COMPTIA® LINUX+™ /LPIC-1

TRAINING AND EXAM PREPARATION GUIDE: LX0-103/101- 400 AND LX0-104/102-400
FIRST EDITION

+ Equally Good for Self-Study and In-Class Training and Exam Preparation
+ Detailed Coverage of ALL Official Exam Objectives
+ Learn by Doing Approach
+ Material Based on Two Major Linux Distributions
+ Separate Sections on LX0-103/101- 400 and LX0-104/102- 400
+ Straightforward and Direct Explanation of Concepts
+ Chapter End One-Sentence Review of Each Key Topic
+ Numerous Simple Procedures and 49 Step-by- Step Exercises
+ 790 Practice Exam Questions with Answers
  414 for LX0-103/101- 400
  376 for LX0-104/102- 400
+ On the Job Administrator Resource

ASGHAR GHORI

CompTIA®
Linux+™/LPIC-1

Training and Exam Preparation Guide

Exam Codes

LX0-103/101-400
LX0-104/102-400

First Edition

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The author has made his best efforts to prepare this book. The contents are based on CompTIA Linux+ Powered by LPI/LPIC-1 certification objectives version 4.0 for exam codes LX0-103/101-400 and LX0-104/102-400 published in January 2015, and are available on CompTIA's website at https://certification.comptia.org/certifications/linux and Linux Professional Institute's website at http://www.lpi.org/our-certifications/lpic-

1-overview. The author makes no representation or warranties of any kind with regard to the completeness or accuracy of the contents herein and accepts no liability whatsoever including but not limited to merchantability, fitness for any particular purpose, or any losses or damages of any kind caused or allegedly caused directly or indirectly from this material. This book may be used to prepare for the CompTIA Linux+ Powered by LPI certification exams LX0-103 and LX0-104 (or LPI's LPIC-1 exam codes 101-400 and 102-400). Neither author nor publisher warrants that use of this publication will ensure passing the relevant exams or that the information contained herein is endorsed by CompTIA or Linux Professional Institute.

Preface

I wrote this book to create the most useful, effective, informative, and educational resource for readers who intend to learn Linux and want to prepare for the CompTIA Linux+/LPIC-1 certification exams, LX0-103/101-400 and LX0-104/102-400. I am confident that I have attained these objectives in this finished product.

In each chapter, I categorized the exam objectives according to the flow of the discussion and where they appeared to best support a convenient and logical learning path. I encourage readers to read each chapter chronologically, learn a concept, command, or topic, try it, ponder over the results, and move on to the next topic. Jumping around may result in confusion, frustration, and spending more time than required.

At the very outset in chapter 1, I furnished assistance to build a lab environment for practicing. Do not skip this chapter. As you read the book, please have your Linux lab systems up and running and switch user IDs or systems as depicted in the command prompt in order to get the most out of your time and effort. Each command demonstrated in this book was actually run on the indicated system and as the indicated user. Do not expect to see an identical output or behavior of a command or program on your lab system. Differences might occur due to variances in hardware configuration or software versions.

The CompTIA Linux+ Powered by LPI/LPIC-1 certification exams are distribution-neutral and vendor-neutral, which means that the exam objectives are not specific to any particular Linux distribution or vendor. However, a closer look at the objectives indicates that they are taken from two major distributions of Linux—Red Hat Enterprise Linux (RHEL) and Debian Linux—and they include topics from the distributions' latest as well as old versions. I, therefore, opted for CentOS Linux (a popular offshoot of RHEL) and Ubuntu Linux (a Debian Linux spinoff) to base the book material.

At the end of each chapter, I have provided an at-a-glance review of the entire chapter, which provides a one-sentence review of key topics discussed in that chapter. The two certification exams are multiple-choice and fill-in-the-blank, so I have provided one quiz per exam that contains sample questions with answers in the appendices. It is recommended to take the first quiz after you have completed Part One and the second quiz after finishing Part Two.

I maintain www.getitcertify.com to support my readers with errata, additional exam information, and links to helpful resources. I have a YouTube channel —https://www.youtube.com/channel/UCudp1t4z-W_OfsrGrE6uLiw—where I upload useful videos on Linux. Visit my website and YouTube channel for updates.

I thank you for reading this book and hope that it serves you well. If you would like

to ask any questions or send me some feedback, please email me at asghar_ghori2002@yahoo.com. We are all learners, and I am always open to suggestions for improvement and suggestions on what you would like to see different in the next edition.

Good luck in your endeavors. Asghar Ghori / October, 2017 / Toronto, Canada

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I am grateful to God who enabled me to write and publish this book successfully.

I would like to express my gratitude to my peers, students, friends, editors, YouTube channel subscribers, and readers of my previous books who offered support, provided comments, and aided in the layout, editing, and proofreading of this work. I am thankful to all of them for their generous assistance.

