharacters:

<table>
<thead>
<tr>
<th>Char</th>
<th>Meaning</th>
<th>Example</th>
<th>Possible output</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>Match with zero or multiple number of any character</td>
<td><code>$ ls -l *.c file*</code></td>
<td>Sample.c, hello.c, file1, file_2, filebc</td>
</tr>
<tr>
<td>?</td>
<td>Match any single character</td>
<td><code>$ ls -l file?</code></td>
<td>filea, fileb, file1</td>
</tr>
<tr>
<td>[ ]</td>
<td>Match with any single character with in the bracket</td>
<td><code>$ ls -l file[abc]</code></td>
<td>filea, fileb, filec</td>
</tr>
<tr>
<td>;</td>
<td>Command separator</td>
<td><code>$ cat filea; date</code></td>
<td>Displays the content of filea and displays the current date and time</td>
</tr>
<tr>
<td></td>
<td>Pipe two commands</td>
<td>`$ cat filea</td>
<td>wc -l`</td>
</tr>
<tr>
<td>()</td>
<td>Group commands, used when the output of the command group has to be redirected</td>
<td><code>$ (echo &quot;***x.c***&quot;; cat x.c) &gt; out</code></td>
<td>Redirects the content of x.c with a heading <em><strong>x.c</strong></em> to the file out</td>
</tr>
</tbody>
</table>

Run the following command:

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

Try the following command out:

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

For example:

```bash
$ 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:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Commands</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>:set hlsearch</td>
<td>This highlights search pattern</td>
</tr>
<tr>
<td>2</td>
<td>:set showmode</td>
<td>Show when you are in insert mode</td>
</tr>
<tr>
<td>3</td>
<td>:set ic</td>
<td>Ignore case when searching</td>
</tr>
<tr>
<td>4</td>
<td>:set noic</td>
<td>Shows case sensitive search</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Commands</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/pat</td>
<td>This searches for the pattern pat and places the cursor where the pattern occurs</td>
</tr>
<tr>
<td>2</td>
<td>/</td>
<td>This repeats the last search</td>
</tr>
<tr>
<td>3</td>
<td>:%s/old/new/g</td>
<td>Globally, all the occurrences of old will be replaced by new</td>
</tr>
<tr>
<td>4</td>
<td>#:,#s/old/new/g</td>
<td>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</td>
</tr>
</tbody>
</table>

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
```
Using Text Processing and Filters in Your Scripts

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

Use the following commands for testing pattern searching facilities:

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

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"

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

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

```bash
$ 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:

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

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
```

[ 49 ]
We will try the following commands on the sample.txt file:

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>grep Fruit sample.txt</td>
<td>This will show all lines with pattern Fruit.</td>
</tr>
<tr>
<td>2</td>
<td>grep Fruit G* sample.txt</td>
<td>This searches pattern Fruit in all files starting with G.</td>
</tr>
<tr>
<td>3</td>
<td>grep &quot;M&quot; sample.txt</td>
<td>This searches all lines starting with M.</td>
</tr>
<tr>
<td>4</td>
<td>grep '6$' sample.txt</td>
<td>This searches lines ending with 6.</td>
</tr>
<tr>
<td>5</td>
<td>grep '1..' sample.txt</td>
<td>This displays lines containing 1 and any character after it.</td>
</tr>
<tr>
<td>6</td>
<td>grep '.6' sample.txt</td>
<td>This shows lines containing .6.</td>
</tr>
<tr>
<td>7</td>
<td>grep '^[AT]' sample.txt</td>
<td>This searches lines starting with A or T.</td>
</tr>
<tr>
<td>8</td>
<td>grep '[0-9]' sample.txt</td>
<td>This contains at least one alphabet.</td>
</tr>
<tr>
<td>9</td>
<td>grep '[A-Z][A-Z] [A-Z]' sample.txt</td>
<td>This searches the upper case, upper case space, and upper case word.</td>
</tr>
<tr>
<td>10</td>
<td>grep '[a-z]{8}' sample.txt</td>
<td>This displays all lines in which there are at least eight consecutive lowercase letters.</td>
</tr>
<tr>
<td>11</td>
<td>grep '&lt;Fruit&gt;' sample.txt</td>
<td>This displays all lines containing a word starting with Fruit. The &lt; is the beginning-of-word anchor.</td>
</tr>
<tr>
<td>12</td>
<td>grep '&lt;Fruit&gt;' sample.txt</td>
<td>This displays the line if it contains the word Fruit. The &lt; is the beginning-of-word anchor and the &gt; is the end-of-word anchor.</td>
</tr>
<tr>
<td>13</td>
<td>grep '&lt;[A-Z].*o&gt;' sample.txt</td>
<td>This displays all lines containing a word starting with an uppercase letter, followed by any number of characters and a word ending in o.</td>
</tr>
<tr>
<td>14</td>
<td>grep -n '^south' sample.txt</td>
<td>This displays line numbers also.</td>
</tr>
<tr>
<td>15</td>
<td>grep -i 'pat' sample.txt</td>
<td>This displays case insensitive search.</td>
</tr>
<tr>
<td>16</td>
<td>grep -v 'Onion' sample.txt &gt; temp mv temp sample.txt</td>
<td>This deletes the line containing pattern.</td>
</tr>
<tr>
<td>17</td>
<td>grep -l 'Nuts' *</td>
<td>This lists files containing pattern.</td>
</tr>
<tr>
<td>18</td>
<td>grep -c 'Nuts' sample.txt</td>
<td>This prints the number of lines where pattern is present.</td>
</tr>
<tr>
<td>19</td>
<td>grep -w 'Nuts' sample.txt</td>
<td>This counts where the whole world pattern is present, not a part of the word.</td>
</tr>
</tbody>
</table>
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.
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
Working with Commands

- 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 -aFl'

$ 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
Working with Commands

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

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

• 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:

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

Output:

```
Today is date
```

A similar example:

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

Or:

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

Output:

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

Further, similar examples include:

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

In this example, new lines are lost.

Another example:

```bash
$ echo "$\$(cal)"
```

Here, the display is properly formatted.

Next, nesting of commands is as follows:

```bash
$ pwd
/home/student/work
```
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.

```bash
$ w; date
```

Output:

```
Fri Mar 20 15:57:23 IST 2015
```

```bash
$ 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
cmd 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:

```bash
$ 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".

```bash
$ 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".

```bash
$ 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
```

[62]
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.
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.

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

To get the content of the variable we need to prefix `§` before the variable.
Exploring Expressions and Variables

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:

```bash
#!/bin/bash
# This script clears the window, greets the user,
# and displays the current date and time.
```
clear                                   # Clear the window
echo "SCRIPT BEGINS"
# Greet the user
echo "Hello $LOGNAME!"

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

my_num=50
my_day="Sunday"

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

SCRIPT BEGINS!!
SCRIPT FINISHED!!

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

#!/bin/bash

planet="Earth"

echo $planet

echo "$planet"

echo \$planet

echo Enter some text
read planet
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:

```bash
$ env
```

Or:

```bash
$ printenv
```
Output:

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:

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

```bash
# 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
echo "Your Timezone is = $TZ"
date

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

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:

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

Create another shell script `export2.sh`

```bash
#!/bin/bash
echo "$foo"
echo "$bar"
```

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.
Exploring Expressions and Variables

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:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
<td>Shell script name or command</td>
</tr>
<tr>
<td>$1-$9</td>
<td>Positional parameters 1–9</td>
</tr>
<tr>
<td>$[10]</td>
<td>Positional parameter 10</td>
</tr>
<tr>
<td>$#</td>
<td>Total number of parameters</td>
</tr>
<tr>
<td>$*</td>
<td>Evaluates to all the positional parameters</td>
</tr>
<tr>
<td>$@</td>
<td>Same as $*, except when double quoted</td>
</tr>
<tr>
<td>&quot;$*&quot;</td>
<td>Displays all parameters as &quot;$1 &quot;$2 &quot;$3&quot;, and so on</td>
</tr>
<tr>
<td>&quot;$@&quot;</td>
<td>Displays all parameters as &quot;$1&quot; &quot;$2&quot; &quot;$3&quot;, and so on</td>
</tr>
</tbody>
</table>

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

```bash
#!/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:

```bash
$ 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:

```bash
#!/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
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:

```bash
#!/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 08:36:53 IST 2015
The month is Apr
```

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:

```bash
#!/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:

```
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:

```bash
#!/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

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.

[79]
Create a `shift_02.sh` script as follows:

```bash
#!/bin/bash

echo '\$#: ' $#
echo '\$@: ' @$
echo '\$*: ' $*
echo
'
'
'
'
'
'
'

shift
echo '\$#: ' $#
echo '\$@: ' @$
echo '\$*: ' $*
'
'
'
'
'

shift 2
echo '\$#: ' $#
echo '\$@: ' @$
echo '\$*: ' $*
'
'
'
'
'

echo '\$1 $2 $9 $9 are: ' $1 $2 $9 $9

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

```bash
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:

```bash
oldargs=$*
```

Then, we can set new positional parameters. Later on, we can bring back our original positional parameters as follows:

```bash
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:

```bash
#!/bin/bash

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

while getopts :xy: opt_char
do
```

Exploring Expressions and Variables

```bash
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:

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

Execute the script and check:

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

Create another `default_argument_2.sh` script:

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

Output:

```
student@ubuntu:/Desktop/work$ ./default_argument_2.sh One Two
One
Two
student@ubuntu:/Desktop/work$
student@ubuntu:/Desktop/work$ ./default_argument_2.sh One
One
student@ubuntu:/Desktop/work$
```

[83]
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[0]}
```

Create an `array_02.sh` script as follows:

```bash
#!/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:

```
```

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.
```

[86]
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.
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:
   ```bash
   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 \(\text{REPLY}\).

Let's write a simple script \(\text{read}_01.sh\), 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 \(\text{read}_02.sh\). 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[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:

<table>
<thead>
<tr>
<th>Format</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>read</td>
<td>This command will read text from a keyboard and store the received text in a built-in variable <code>REPLY</code>.</td>
</tr>
<tr>
<td>read value</td>
<td>This reads a text from a keyboard or standard input and stores it into the variable value.</td>
</tr>
<tr>
<td>read first last</td>
<td>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.</td>
</tr>
<tr>
<td>read –e</td>
<td>This is used in interactive shells for command-line editing. If vi editor is used, then vi commands can be used.</td>
</tr>
<tr>
<td>read –a array_name</td>
<td>This will store a list of words received in to an array.</td>
</tr>
<tr>
<td>read –r line</td>
<td>The text with backslash can be received here.</td>
</tr>
<tr>
<td>read –p prompt</td>
<td>This will print the prompt and wait for the user input. The received text will be stored in the variable <code>REPLY</code>.</td>
</tr>
</tbody>
</table>

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:

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

Let's write the script \texttt{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:

\begin{verbatim}
Command is here\_01.sh
First Argument is Monday
Second Argument is Tuesday
\end{verbatim}

The text block created in the preceding script between the \texttt{quit} words is called as the \texttt{here} document. We can treat this \texttt{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 \texttt{sort} command along with the \texttt{here} document:

1. Write the script \texttt{here\_02.sh} as follows:
```
#!/bin/bash
sort << EOF
> cherry
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`:
   ```bash
   #!/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:
   ```bash
   $ 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`:
   ```bash
   #!/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`:

```bash
#!/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:

```bash
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
$ 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:

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

1. Let's see the following example `hereString_01.sh`:

```bash
#!/bin/bash
wc -w <<< 'Good Morning and have a nice day !'
```

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

```bash
$ 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:
```bash
#!/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
```
Neat Tricks with Shell Scripting

```
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
$ cat file_02.sh
$ sample_input.txt
```

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
"">
# 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

exef 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:

```bash
#!/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 $0 script :"
ls -1 /proc/$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:

```bash
#!/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`:

```bash
#!/bin/bash
exec 4> output.txt
cat /proc/cpuinfo >&4
eexec 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:
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:

<table>
<thead>
<tr>
<th>Command</th>
<th>What it does</th>
</tr>
</thead>
<tbody>
<tr>
<td>exec command</td>
<td>This command will replace shell and execute it. Therefore, it will not return to its original shell, which started it.</td>
</tr>
<tr>
<td>exec &gt; data.txt</td>
<td>This opens <code>data.txt</code> for writing standard output.</td>
</tr>
<tr>
<td>exec &lt; data.txt</td>
<td>This opens <code>data.txt</code> for reading standard input.</td>
</tr>
<tr>
<td>exec 3&lt; data.txt</td>
<td>This opens <code>data.txt</code> for reading with descriptor 3.</td>
</tr>
<tr>
<td>sort &lt;&amp;3</td>
<td>This will sort <code>data.txt</code> file</td>
</tr>
<tr>
<td>exec 4&gt;data.txt</td>
<td>This opens <code>data.txt</code> for writing with descriptor 4.</td>
</tr>
<tr>
<td>ll &gt;&amp;4</td>
<td>The output of <code>ll</code> is redirected to <code>data.txt</code>.</td>
</tr>
<tr>
<td>exec 6&lt;&amp;5</td>
<td>This makes fd 6 a copy of fd 5</td>
</tr>
<tr>
<td>exec 4&lt;&amp;-</td>
<td>This closes fd 4.</td>
</tr>
</tbody>
</table>

### 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:
  
  o debug_sp: line 11: [7: command not found]
  o 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:

```bash
cat hello.sh
```

```bash
$ 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`:

```bash
#!/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:

```bash
$ 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
$ 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
date
"Your present working directory is $PWD
date
"Your present working directory is /home/student/work
date
Good-bye $LOGNAME
Good-bye student

[ 108 ]
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:

```bash
$ 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
$ bash –n debug_03.sh One Two
```

Let's test the same script with the –v option:

```bash
$ 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 :
  =
  ls d* debug_02.sh debug_03.sh in current folder are:
  =
  debug_02.sh debug_03.sh"
```
Let us test the same script with the \texttt{-x} option:

\begin{verbatim}
$ bash -x debug_03.sh One Two
\end{verbatim}

\textbf{Output:}

\begin{verbatim}
+ echo \texttt{`342\200\234Total' number of parameters are = \texttt{2`342\200\235'}
"Total number of parameters are = 2"
+ echo \texttt{`342\200\234Script' name = \texttt{debug_03.sh342\200\235'}
"Script name = debug_03.sh"
+ echo \texttt{`342\200\234First' Parameter is \texttt{India342\200\235'}
"First Parameter is India"
+ echo \texttt{`342\200\234Second' Parameter is \texttt{Delhi342\200\235'}
"Second Parameter is Delhi"
+ echo \texttt{`342\200\234All' parameters are = India Delhi342\200\235'}
"All parameters are = India Delhi"
+ echo \texttt{`342\200\234File' names starting with debug_02.sh debug_03.sh in current folder are \texttt{`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
\end{verbatim}

Let's test one more program, which will give a syntax error during the \texttt{-n} and \texttt{-x} options debugging. Write the Shell script \texttt{debug_04.sh} as follows:

\begin{verbatim}
#!/bin/bash
  echo "Commands in bin directory are : $var"
  for var in $(ls )
do
    echo -n -e "$var   
do
\end{verbatim}

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

\begin{verbatim}
$ chmod u+x debug_04.sh
$ bash -n debug_04.sh
\end{verbatim}

\textbf{Output:}

\begin{verbatim}
d debug_04.sh: line 7: syntax error near unexpected token `do'
d debug_04.sh: line 7: `do'
\end{verbatim}
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:

```bash
#!/bin/bash
str1="USA"
str2="Canada";

[ $str1 = $str2 ]
echo $?
Set –x

[ $str1 != $str2 ]
echo $?;
```

[112]
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:

<table>
<thead>
<tr>
<th>Short notation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>set -f</td>
<td>Disables globbing. In this case, the file name expansions using wildcards or metacharacters will be disabled.</td>
</tr>
<tr>
<td>set -v</td>
<td>This will print the Shell script lines as they are read by the shell.</td>
</tr>
<tr>
<td>set -x</td>
<td>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.</td>
</tr>
<tr>
<td>set -n</td>
<td>This reads all commands and checks the syntax, but does not execute them.</td>
</tr>
</tbody>
</table>

**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:

```bash
: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:

   ```bash
   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:

   ```bash
   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.
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.
Performing Arithmetic Operations in Shell Scripts

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
  $ 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:

```bash
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"
```
Performing Arithmetic Operations in Shell Scripts

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:

```bash
$ 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-precendence 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:

```bash
$ 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: <=, >=, <, >
Performing Arithmetic Operations in Shell Scripts

- Bitwise AND: &
- Bitwise OR: |
- 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`
```

```bash
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
```
Performing Arithmetic Operations in Shell Scripts

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 a^b
$ 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, \(4 \times 5\) 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:

```bash
#!/bin/bash
echo "Enter first value"
read number_1
echo "Enter second value"
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.
Performing Arithmetic Operations in Shell Scripts

Let's write the shell called script arithmetic_04.sh as follows:

```bash
#!/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:

```bash
#!/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
  ```
In the preceding examples, we displayed the decimal 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/](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
Performing Arithmetic Operations in Shell Scripts

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:

```bash
$ 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:

```bash
#!/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"
```

Let's test the program:

```bash
$ 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.
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 \texttt{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 \texttt{test}
- Using \texttt{if-else}
- Switching \texttt{case}
- Using \texttt{select}
- Working with the \texttt{for} loop
- Working with the \texttt{while} loop
- Controlling loops:
  - The \texttt{continue} statement
  - The \texttt{break} statement
Automating Decision Making in Scripts

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
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 " ".

```
$ echo $?
1        # non zero values means error
```
Automating Decision Making in Scripts

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/:

<table>
<thead>
<tr>
<th>Test operator</th>
<th>Tests true if</th>
</tr>
</thead>
<tbody>
<tr>
<td>-n string</td>
<td>True if the length of string is nonzero.</td>
</tr>
<tr>
<td>-z string</td>
<td>True if the length of string is zero.</td>
</tr>
<tr>
<td>string1 != string2</td>
<td>True if the strings are not equal.</td>
</tr>
<tr>
<td>string1 == string2</td>
<td>True if the strings are equal.</td>
</tr>
<tr>
<td>string1 = string2</td>
<td></td>
</tr>
<tr>
<td>string1 &gt; string2</td>
<td>True if string1 sorts after string2 lexicographically.</td>
</tr>
<tr>
<td>string1 &lt; string2</td>
<td>True if string1 sorts before string2 lexicographically.</td>
</tr>
</tbody>
</table>

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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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`:

<table>
<thead>
<tr>
<th>Test Operator</th>
<th>Tests True If</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[ integer_1 -eq integer_2 ]</code></td>
<td>integer_1 is equal to integer_2</td>
</tr>
<tr>
<td><code>[ integer_1 -ne integer_2 ]</code></td>
<td>integer_1 is not equal to integer_2</td>
</tr>
<tr>
<td><code>[ integer_1 -gt integer_2 ]</code></td>
<td>integer_1 is greater than integer_2</td>
</tr>
<tr>
<td><code>[ integer_1 -ge integer_2 ]</code></td>
<td>integer_1 is greater than or equal to integer_2</td>
</tr>
<tr>
<td><code>[ integer_1 -lt integer_2 ]</code></td>
<td>integer_1 is less than integer_2</td>
</tr>
<tr>
<td><code>[ integer_1 -le integer_2 ]</code></td>
<td>integer_1 is less than or equal to integer_2</td>
</tr>
</tbody>
</table>

Let's write the Shell script `test03.sh` for learning various the numerical test operators' usage:

```bash
#!/bin/bash
num1=10
num2=30

echo `($(num1 < num2))` # compare for less than
[ $num1 -lt $num2 ]      # compare for less than
echo $?
Let's test the following program:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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

Let's write the script `test05.sh` for using string and numerical test operations:

```bash
#!/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:

```bash
#!/bin/bash
echo "Please enter 1st Number"
read num1
echo "Please enter 2nd Number"
read num2
echo