George Doumas, you deserve special kudos for your invaluable and productive feedback in minimizing the number of technical and grammatical errors and mistakes.

I want to express my special thanks to my wife and children who tolerated my mental absence as I sat right in front of them and worked on this project. I could not have accomplished it without their support.

Lastly, I would like to offer my very special tributes to my deceased parents and sister.

About The Author

Asghar Ghori is a seasoned Linux/UNIX consultant, trainer, and author. As a consultant, his experience ranges from IT infrastructure deployment, support, and administration to architecture, design, and consulting. As a trainer, Ghori has designed and delivered numerous training programs. He has six books on UNIX and Linux to his credit.

Ghori holds a bachelor of science in engineering. He is CompTIA Linux+ Powered by LPI/LPIC-1 Certified, RHCE, RHCSA, HP CSA, HP CSE, SCSA, IBM Certified Specialist for AIX, and CNE. He holds ITIL Foundation and PMP certifications as well.

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Previous publications of Asghar Ghori are:

1. RHCSA & RHCE Red Hat Enterprise Linux 7: Training and Exam Preparation Guide (EX200 and EX300), Third Edition (ISBN: 978-1495148200), published March 2015
2. Red Hat Certified System Administrator & Engineer: Training Guide and a Quick Deskside Reference (ISBN: 978-1467549400) (RHEL version 6), published December 2012
3. Red Hat Certified Technician & Engineer (RHCT and RHCE) Training Guide and Administrator's Reference (ISBN: 978-1615844302) (RHEL version 5), published August 2009
4. HP-UX: HP Certified Systems Administrator, Exam HP0-A01, Training Guide and Administrator's Reference (ISBN: 978-1606436547) (HP-UX 11iv3), published October 2008
5. HP Certified Systems Administrator, Exam HP0-095, Training Guide and Administrator's Reference (ISBN: 978-1424342310) (HP-UX 11iv2 and 11iv3), published August 2007
6. Certified System Administrator for HP-UX: Study Guide and Administrator's Reference (ISBN: 978-1419645938) (HP-UX 11iv1), published August 2006

Conventions Used In This Book

The following typographic and other conventions are used in this book:

Book Antiqua Italic 10 pt. is used to highlight new terms. For example:

> "The term open source is referred to the software with source code that is available to the public for download, duplication, amendment, repackaging, and re-sharing."

Times Roman Italic 10 pt. is used in text paragraphs to highlight names of commands, files, directories, service daemons, users, groups, hostnames, domains, and URLs. For example:

> "It has three additional hard links named fsck.ext2, fsck.ext3, and fsck.ext4 (on ubuntu14, they are soft links under /sbin)."

Times New Roman 9 pt. is used to segregate command output, contents of shell scripts and configuration files, and information expected to be entered in configuration files from surrounding text. This font and size is also used for text in tables.

Times Roman Bold 10 pt. is used to highlight commands within text paragraphs (example 1) and on the command line (example 2) that the user is expected to execute.

Example 1:

> "The telinit command is symlinked to init (run **ll /sbin/telinit** to verify), so it does not really matter which of the two you run, as both will have an identical effect."

Example 2:

> [user1@centos73 ~]$ **ls >> ls.out**

Consolas 10 pt. is used for the command prompts, which identify the user account and the system where the user is expected to type and run a command. For instance, command prompts [user1@centos73 ~]$ and user1@ubuntu14:~$ indicate user1 running a command on centos73/ubuntu14 and the command prompt [root@centos511 ~]# represents the root user on centos511.

All headings and sub-headings are in California FB font, and are bolded.

Key sequences, such as Ctrl+a and Ctrl+c, imply that the user holds down the Ctrl key and then press the other key. Courier New 10 pt. is used to highlight such combinations. This font is also used for keystrokes, such as Enter and Esc.

. . . . . Dotted lines represent truncated command output for brevity.

About CompTIA Linux+ Powered by LPI/LPIC-1 Certification Exams

The CompTIA Linux+ Powered by LPI certification exams (LX0-103 and LX0-104) [also referred to as LPIC-1 exams 101-400 and 102-400] test a candidate's foundational knowledge of the Linux system. Each exam is 90 minutes in length and there is a mix of 60 single-response, multiple-response, and fill-in-the-blank type questions. During the exams, candidates do not have access to the Internet, a running Linux system, an electronic gadget, or to printed and electronic documentation, and they are not allowed to talk to other candidates taking the exam. Visit https://certification.comptia.org/certifications/linux or http://www.lpi.org/our-certifications/lpic-1-overview for up-to-date and in-depth information and exam policies.

The official exam objectives are grouped in 10 major categories (or topics)—4 for LX0-103/101-400 and 6 for LX0-104/102-400. Each major topic also indicates a percentage of its coverage. These 10 major topics and their percentages are:

LX0-103/101-400	
Topic 101: System architecture	14%
Topic 102: Linux installation and package management	18%
Topic 103: GNU and Unix commands	43%
Topic 104: Devices, Linux File Systems, and Filesystem Hierarchy Standard	25%
Total:	**100**

LX0-104/102-400	
Topic 105: Shells, Scripting, and Data Management	17
Topic 106: User Interfaces and Desktops	8
Topic 107: Administrative Tasks	20
Topic 108: Essential System Services	17
Topic 109: Networking Fundamentals	23
Topic 110: Security	15
Total:	**100**

Each major topic is divided into multiple sub-topics (or exam objectives). There are a total of 86 objectives for LX0-103/101-400 and 75 for LX0-104/102-400. Each objective provides a description, lists the knowledge areas, and highlights the files, key terms, and commands that are included in it.

Each objective has a "weight" associated with it, which designates the number of questions to expect on the exam from that objective. For instance, objective 101.1 with weight 2 implies that you expect to see 2 questions on the exam covering knowledge areas 1 to 8 and the listed files, terms, and utilities.

Based on the above explanation, here is the number of questions from each topic that you should expect to see on the certification exams:

LX0-103/101-400	%	?s
Topic 101: System architecture	14%	
Topic 102: Linux installation and package management	18%	
Topic 103: GNU and Unix commands	43%	
Topic 104: Devices, Linux File Systems, and Filesystem Hierarchy Standard	25%	
Total:	**100%**	

LX0-104/102-400	%
Topic 105: Shells, Scripting, and Data Management	17%
Topic 106: User Interfaces and Desktops	8%
Topic 107: Administrative Tasks	20%
Topic 108: Essential System Services	17%
Topic 109: Networking Fundamentals	23%
Topic 110: Security	15%
Total:	**100%**

For convenience, I have enumerated “key knowledge areas” under exam objectives and highlighted the chapter(s) where you can find them. I have also provided a description alongside each objective for assistance in locating them in the book. If an objective spans multiple chapters, apposite references are furnished. This information is furnished at the beginning of each chapter as well.

I have also summarized the exam objectives, chapters you can find them, associated weights, the number of questions to expect on the exam, and other useful information in a tabular format under “Summary of Exam Objectives and Relevant Details” following the detailed list of the exam objectives. This summary contains most of the information that I have already described here; however, the intent is to provide a quick and convenient reference.

LX0-103/101-400 Exam Objectives

Topic 101: System Architecture (14%)

101.1 Determine and configure hardware settings (weight 2) [this entire objective is covered in chapter 7]

Candidates should be able to determine and configure fundamental system hardware.

Key Knowledge Areas:

1. Enable and disable integrated peripherals
2. Configure systems with or without external peripherals such as keyboards
3. Differentiate between the various types of mass storage devices
4. Know the differences between coldplug and hotplug devices
5. Determine hardware resources for devices
6. Tools and utilities to list various hardware information (e.g. lsusb, lspci, etc.)
7. Tools and utilities to manipulate USB devices
8. Conceptual understanding of sysfs, udev, dbus

The following is a partial list of the used files, terms and utilities: /sys, /proc, /dev, modprobe, lsmod, lspci, lsusb

101.2 Boot the system (weight 3) [this entire objective is covered in chapter 6]

Candidates should be able to guide the system through the booting process.

Key Knowledge Areas:

9. Provide common commands to the bootloader and options to the kernel at boot time
10. Demonstrate knowledge of the boot sequence from BIOS to boot completion
11. Understanding of SysVinit and systemd

12. Awareness of Upstart

13. Check boot events in the log files

The following is a partial list of the used files, terms and utilities: dmesg, BIOS, bootloader, kernel, initramfs, init, SysVinit, system

101.3 Change runlevels / boot targets and shutdown or reboot system (weight 3) [this entire objective is covered in chapter 6]

Candidates should be able to manage the SysVinit runlevel or systemd boot target of the system. This objective includes changing to single user mode, shutdown or rebooting the system. Candidates should be able to alert users before switching runlevels / boot targets and properly terminate processes. This objective also includes setting the default SysVinit runlevel or systemd boot target. It also includes awareness of Upstart as an alternative to SysVinit or systemd.

Key Knowledge Areas:

14. Set the default runlevel or boot target

15. Change between runlevels / boot targets including single user mode

16. Shutdown and reboot from the command line

17. Alert users before switching runlevels / boot targets or other major system events

18. Properly terminate processes

The following is a partial list of the used files, terms and utilities: /etc/inittab, shutdown, init, /etc/init.d, telinit, system, systemctl, /etc/systemd/, /usr/lib/system/, wall

Topic 102: Linux Installation and Package Management (18%)

102.1 Design hard disk layout (weight 2) [this entire objective is covered in chapter 8]

Candidates should be able to design a disk partitioning scheme for a Linux system.