# Test for Equal
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 $?;

# Test for Two Strings Are Equal

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
```
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:

<table>
<thead>
<tr>
<th>Test Operator</th>
<th>Tests True If</th>
</tr>
</thead>
<tbody>
<tr>
<td>-b file_name</td>
<td>Check if file is Block special file</td>
</tr>
<tr>
<td>-c file_name</td>
<td>Check if file is Character special file</td>
</tr>
<tr>
<td>-d file_name</td>
<td>Check if Directory is existing</td>
</tr>
<tr>
<td>-e file_name</td>
<td>Check if File existence</td>
</tr>
<tr>
<td>-f file_name</td>
<td>Check if file is Regular file and not a directory</td>
</tr>
<tr>
<td>-g file_name</td>
<td>Check if file has Set-group-ID set</td>
</tr>
<tr>
<td>-k file_name</td>
<td>Check if file has Sticky bit set</td>
</tr>
<tr>
<td>-L file_name</td>
<td>Check if file is a symbolic link</td>
</tr>
<tr>
<td>-p file_name</td>
<td>Check if file is a named pipe</td>
</tr>
<tr>
<td>-u file_name</td>
<td>Check if file exists and is owned by the effective user ID</td>
</tr>
<tr>
<td>-r file_name</td>
<td>Check if file is readable</td>
</tr>
<tr>
<td>-S file_name</td>
<td>Check if file is a socket</td>
</tr>
<tr>
<td>-z file_name</td>
<td>Check if file has nonzero size</td>
</tr>
<tr>
<td>-t fd</td>
<td>Check if file has fd (file descriptor) and is opened on a terminal</td>
</tr>
<tr>
<td>-u file_name</td>
<td>Check if file has Set-user-ID bit set</td>
</tr>
<tr>
<td>-w file_name</td>
<td>Check if file is writable</td>
</tr>
<tr>
<td>-x file_name</td>
<td>Check if file is executable</td>
</tr>
</tbody>
</table>
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/:

<table>
<thead>
<tr>
<th>Test Operator</th>
<th>Tests True If</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ file_1 -nt file_2 ]</td>
<td>Check if file is newer than file2</td>
</tr>
<tr>
<td>[ file_1 -ot file_2 ]</td>
<td>Check if file is file1 is older than file2</td>
</tr>
<tr>
<td>[ file_1 -ef file_2 ]</td>
<td>Check if file1 and file2 have the same device or inode numbers</td>
</tr>
</tbody>
</table>

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:

```bash
#!/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:

```bash
#!/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/`:

<table>
<thead>
<tr>
<th>Test Operator</th>
<th>Tests True If</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[ string_1 -a string_1 ]</code></td>
<td>Both string_1 and string_2 are true</td>
</tr>
<tr>
<td><code>[ string_1 -o string_2 ]</code></td>
<td>Either string_1 or string_2 is true</td>
</tr>
<tr>
<td><code>! string_1</code></td>
<td>Not a string_1 match</td>
</tr>
<tr>
<td><code>[[ pattern_1 &amp;&amp; pattern_2 ]]</code></td>
<td>Both pattern_1 and pattern_2 are true</td>
</tr>
<tr>
<td>`[[ pattern_1</td>
<td></td>
</tr>
<tr>
<td><code>[[ ! pattern ]]</code></td>
<td>Not a pattern match</td>
</tr>
</tbody>
</table>
We can use the test operator for strings along with pattern matching as follows:

```bash
$ name=Ganesh
$ [[ $name == [Gg]anesh ]]       # Wildcards allowed
$ echo $? 0
```

The following is the example for multiple strings with the && logical operator:

```bash
$ 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:

```bash
$ shopt -s extglob     # we are enabling extended pattern matching
$ city=Kannur
$ [[ $city == [Ik]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:

```bash
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:
```bash
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:
```bash
if [ string/numeric expression ]
    then
        command
fi
```

Alternatively, use the following syntax:
```bash
if [[ string expression ]]
    then
        command
fi
```

Alternatively, use the following syntax:
```bash
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:
```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/bin/bash
echo "Enter the cost of product a"
read a
echo "Enter the cost of product b"
read b
```
Automating Decision Making in Scripts

```bash
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:

```bash
#!/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:

```bash
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:

```bash
$ chmod +x if_03.sh
$ ./if_03.sh
```

The following will be the output after executing the preceding commands:

```bash
$ ./ 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:

```bash
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:

```bash
#!/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:

```bash
#!/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:

```bash
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:

```bash
#!/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
Automating Decision Making in Scripts

```bash
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:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
#!/bin/bash
file1="File1"
file2="File2"
if cp $file1 $file2
then
    echo "Copy Command Executed Successfully"
    echo "Content of file named File1 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 File1 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:

```bash
#!/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
$ ./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:

```bash
#!/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:

```bash
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:

```bash
#!/bin/bash

echo "Kindly enter name of directory : ">
read file

if [[ -d $file ]]
then
   echo "$file is a directory"
else
   echo "$file is a file."
fi
```

```bash
else
   echo "$file is neither a file nor a directory. "
fi
```
Let's test the program:

```bash
$ chmod +x if_18.sh
$ ./is_18.sh
```

The following will be the output after executing the preceding commands:

```bash
$ ./ 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:

```bash
    case variable in
        value1)
            command(s)
        ;;
        value2)
            command(s)
        ;;
        *)
            command(s)
        ;;
    esac
```

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:

```bash
#!/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"
       ;;
     *) echo "Invalid key"
       ;;
    esac
```
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
Automating Decision Making in Scripts

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:

```bash
#!/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:

```bash
#!/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][aR][eE])
    echo "Second Day Tuesday"
  ;;
  [wW][eE][dD][nN][eE][sS][aR][eE])
    echo "Third Day Wednesday"
  ;;
  [tT][hH][rR][uU][sS][aR][eE])
    echo "Fourth Day Thursday"
  ;;
  [fF][rR][iI][yY][aA][yY])
    echo "Fifth Day Friday"
  ;;
  [sS][aA][tT][uU][rR][aA][yY])
    echo "Sixth Day Saturday"
  ;;
  [sS][uU][nN][dD][aA][yY])
    echo "Seventh Day Sunday"
  ;;
  *)
    echo "Invalid Day of Week"
  ;;
estac
```
Let's test the program:

```bash
$ chmod +x case_04.sh
$ ./case_04.sh
```

The following will be the output after executing the preceding commands:

```bash
$ ./ 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:

```bash
#!/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:

```bash
$ 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:

```bash
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`:

```bash
#!/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
**Automating Decision Making in Scripts**

"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

[168]
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"
```
Automating Decision Making in Scripts

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:

```bash
#!/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" ;;
one) break ;;
*) echo "ERROR: Invalid selection, $REPLY." ;;
esac
done
```

Let's test the program:

```bash
$ 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:

```bash
#!/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:

```bash
for variable in element1 element2 element3
do
commands
done
```

The simple script with the *for* loop could be as follows:

```bash
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:

```bash
for ((;;))
do
  command
done
```
Let's write a simple script `for_01.sh`. In this script, we will print the `var` variable 10 times:

```bash
#!/bin/bash
for var in {1..10}
done
```

Let's test the program:

```bash
$ chmod +x for_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:

```bash
#!/bin/bash
max=10
for ((i=1; i<=max; i++))
done
```

Let's test the program:

```bash
$ chmod +x for_02.sh
$ ./for_02.sh
```

The following will be the output after executing the preceding commands:

```
1
2
3
4
5
6
7
8
9
10
```
Automating Decision Making in Scripts

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:

```bash
#!/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
```
In the following script for_04.sh, we create users11 to user20 along with their home directory:

```bash
#!/bin/bash
for var in user{11..20}
do
  useradd -m $var
  passwd -d $var
done
```

Let's test the program:

```bash
$ chmod +x for_04.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:

```bash
#!/bin/sh
for var in $*
do
  echo "command line contains: $var"
done
```

Let's test the program:

```bash
$ 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
```

[175]
Automating Decision Making in Scripts

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:

```bash
#!/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:

```bash
$ 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:

```bash
$ 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:

```bash
#!/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:

```bash
#!/bin/bash
for x in 1 2 3
do
    echo before $x
    continue 1
    echo after $x
done
exit 0
```
Automating Decision Making in Scripts

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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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
        #!/bin/bash
```
Automating Decision Making in Scripts

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 ))
        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 content:

```bash
#!/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
```
Automating Decision Making in Scripts

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
Automating Decision Making in Scripts

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:

```bash
#!/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 ""
```

Automating Decision Making in Scripts

```
    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`:

```bash
#!/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:

```bash
#!/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:

```bash
#/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.
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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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
```
Working with Functions

Output:

```bash
hello ()
{
    echo 'Hello world!' 
}
```

**Removing functions**

If we no longer need the function in shell, then we use following command:

```bash
$ 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:

```bash
$ name arg1 arg2 arg3 . . .
```

Let's type a function as follows:

```bash
$ hello() { echo "Hello $1, let us be a friend."; }
```

Call the function in the command line as follows:

```bash
$ 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:

```bash
#!/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:

```bash
#!/bin/bash
countries()
{
    # let us store first argument $1 in variable temp
temp=$1
```
Working with Functions

```bash
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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/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:

```bash
#!/bin/bash
name="John"
hello()
{
  name="Maya"
  echo $name
}

hello
```

```
$ name# name contains John
Maya# name contains Maya
```

```
$ echo $name
Maya # name contains Maya
```
Test the script as follows:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
$ 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:

```bash
#!/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:

```bash
#!/bin/bash
yes_or_no() {
    echo "Is your name $*?"
    while true
        do
            echo -n "Please reply yes or no :"
            read reply
            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
Working with Functions

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 &
```

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:

```bash
$ source filename [arguments]
```

Or:

```bash
$ . filename [arguments]
```

```
$ source functions.sh
```

Or:

```bash
$ . functions.sh
```

If we pass command-line arguments, these will be handled inside a script as `$1`, `$2`, and more:

```bash
$ source functions.sh arg1 arg2
```

Or:

```bash
$ ./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 `USA India 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 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`. 
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.
Using Advanced Functionality in Scripts

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:

```bash
$ kill -l
$ trap –l
```

Output:

```
student@ubuntu:~$ 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) SIGSTP
21) SIGTTIN  22) SIGTTOU 23) SIGURG  24) SIGXCPU  25) SIGFSZ
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:

```bash
$ stty -a
```

The following is a list of a few of the standard signals that a process can use:

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>EXIT</td>
<td>The shell exits.</td>
<td>Termination</td>
</tr>
<tr>
<td>1</td>
<td>SIGHUP</td>
<td>The terminal has been disconnected.</td>
<td>Termination</td>
</tr>
<tr>
<td>2</td>
<td>SIGINT</td>
<td>The user presses Ctrl + C</td>
<td>Termination</td>
</tr>
<tr>
<td>3</td>
<td>SIGQUIT</td>
<td>The user presses Ctrl + \</td>
<td>Termination</td>
</tr>
<tr>
<td>Number</td>
<td>Name</td>
<td>Description</td>
<td>Action</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>4</td>
<td>SIGILL</td>
<td>This gives an illegal hardware instruction.</td>
<td>Program error</td>
</tr>
<tr>
<td>5</td>
<td>SIGTRAP</td>
<td>This is produced by debugger.</td>
<td>Program error</td>
</tr>
<tr>
<td>8</td>
<td>SIGFPE</td>
<td>This gives an arithmetic error, such as division by zero.</td>
<td>Program error</td>
</tr>
<tr>
<td>9</td>
<td>SIGKILL</td>
<td>This cannot be caught or ignored.</td>
<td>Termination</td>
</tr>
</tbody>
</table>

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:

```bash
$ 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:

```bash
$ 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:

```bash
#!/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:

```bash
$ chmod +x trap_01.sh
$ ./ trap_01.sh
```

Output:

```
^Ccaught signal SIGINT
^CQuit (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
Caught 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 backup 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 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:

```bash
$ dialog --yesno "Would you like to continue?" 10 50
```

We can have the same yes/no dialog box with a title as follows:

```bash
$ dialog --title "yesno box" --yesno "Would you like to continue?" 10 50
```

Let's write the Shell script `dialog_01.sh` as follows:

```bash
#!/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.

```bash
result=$?
case $result in
  0) rm ~/work/sample.txt
```
Using Advanced Functionality in Scripts

    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

```bash
Please enter something.
Ganesh Naik
```

[216]
Let's write the Shell script dialog_02.sh to create an input box as follows:

```bash
#!/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=0
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
```

![Textbox Example](image)

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:

```bash
#!/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=$?
```

[218]
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:

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
```
Using Advanced Functionality in Scripts

```
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\n1,2,3..., or the first character of choice\nas 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:

```bash
$ chmod +x dialog_04.sh
$ ./dialog_04.sh
```

Output:

![Screenshot of checklist box](image.png)

**The checklist box (checklist)**

In this case, we can present the user with a choice to select one or multiple options from a list:

```bash
# dialog --checklist "This is a checklist" 10 50 2 \
"a" "This is one option" "off" \ 
"b" "This is the second option" "on"
```

![Screenshot of checklist box](image.png)

**The radiolist box (radiolist)**

If you want the user to select only one option out of many choices, then radiolist is a suitable option:

```bash
# dialog --radiolist "This is a selective list, where only one \noption can be chosen" 10 50 2 \
"a" "This is the first option" "off" \ 
"b" "This is the second option" "on"
```

![Screenshot of radiolist box](image.png)
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:

```bash
#!/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.
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:

```bash
$ 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:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Run level number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Halting the system</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Single-user mode</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Multi-user mode</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>Multi-user with network support</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>Not used</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>Graphical user interface with multi-user and networking support</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>Rebooting the system</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Folder name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rc0.d/</td>
<td>The scripts called during shutting down</td>
</tr>
<tr>
<td>2</td>
<td>rc1.d/</td>
<td>The run level 1 scripts</td>
</tr>
<tr>
<td>3</td>
<td>rc2.d/</td>
<td>The run level 2 scripts</td>
</tr>
<tr>
<td>4</td>
<td>rc3.d/</td>
<td>The run level 3 scripts</td>
</tr>
<tr>
<td>5</td>
<td>rc4.d/</td>
<td>The run level 4 scripts</td>
</tr>
</tbody>
</table>
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:

```bash
$ 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.bashrc 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 its 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.
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:

![Diagram](image)

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.

![Text file sed's pattern space (buffer) sed's output](image)

**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 its usage in sed:

<table>
<thead>
<tr>
<th>Metacharacter</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>^</td>
<td>This is the beginning-of-line anchor</td>
</tr>
<tr>
<td>$</td>
<td>This is the end-of-line anchor</td>
</tr>
<tr>
<td>.</td>
<td>This matches one character, but not the newline character</td>
</tr>
<tr>
<td>*</td>
<td>This matches zero or more characters</td>
</tr>
<tr>
<td>[ ]</td>
<td>This matches one character in the set</td>
</tr>
<tr>
<td>[^ ]</td>
<td>This matches one character not in the set</td>
</tr>
<tr>
<td>(.)</td>
<td>This saves matched characters</td>
</tr>
<tr>
<td>&amp;</td>
<td>This saves the search string so it can be remembered in the replacement string</td>
</tr>
<tr>
<td>(&lt;)</td>
<td>This is the beginning-of-word anchor</td>
</tr>
<tr>
<td>(&gt;)</td>
<td>This is the end-of-word anchor</td>
</tr>
<tr>
<td>x{m}</td>
<td>This is the repetition of the character x:m times</td>
</tr>
<tr>
<td>x{m,}</td>
<td>This means at least m times</td>
</tr>
<tr>
<td>x{m,n}</td>
<td>This means between m and n times</td>
</tr>
</tbody>
</table>

**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
```
Pattern Matching and Regular Expressions with sed and awk

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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Capital</th>
<th>ISD Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Washington</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>Tokyo</td>
<td>81</td>
</tr>
<tr>
<td>India</td>
<td>Delhi</td>
<td>91</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Capital</th>
<th>ISD Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Washington</td>
<td>1</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Capital</th>
<th>ISD Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Washington</td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>Beijing</td>
<td>86</td>
</tr>
<tr>
<td>Japan</td>
<td>Tokyo</td>
<td>81</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Capital</th>
<th>ISD Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Washington</td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>Beijing</td>
<td>86</td>
</tr>
<tr>
<td>India</td>
<td>Delhi</td>
<td>91</td>
</tr>
</tbody>
</table>
Pattern Matching and Regular Expressions with sed and awk

The line containing the Japan pattern is deleted. All other lines are printed:

$ sed '/Japan/id' 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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

$ sed 's/Cashew/Almonds/g' shopping.txt
The output is as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Almonds</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15.5</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10.5</td>
</tr>
</tbody>
</table>

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 the 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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6**</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6**</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3**</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

For example:

`sed -e '5d' -e 's/Cashew/Almonds/' shopping.txt`

The output is as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Almonds</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

$ sed '/Orange/a\n
**** Buy one get one free offer on this item ! ****' shopping.txt

The output is as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**** Buy one get one free offer on this item ! ****
Pattern Matching and Regular Expressions with sed and awk

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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\nNew 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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

For example:

$ sed '/Papaya/c\n    Papaya is out of stock today !' shopping.txt

The output is as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

$ sed '2,4y/abcdefghijklmnopqrstuvwxyz/ABCDEFGHIJKLMNOPQRSTUVW XYZ/' shopping.txt

The output will be:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLE</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>ORANGE</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>PAPAYA</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

For example:

$ sed '3q' shopping.txt
The output will be:

```
<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>
```

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:

```
<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cashew</td>
<td>1</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
```

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
```
Pattern Matching and Regular Expressions with `sed` and `awk`

The output is as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Unit_Price</th>
<th>Total_Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Papaya</td>
<td>2</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Chicken</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Apple</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

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

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

---

[250]
The output is as follows:

```
# This is my first sed script by :

li

Stock status report
/orange/a

Fresh Oranges are not available in this season.
Fresh Oranges will be available from next month
/or/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 `li\` 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 Aho, Peter Weinberger and Brian Kernighan. 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:
  
  ```bash
  $ awk 'pattern' filename
  ```

  In this case, all the lines containing `pattern` will be printed.

- Syntax using only action:
  
  ```bash
  $ awk '{action}' filename
  ```

  In this case, `action` will be applied on all lines

- Syntax using pattern and action:
  
  ```bash
  $ 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:

```
        Happy Birth Day
            $0

        Happy         Birth         Day
            $1         $2         $3
```
Pattern Matching and Regular Expressions with sed and awk

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
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:

$ 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:

\begin{verbatim}
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
\end{verbatim}

$ awk '/Bill/' people.txt

The output will be:

\begin{verbatim}
Bill Thomas  8000  08/9/1968
\end{verbatim}

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:

\begin{verbatim}
Bill Thomas  8000  08/9/1968
Fred Martin  6500  22/7/1982
Marie Jones  6000  05/8/1972
Tom Walker   7000  14/1/1977
\end{verbatim}

In this example, when field 3 is greater than 5000, that record is printed on screen.

\section*{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:

\begin{verbatim}
pattern{ action statement; action statement; .. }
\end{verbatim}

or

\begin{verbatim}
pattern
{    action statement
    action statement
}
\end{verbatim}
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:

<table>
<thead>
<tr>
<th>Metacharacter</th>
<th>What it does</th>
</tr>
</thead>
<tbody>
<tr>
<td>.</td>
<td>A single character is matched</td>
</tr>
<tr>
<td>*</td>
<td>Zero or more characters are matched</td>
</tr>
<tr>
<td>^</td>
<td>The beginning of the string is matched</td>
</tr>
<tr>
<td>$</td>
<td>The end of the string is matched</td>
</tr>
<tr>
<td>+</td>
<td>One or more of the characters are matched</td>
</tr>
<tr>
<td>?</td>
<td>Zero or one of the characters are matched</td>
</tr>
<tr>
<td>[ABC]</td>
<td>Any one character in the set of characters A, B, or C is matched</td>
</tr>
<tr>
<td>[^ABC]</td>
<td>Any one character not in the set of characters A, B, or C is matched</td>
</tr>
<tr>
<td>[A–Z]</td>
<td>Any one character in the range from A to Z is matched</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>(AB)+</td>
<td>One or more sets of AB; such as AB, ABAB, and so on is matched</td>
</tr>
<tr>
<td>*</td>
<td>A literal asterisk is matched</td>
</tr>
<tr>
<td>&amp;</td>
<td>This is used to represent the replacement string when it is found in the search string</td>
</tr>
</tbody>
</table>

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
```
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 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

(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:

```awk
name = "Ganesh"
```

The variable name is of the string type:

```awk
j++
```

The variable j is a number. Variable j is initialized to zero and it is incremented by one:

```awk
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:

```awk
name + 0
```

The technique to modify the number type variable to the string type is as follows:

```awk
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:

```awk
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:

```bash
$ 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:

```bash
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:

```bash
$ awk '{ for( i = 1; i <= NF; i++) print NF, $i }' people.txt
```
Initially, the \textit{i} variable is initialized to 1. Then, the condition is checked to see whether \textit{i} is less than NF. If true, then the action of printing NF and the field is performed. Then \textit{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 \texttt{while} loop for doing the tasks repeatedly. \texttt{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:

```awk
while(condition)
  actions
```

An example of using the \texttt{while} construct in \texttt{awk} is as follows:

```bash
$ 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 \textit{i} is initialized to 1. Then, while \textit{i} is smaller or equal to NF, the print action will be performed. The \texttt{print} command will print fields from the record from the file \texttt{people.txt}. In the action block, \textit{i} is incremented by one. The \texttt{while} construct will perform the action repeatedly until \textit{i} is less than or equal to NF.