Key Knowledge Areas:

19. Allocate filesystems and swap space to separate partitions or disks

20. Tailor the design to the intended use of the system

21. Ensure the /boot partition conforms to the hardware architecture requirements for booting

22. Knowledge of basic features of LVM

The following is a partial list of the used files, terms and utilities: /(root) filesystem, /var filesystem, /home filesystem, /boot filesystem, swap space, mount points, partitions

102.2 Install a boot manager (weight 2) [this entire objective is covered in chapter 6]

Candidates should be able to select, install and configure a boot manager.

Key Knowledge Areas:

23. Providing alternative boot locations and backup boot options

24. Install and configure a bootloader such as GRUB Legacy

25. Perform basic configuration changes for GRUB 2

26. Interact with the bootloader

The following is a partial list of the used files, terms and utilities: menu.lst, grub.cfg and grub.conf; grub-install, grub-mkconfig, MBR

102.3 Manage shared libraries (weight 1) [this entire objective is covered in chapter 5]

Candidates should be able to determine the shared libraries that executable programs depend on and install them when necessary.

Key Knowledge Areas:

27. Identify shared libraries

28. Identify the typical locations of system libraries

29. Load shared libraries

The following is a partial list of the used files, terms and utilities: ldd, ldconfig, /etc/ld.so.conf, LD_LIBRARY_PATH

102.4 Use Debian package management (weight 3) [this entire objective is covered in chapter 5]

Candidates should be able to perform package management using the Debian package tools.

Key Knowledge Areas:

30. Install, upgrade and uninstall Debian binary packages

31. Find packages containing specific files or libraries which may or may not be installed

32. Obtain package information like version, content, dependencies, package integrity and installation status (whether or not the package is installed)

The following is a partial list of the used files, terms and utilities: /etc/apt/sources.list, dpkg, dpkg-reconfigure, apt-get, apt-cache, aptitude

102.5 Use RPM and YUM package management (weight 3) [this entire objective is covered in chapter 5]

Candidates should be able to perform package management using RPM and YUM tools.

Key Knowledge Areas:

33. Install, re-install, upgrade and remove packages using RPM and YUM

34. Obtain information on RPM packages such as version, status, dependencies, integrity and signatures

35. Determine what files a package provides, as well as find which package a specific file comes from

The following is a partial list of the used files, terms and utilities: rpm, rpm2cpio, /etc/yum.conf, /etc/yum.repos.d/, yum, yumdownloader

Topic 103: GNU and Unix Commands (43%)

103.1 Work on the command line (weight 4) [a part of this objective is

covered in chapter 1 and the rest in chapter 4]

Candidates should be able to interact with shells and commands using the command line. The objective assumes the Bash shell.

Key Knowledge Areas:

36. Use single shell commands and one line command sequences to perform basic tasks on the command line [chapter 1]

37. Use and modify the shell environment including defining, referencing and exporting environment variables [chapter 4]

38. Use and edit command history [chapter 4]

39. Invoke commands inside and outside the defined path [chapter 4]

The following is a partial list of the used files, terms and utilities: [chapter 1: pwd, man, and uname], [chapter 4: bash, echo, env, export, set, unset, history, and .bash_history]

103.2 Process text streams using filters (weight 3) [a part of this objective is covered in chapter 2 and the rest in chapter 3]

Candidates should be able to apply filters to text streams.

Key Knowledge Areas:

40. Send text files and output streams through text utility filters to modify the output using standard UNIX commands found in the GNU textutils package

The following is a partial list of the used files, terms and utilities: [chapter 2: head, tail, and less], [chapter 3: cat, cut, expand, fmt, od, join, nl, paste, pr, sed, sort, split, tr, unexpand, uniq, and wc]

103.3 Perform basic file management (weight 4) [most of this objective is covered in chapter 2, a part in chapter 4, and tar/cpio and dd commands in chapters 1 and 8, respectively]

Candidates should be able to use the basic Linux commands to manage files and directories.

Key Knowledge Areas:

41. Copy, move and remove files and directories individually [chapter 2]

42. Copy multiple files and directories recursively [chapter 2]

43. Remove files and directories recursively [chapter 2]

44. Use simple and advanced wildcard specifications in commands [chapter 4]

45. Using find to locate and act on files based on type, size, or time [chapter 2]

46. Usage of tar, cpio and dd [chapters 1 and 8]

The following is a partial list of the used files, terms and utilities: [chapter 1: tar, cpio, gzip, gunzip, bzip2, xz], [chapter 2: cp, find, mkdir, mv, ls, rm, rmdir, touch, file], [chapter 4: file globbing], [chapter 8: dd]

103.4 Use streams, pipes and redirects (weight 4) [a part of this objective is covered in chapter 2 and the rest in chapter 4]

Candidates should be able to redirect streams and connect them in order to efficiently process textual data. Tasks include redirecting standard input, standard output and standard error, piping the output of one command to the input of another command, using the output of one command as arguments to another command and sending output to both stdout and a file.

Key Knowledge Areas:

47. Redirecting standard input, standard output and standard error [chapter 4]

48. Pipe the output of one command to the input of another command [chapter 4]

49. Use the output of one command as arguments to another command [chapter 2]

50. Send output to both stdout and a file [chapter 4]

The following is a partial list of the used files, terms and utilities: [chapter 2: xargs] and [chapter 4: tee]

103.5 Create, monitor and kill processes (weight 4) [most of this objective is covered in chapter 4, with the exception of the uptime and free commands that are explained in chapters 1 and 8, respectively]

Candidates should be able to perform basic process management.

Key Knowledge Areas:

51. Run jobs in the foreground and background

52. Signal a program to continue running after logout

53. Monitor active processes

54. Select and sort processes for display

55. Send signals to processes

The following is a partial list of the used files, terms and utilities: [chapter 1: uptime], [chapter 4: &, bg, fg, jobs, kill, nohup, ps, top, pgrep, pkill, killall, screen], and [chapter 8: free]

103.6 Modify process execution priorities (weight 2) [this entire objective is covered in chapter 4]

Candidates should be able to manage process execution priorities.

Key Knowledge Areas:

56. Know the default priority of a job that is created

57. Run a program with higher or lower priority than the default

58. Change the priority of a running process

The following is a partial list of the used files, terms and utilities: nice, ps, renice, top

103.7 Search text files using regular expressions (weight 2) [this entire objective is covered in chapter 3]

Candidates should be able to manipulate files and text data using regular expressions. This objective includes creating simple regular expressions containing several notational elements. It also includes using regular expression tools to perform searches through a filesystem or file content.

Key Knowledge Areas:

59. Create simple regular expressions containing several notational elements

60. Use regular expression tools to perform searches through a filesystem or file

content

The following is a partial list of the used files, terms and utilities: grep, egrep, fgrep, sed, regex(7)

103.8 Perform basic file editing operations using vi (weight 3) [this entire objective is covered in chapter 3]

Candidates should be able to edit text files using vi. This objective includes vi navigation, basic vi modes, inserting, editing, deleting, copying and finding text.

Key Knowledge Areas:

61. Navigate a document using vi
62. Use basic vi modes
63. Insert, edit, delete, copy and find text

The following is a partial list of the used files, terms and utilities: vi, /, ?, h, j, k, l, i, o, a, c, d, p, y, dd, yy, ZZ, :w!, :q!, :e!

Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard (25%)

104.1 Create partitions and filesystems (weight 2) [this entire objective is covered in chapter 8]

Candidates should be able to configure disk partitions and then create filesystems on media such as hard disks. This includes the handling of swap partitions.

Key Knowledge Areas:

64. Manage MBR partition tables
65. Use various mkfs commands to create various filesystems such as ext2/ext3/ext4, XFS, VFAT
66. Awareness of ReiserFS and Btrfs
67. Basic knowledge of gdisk and parted with GPT

The following is a partial list of the used files, terms and utilities: fdisk, gdisk, parted,

mkfs, mkswap

104.2 Maintain the integrity of filesystems (weight 2) [this entire objective is covered in chapter 8]

Candidates should be able to maintain a standard filesystem, as well as the extra data associated with a journaling filesystem.

Key Knowledge Areas:

68. Verify the integrity of filesystems

69. Monitor free space and inodes

70. Repair simple filesystem problems

The following is a partial list of the used files, terms and utilities: du, df, fsck, e2fsck, mke2fs, debugfs, dumpe2fs, tune2fs, xfs tools (such as xfs_metadump and xfs_info)

104.3 Control mounting and unmounting of filesystems (weight 3) [this entire objective is covered in chapter 8]

Candidates should be able to configure the mounting of a filesystem.

Key Knowledge Areas:

71. Manually mount and unmount filesystems

72. Configure filesystem mounting on bootup

73. Configure user mountable removable filesystems

The following is a partial list of the used files, terms and utilities: /etc/fstab, /media, mount, umount

104.4 Manage disk quotas (weight 1) [this entire objective is covered in chapter 8]

Candidates should be able to manage disk quotas for users.

Key Knowledge Areas:

74. Set up a disk quota for a filesystem

75. Edit, check and generate user quota reports

The following is a partial list of the used files, terms and utilities: quota, edquota, repquota, quotaon

104.5 Manage file permissions and ownership (weight 3) [this entire objective is covered in chapter 2]

Candidates should be able to control file access through the proper use of permissions and ownerships.