**Using the do while loop**

The \texttt{do while} loop is similar to \texttt{while} loop; but the difference is, even if the condition is true, at least once the action will be performed unlike the \texttt{while} loop.

The syntax is as follows:

```bash
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.
Symbols

<< here operator
  used, for data transfer 96, 97
  used, for ftp usage 96, 97
-n option
  used, for debugging Shell 106
<<< operator
  and here string 98
? variable
  using 148, 149
-v option
  used, for displaying commands 107
-x option (xtrace)
  used, for tracing execution 109-111

A

a command
  using 245
actions, awk
  defining 261, 262
address, stream editor (sed) 236
arithmetic expansion
  using 124-127
arithmetic operations
  declare command, using 117, 118
  declared integer variables, listing 119
  expr command, using 122, 123
  let command, using 120, 121
arrays
  creating 84
  initializing 84
  values, accessing 85-87
  working with 84
at command
  using 29
awk
  about 252
  actions, defining 260-262
  commands, using within file 256
  do while loop, using 266
  field 257
  for loop, using 265
  if statement, used for decision making 264
  input, using from commands 254, 255
  input, using from files 253
  patterns, defining 260
  records 257
  regular expressions 262
  script file, writing 263
  using 252
  variables, using 264
  while loop, using 266
  working with 255, 256

B

Bash Shell
  debugging options 112
bc utility
  URL 129
binary arithmetic operations 128
binary file operators
  options 143, 144
Bourne Shell 2
break command
used, for exiting from loop 179, 180

C

case command
used, for processing multiple
decision-making operations 161-167
c command
using 247
check list box (checklist)
creating 221
chmod command 14
command
exit status, checking 134
grouping 60
separators 59
substituting 57-59
command interpretation, Shell
about 53, 54
execution sequence 54
exit status 56, 57
internal commands, checking 55
internal commands, disabling 55
command line arguments
about 74
set command 76-78
shift 79
working with 75
command source
used, for executing functions 205
comm command 39, 40
compilation 7
conditional constructs 145
configuration file
used, for customizing dialog boxes 223
continue command
used, for exiting from current loop
iteration 177-179
CPU usages
in modes 27
crontab
using 30-32
cut command 36, 37

D
daemon process 19
data
sharing, by multiple functions 200
d command
using 238-240
debugging
prerequisites 106
process 106
set command, using 112
vi editor setting 113
declare command
using, for arithmetic operations 117, 118
default parameters 83, 84
dialog boxes
check list box (checklist), creating 221
creating, with dialog utility 213
customizing, with configuration file 223
input box (inputbox), creating 216, 217
menu box (menu), creating 219, 221
message box (msgbox), creating 214
message box (msgbox), creating with
title 214
password box, creating 218
progress meter box (gauge), creating 222
radio list box (radiolist), creating 221
textbox (textbox), creating 218
yes/no box (yesno), creating 215
dialog utility 225
diff command 35, 36
do while loop
using, in awk 266
working with 181-184

e

e command
using 243
eif command 159
else command 159
environment variables
exporting 71-73
local variable 70
working with 68-70
exec command
used, for file handling 105
used, for handling-related operations 105

exit command
using 148, 149

exit status
about 56
of commands, checking 134, 135

expr command
using, for arithmetic operations 122

F

dfields, awk
about 259
field separators 259
input field separator 260

dfile
closing 99
command, executing 104, 105
modifying, with stream editor (sed) 237
opening 99
reading from 100, 101
reading, line by line 104
results, executing 104, 105
writing 99-101
writing, to another file 101, 102
dfile descriptor (fd)
about 41
assigning, to file with exec command 99
information, displaying from /proc folder 103
read command, using 101
dfile handling
about 98
dexec command 99
dexec command, used for assigning file descriptor(fd) to file 99
if command, using 153-155
dfile permissions
changing, by numeric method 14
changing, by symbolic method 14
modifying 13, 14

DFile Transfer Protocol (FTP) 96
dfloating-point arithmetic 129-131
dfor command
used, for looping 172-177
dfor loop
using, in awk 265
dfunctions
about 191
advantages 192
arguments/arguments, passing 196-199
data, sharing 200
defining 192-195
displaying 195
executing, in background 204
executing, with commands source 205
executing, with period (.) 205
information, returning 202, 203
library of functions, creating 205, 206
local variables, declaring 200, 201
removing 196
traps, using 211, 212
word or string, returning 204
dG
gawk 252
g command
using 249
dgetopts 81, 82
Graphical user interface (GUI) 1
grep command
used, for pattern searching 48-50

H

hardware interrupt 207
h command
using 249
head command 34
Hello World script
writing 5, 6
here document
about 92, 93
and << operator 92, 93
here operator
and Utility ed 95, 96
using, with sort command 93
using, with wc command 94
here string
and <<< operator 98
using 98
hex arithmetic operations 128
holding buffer 249

I
i command
using 246
if command
about 159
used, for file handling 153-155
using 145-147
if construct
and multiple test commands 155-158
used, for numerical decision
making 147, 148
used, for string handling 149-151
if statement
using, in awk 264
init process 225, 226
inittab 225, 226
input box (inputbox)
creating 216, 217
interactive Shell scripts
about 89-91
read command, with options 92
internal commands, Shell
checking 55
disabling 55
Internal Field Separator (IFS)
about 188, 189, 256
and loops 188
interpreter 7
I/O redirection
about 41-44
brace expansion 45, 46
commands 43
file descriptors 41
iostat command 26-28

J
join command 37, 38

K
Kernel start-up 225, 226

L
let command
using, for arithmetic operations 120-122
library of functions
creating 205, 206
Linux
about 1, 4
boot-up sequence 17, 18
directory structure 8
loop output, redirecting to 187
system startup 225
local variable
about 70
declaring, in functions 200, 201
scope 70, 71
logical operators
about 46
about 61m 62
options 144, 145
loop
and Internal Field Separator (IFS) 188, 189
exiting, with break command 179, 180
iteration, exiting with continue
command 177-179
output, redirecting to Linux command 187
running, in background 188
using, with with for command 172-177

M
macros 32
menu box (menu)
creating 219, 221
message box (msgbox)
creating 214
metacharacters
about 44-49
using 236
monitoring tools, process
iostat command 26, 29
top command 26-28
vmstat command 26-28
multiple test commands
and if construct 156-158
noexec 106

nohup command
used, for running process when logged out 212, 213

NR variable 258
null values
checking 151-153
numerical comparison operators
for test command 138-142
numerical decision making
with if constructs 147, 148

octal arithmetic operations 128
orphan process 19
Output Field Separator (OFS) 256

password box
creating 218
paste command 37
pattern
defining 260
    matching, with vi editor 46-48
    searching, with grep command 48-50
    searching facilities, testing 48
pattern space 235
p command
    using 237, 238
period (.)
used, for executing functions 205
permissions
chmod command 14
    execute permission 13
    read permission 13
    setgid functionality 15
    setuid feature 15
    sticky bit 15
    umask, setting 14
    working with 13
    write permission 13
pipes 63

positional parameters
about 81
resetting 81
process
about 17
basics 17-19
daemon process 19
managing 23-25
monitoring tools 26
monitoring, with ps command 19-23
orphan process 19