Key Knowledge Areas:

76. Manage access permissions on regular and special files as well as directories

77. Use access modes such as suid, sgid and the sticky bit to maintain security

78. Know how to change the file creation mask

79. Use the group field to grant file access to group members

The following is a partial list of the used files, terms and utilities: chmod, umask, chown, chgrp

104.6 Create and change hard and symbolic links (weight 2) [this entire objective is covered in chapter 2]

Candidates should be able to create and manage hard and symbolic links to a file.

Key Knowledge Areas:

80. Create links

81. Identify hard and/or soft links

82. Copying versus linking files

83. Use links to support system administration tasks

The following is a partial list of the used files, terms and utilities: ln, ls

104.7 Find system files and place files in the correct location (weight 2) [this entire objective is covered in chapter 2]

Candidates should be thoroughly familiar with the Filesystem Hierarchy Standard (FHS), including typical file locations and directory classifications.

Key Knowledge Areas:

84. Understand the correct locations of files under the FHS

85. Find files and commands on a Linux system

86. Know the location and purpose of important file and directories as defined in the FHS

The following is a partial list of the used files, terms and utilities: find, locate, updated, whereis, which, type, /etc/updated.conf

LX0-104/102-400 Exam Objectives

Topic 105: Shells, Scripting and Data Management (17%)

105.1 Customize and use the shell environment (weight 4) [a part of this objective is covered in chapter 9; most of it in chapter 10; and env, export, set, unset, alias, and lists commands/topics are explained in chapter 4]

Candidates should be able to customize shell environments to meet users' needs. Candidates should be able to modify global and user profiles.

Key Knowledge Areas:

1. Set environment variables (e.g. PATH) at login or when spawning a new shell [chapter 10]
2. Write Bash functions for frequently used sequences of commands [chapter 9]
3. Maintain skeleton directories for new user accounts [chapter 10]
4. Set command search path with the proper directory [chapter 10]

The following is a partial list of the used files, terms and utilities: [chapter 10: source, /etc/bash.bashrc, /etc/profile, ~/.bash_profile, ~/.bash_login, ~/.profile, ~/.bashrc, ~/.bash_logout], [chapter 4: env, export, set, and unset, alias, and lists], and [chapter 9: function]

105.2 Customize or write simple scripts (weight 4) [most of this objective is covered in chapter 9 and the rest in chapter 15]

Candidates should be able to customize existing scripts, or write simple new Bash scripts.

Key Knowledge Areas:

5. Use standard sh syntax (loops, tests) [chapter 9]
6. Use command substitution [chapter 9]
7. Test return values for success or failure or other information provided by a

command [chapter 9]

8. Perform conditional mailing to the superuser [chapter 15]

9. Correctly select the script interpreter through the shebang (#!) line [chapter 9]

10. Manage the location, ownership, execution and suid-rights of scripts [chapter 9]

The following is a partial list of the used files, terms and utilities: [chapter 9: for, while, test, if, read, seq, exec]

105.3 SQL data management (weight 2) [this entire objective is covered in chapter 9]

Candidates should be able to query databases and manipulate data using basic SQL commands. This objective includes performing queries involving joining of 2 tables and/or subselects.

Key Knowledge Areas:

11. Use of basic SQL commands

12. Perform basic data manipulation

The following is a partial list of the used files, terms and utilities: insert, update, select, delete, from, where, group by, order by, join

Topic 106: User Interfaces and Desktops (8%)

106.1 Install and configure X11 (weight 2) [this entire objective is covered in chapter 13]

Candidates should be able to install and configure X11.

Key Knowledge Areas:

13. Verify that the video card and monitor are supported by an X server

14. Awareness of the X font server

15. Basic understanding and knowledge of the X Window configuration file

The following is a partial list of the used files, terms and utilities: /etc/X11/xorg/xorg.conf, xhost, DISPLAY, xwininfo, xdpyinfo, X

106.2 Setup a display manager (weight 1) [this entire objective is covered in chapter 13]

Candidates should be able to describe the basic features and configuration of the LightDM display manager. This objective covers awareness of the display managers XDM (X Display Manger), GDM (Gnome Display Manager) and KDM (KDE Display Manager).

Key Knowledge Areas:

16. Basic configuration of LightDM
17. Turn the display manager on or off
18. Change the display manager greeting
19. Awareness of XDM, KDM and GDM

The following is a partial list of the used files, terms and utilities: lightdm, /etc/lightdm

106.3 Accessibility (weight 1) [this entire objective is covered in chapter 13]

Demonstrate knowledge and awareness of accessibility technologies.

Key Knowledge Areas:

20. Basic knowledge of keyboard accessibility settings (AccessX)
21. Basic knowledge of visual settings and themes
22. Basic knowledge of assistive technology (ATs)

The following is a partial list of the used files, terms and utilities: Sticky/repeat keys, mouse keys, high contrast/large print desktop themes, screen reader, braille display, screen magnifier, on-screen keyboard, gestures (used at login, for example gdm), orca, GOK, emacspeak

Topic 107: Administrative Tasks (20%)

107.1 Manage user and group accounts and related system files (weight 5) [this entire objective is covered in chapter 10]

Candidates should be able to add, remove, suspend and change user accounts.

Key Knowledge Areas:

23. Add, modify and remove users and groups

24. Manage user/group info in password/group databases

25. Create and manage special purpose and limited accounts

The following is a partial list of the used files, terms and utilities: /etc/passwd, /etc/shadow, /etc/group, /etc/skel, chage, getent, groupadd, groupdel, groupmod, passwd, useradd, userdel, usermod

107.2 Automate system administration tasks by scheduling jobs (weight 4) [this entire objective is covered in chapter 14]

Candidates should be able to use cron or anacron to run jobs at regular intervals and to use at to run jobs at a specific time.

Key Knowledge Areas:

26. Manage cron and at jobs

27. Configure user access to cron and at services

28. Configure anacron

The following is a partial list of the used files, terms and utilities: /etc/cron.{d,daily,hourly,monthly,weekly}, /etc/at.deny, /etc/at.allow, /etc/crontab, /etc/cron.allow, /etc/cron.deny, /var/spool/cron/*, crontab, at, atq, atrm, anacron, /etc/anacrontab

107.3 Localisation and internationalization (weight 3) [this entire objective is covered in chapter 12]

Candidates should be able to localize a system in a different language than English. As well, an understanding of why LANG=C is useful when scripting.

Key Knowledge Areas:

29. Configure locale settings and environment variables

30. Configure timezone settings and environment variables

The following is a partial list of the used files, terms and utilities: /etc/timezone, /etc/localtime, /usr/share/zoneinfo, environment variables (LC_*, LC_ALL, LANG, TZ), /usr/bin/locale, tzselect, tzconfig, date, iconv, UTF-8, ISO-8859, ASCII, unicode

Topic 108: Essential System Services (17%)

108.1 Maintain system time (weight 3) [this entire objective is covered in chapter 12]

Candidates should be able to properly maintain the system time and synchronize the clock via NTP.

Key Knowledge Areas:

31. Set the system date and time
32. Set the hardware clock to the correct time in UTC
33. Configure the correct timezone
34. Basic NTP configuration
35. Knowledge of using the pool.ntp.org service
36. Awareness of the ntpq command

The following is a partial list of the used files, terms and utilities: /usr/share/zoneinfo, /etc/timezone, /etc/localtime, /etc/ntp.conf, date, hwclock, ntpd, ntpdate, pool.ntp.org

108.2 System logging (weight 3) [this entire objective is covered in chapter 14]

Candidates should be able to configure the syslog daemon. This objective also includes configuring the logging daemon to send log output to a central log server or accept log output as a central log server. Use of the systemd journal subsystem is covered. Also, awareness of rsyslog and syslog-ng as alternative logging systems is included.

Key Knowledge Areas:

37. Configuration of the syslog daemon
38. Understanding of standard facilities, priorities and actions

39. Configuration of logrotate

40. Awareness of rsyslog and syslog-ng

The following is a partial list of the used files, terms and utilities: syslog.conf, syslogd, klogd, /var/log/, logger, logrotate, /etc/logrotate.conf, /etc/logrotate.d/, journalctl, /etc/systemd/journald.conf, /var/log/journal

108.3 Mail Transfer Agent (MTA) basics (weight 3) [this entire objective is covered in chapter 15]

Candidates should be aware of the commonly available MTA programs and be able to perform basic forward and alias configuration on a client host. Other configuration files are not covered.

Key Knowledge Areas:

41. Create e-mail aliases

42. Configure e-mail forwarding

43. Knowledge of commonly available MTA programs (postfix, sendmail, qmail, exim) (no configuration)

The following is a partial list of the used files, terms and utilities: ~/.forward, sendmail emulation layer commands, newaliases, mail, mailq, postfix, sendmail, exim, qmail

108.4 Manage printers and printing (weight 2) [this entire objective is covered in chapter 13]

Candidates should be able to manage print queues and user print jobs using CUPS and the LPD compatibility interface.

Key Knowledge Areas:

44. Basic CUPS configuration (for local and remote printers)

45. Manage user print queues

46. Troubleshoot general printing problems

47. Add and remove jobs from configured printer queues

The following is a partial list of the used files, terms and utilities: CUPS configuration

files, tools and utilities; /etc/cups, lpd legacy interface (lpr, lprm, lpq)

Topic 109: Networking Fundamentals (23%)

109.1 Fundamentals of internet protocols (weight 4) [this entire objective is covered in chapter 11]

Candidates should demonstrate a proper understanding of TCP/IP network fundamentals.