running, when logged out with nohup command 212, 213
zombie process 19
process ID 18
progress meter box (gauge)
    creating 222
ps command
    used, for monitoring process 19-23

Q
q command
    using 248

radio list box (radiolist)
    creating 221
range
defining, of selected lines 241, 242
r command
    using 2443
read command
    related options 92
    used, for reading user input 89-91
read-only variables
    working with 74
records, awk
    $0 variable 257
    about 257
    NR variable 258
    record separator 257
regular expressions
    about 233, 234
    in awk 262
metacharacters 262
using, in stream editor (sed) 235
run levels
about 225-227
listing 227

S
s command
using 240, 241
script
running, when logged out with nohup
command 212, 213
select command
used, for implementing simple
menus 167-171
set command
about 76-78
set-n 113
used, for debugging process 112
setgid functionality 15
setuid feature 15
Shell
about 1
command interpretation 53
comparisons 2
tasks 3
working 3, 4
Shell commands
about 9-12
cat command 11, 12
echo cpmmad 12
man command 9
passwd command 9, 10
Shell scripts
advantages 7
best practices 114
limitations 7
shift
about 79, 81
positional parameters, resetting 81
signals
about 208, 209, 225
ignoring 210
listing 211
resetting 210
simple menus
implementing, with select
command 167-171
sort command
using, with here operator 93
start_kenel() function 18
step increment 240
sticky bit 15
stream editor (sed)
about 234, 235
addressing 236, 237
appending, with a command 245
changing, with c command 247
deleting, with d command 238-240
exchanging, with x command 249
file, modifying 237
file, reading with r command 244
file, writing with w command 244
going, with g command 249
holding, with h command 249, 250
inserting, with i command 246
multiple editing, with e command 249
printing, with p command 237, 238
quitting, with q command 248
range, defining 241, 242
regular expressions, using 235
scripting 250, 251
substituting, with s command 240, 241
transforming, with y command 247, 248
string
comparison options, using with test
commands 136, 137
handling, with if construct 149-151
system initialization boot scripts 227, 228

T
table declare options 77
tail command 34
test command
about 135
file test options 142
for logical test operators 144, 145
numerical comparison operators 138-141
string comparison options 136-142
used, for file testing of binary
operators 143, 144
using, with double brackets 136
using, with single brackets 135

**textbox (textbox)**
creating 218

**text filtering tools**
about 33, 34
comm command 39, 40
cut command 36
diff command 35, 36
head command 34
join command 37, 38
paste command 37
tail command 34
tr command 40
uniq command 38, 39

**top command 26-28**

**trap command**
using 209

**traps**
about 207-209, 225
using, in function 211, 212

**tr command** 40


**U**

uniq command 38, 39
until command
using 186, 187

**user initialization scripts**
about 229
systemwide settings scripts 229
user level settings 229, 230


**V**

variables
about 65-68
declare command, using 66
dislodg command, using 66
evironment variables 68
read-only variables 74
set command, using 66
unset command, using 66
using, in awk 264

**variable substitution**
turning off 97

**verbose mode** 107

**vi editor**
commands 47
used, for learning pattern matching 46-48

**vmstat command** 26, 28


**W**

**wall command**
used, for sending message for logged-in
users 96

**wc command**
using, with here operator 94

**w command**
using 244

**while loop**
using, in awk 266


**X**

**x command**
using 249


**Y**

**y command**
using 247, 248

**yes/no box (yesno)**
creating 215


**Z**

**zombie process** 19
Thank you for buying
Learning Linux Shell Scripting

About Packt Publishing

Our books and publications share the experiences of your fellow IT professionals in adapting and customizing today’s systems, applications, and frameworks. Our solution-based books give you the knowledge and power to customize the software and technologies you're using to get the job done. Packt books are more specific and less general than the IT books you have seen in the past. Our unique business model allows us to bring you more focused information, giving you more of what you need to know, and less of what you don't.

Packt is a modern yet unique publishing company that focuses on producing quality, cutting-edge books for communities of developers, administrators, and newbies alike. For more information, please visit our website at [www.packtpub.com](http://www.packtpub.com).

About Packt Open Source
In 2010, Packt launched two new brands, Packt Open Source and Packt Enterprise, in order to continue its focus on specialization. This book is part of the Packt Open Source brand, home to books published on software built around open source licenses, and offering information to anybody from advanced developers to budding web designers. The Open Source brand also runs Packt’s Open Source Royalty Scheme, by which Packt gives a royalty to each open source project about whose software a book is sold.

Writing for Packt
We welcome all inquiries from people who are interested in authoring. Book proposals should be sent to author@packtpub.com. If your book idea is still at an early stage and you would like to discuss it first before writing a formal book proposal, then please contact us; one of our commissioning editors will get in touch with you.

We're not just looking for published authors; if you have strong technical skills but no writing experience, our experienced editors can help you develop a writing career, or simply get some additional reward for your expertise.
Over 110 practical recipes to solve real-world shell problems, guaranteed to make you wonder how you ever lived without them

1. Master the art of crafting one-liner command sequence to perform text processing, digging data from files, backups to sysadmin tools, and a lot more.

2. And if powerful text processing isn't enough, see how to make your scripts interact with the web-services like Twitter, Gmail.

3. Explores the possibilities with the shell in a simple and elegant way - you will see how to effectively solve problems in your day to day life.

Your one-stop guide to reading, writing, and debugging simple and complex Z shell scripts

1. A step-by-step guide that will show you how to use zsh and its repertoire of powerful features to improve the efficiency of your daily tasks.

2. Learn how to configure and use zsh.

3. Discover some advanced features of zsh such as process and parameter substitution, running on restricted functionality mode, and emulating other shells.

Please check www.PacktPub.com for information on our titles
PowerShell
Troubleshooting Guide

Minimize debugging time and maximize troubleshooting efficiency by leveraging the unique features of the PowerShell language

1. Reduce troubleshooting surprises by understanding the PowerShell language.
2. Avoid parameter passing mistakes by using PowerShell’s unique pipeline binding capabilities.
3. Answer questions such as what, how, and why in troubleshooting sessions by utilizing PowerShell’s various write-cmdlets.

Penetration Testing with the Bash shell

Make the most of the Bash shell and Kali Linux's command line based security assessment tools

1. Utilize the command line to create, run, and execute tests.
2. Learn useful command line based information processing utilities and unlock the problem solving power of a Linux terminal.
3. Practical demonstrations using in-depth explanations and screenshots to help you use the Linux Bash terminal to tackle a collection of common security-related problems.

Please check www.PacktPub.com for information on our titles