Key Knowledge Areas:

48. Demonstrate an understanding of network masks and CIDR notation
49. Knowledge of the differences between private and public “dotted quad” IP addresses
50. Knowledge about common TCP and UDP ports and services (20, 21, 22, 23, 25, 53, 80, 110, 123, 139, 143, 161, 162, 389, 443, 465, 514, 636, 993, 995)
51. Knowledge about the differences and major features of UDP, TCP and ICMP
52. Knowledge of the major differences between IPv4 and IPv6
53. Knowledge of the basic features of IPv6

The following is a partial list of the used files, terms and utilities: /etc/services, IPv4, IPv6, subnetting, TCP, UDP, ICMP

109.2 Basic network configuration (weight 4) [this entire objective is covered in chapter 11, with the exception of the /etc/nsswitch.conf file that is explained in chapter 12]

Candidates should be able to view, change and verify configuration settings on client hosts.

Key Knowledge Areas:

54. Manually and automatically configure network interfaces
55. Basic TCP/IP host configuration

56. Setting a default route

The following is a partial list of the used files, terms and utilities: [chapter 11: /etc/hostname, /etc/hosts, ifconfig, ifup, ifdown, ip, route, ping] and [chapter 12: /etc/nsswitch.conf]

109.3 Basic network troubleshooting (weight 4) [this entire objective is covered in chapter 11, with the exception of the host and dig commands that are explained in chapter 12]

Candidates should be able to troubleshoot networking issues on client hosts.

Key Knowledge Areas:

57. Manually and automatically configure network interfaces and routing tables to include adding, starting, stopping, restarting, deleting or reconfiguring network interfaces

58. Change, view, or configure the routing table and correct an improperly set default route manually

59. Debug problems associated with the network configuration

The following is a partial list of the used files, terms and utilities: [chapter 11: ifconfig, ip, ifup, ifdown, route, hostname, netstat, ping, ping6, traceroute, traceroute6, tracepath, tracepath6, netcat] and [chapter 12: host, dig]

109.4 Configure client side DNS (weight 2) [this entire objective is covered in chapter 12]

Candidates should be able to configure DNS on a client host.

Key Knowledge Areas:

60. Query remote DNS servers

61. Configure local name resolution and use remote DNS servers

62. Modify the order in which name resolution is done

The following is a partial list of the used files, terms and utilities: /etc/hosts, /etc/resolv.conf,/etc/nsswitch.conf, host, dig, getent

Topic 110: Security (15%)

110.1 Perform security administration tasks (weight 3) [most of this objective is covered in chapter 10, and the rest is split between chapters 11 and 15]

Candidates should know how to review system configuration to ensure host security in accordance with local security policies.

Key Knowledge Areas:

63. Audit a system to find files with the suid/sgid bit set [chapter 15]
64. Set or change user passwords and password aging information [chapter 10]
65. Being able to use nmap and netstat to discover open ports on a system [chapter 11]
66. Set up limits on user logins, processes and memory usage [chapter 10]
67. Determine which users have logged in to the system or are currently logged in [chapter 10]
68. Basic sudo configuration and usage [chapter 10]

The following is a partial list of the used files, terms and utilities: [chapter 10: passwd, chage, sudo, /etc/sudoers, su, usermod, ulimit, who, w, and last], [chapter 11: nmap, netstat], and [chapter 15: find, fuser, and lsof]

110.2 Setup host security (weight 3) [this objective is split equally among chapters 10, 11, and 14; the /etc/inittab and /etc/init.d/* are explained in chapter 6]

Candidates should know how to set up a basic level of host security.

Key Knowledge Areas:

69. Awareness of shadow passwords and how they work [chapter 10]
70. Turn off network services not in use [chapter 11]
71. Understand the role of TCP wrappers [chapter 14]

The following is a partial list of the used files, terms and utilities: , [chapter 6:

/etc/inittab, /etc/init.d/*], [chapter 10: /etc/nologin, /etc/passwd, /etc/shadow], [chapter 14: /etc/hosts.allow, /etc/hosts.deny], and [chapter 11: /etc/xinetd.d/*, /etc/xinetd.conf, /etc/inetd.d/*, /etc/inetd.conf]

110.3 Securing data with encryption (weight 3) [the entire objective is covered in chapter 15]

The candidate should be able to use public key techniques to secure data and communication.

Key Knowledge Areas:

72. Perform basic OpenSSH 2 client configuration and usage

73. Understand the role of OpenSSH 2 server host keys

74. Perform basic GnuPG configuration, usage and revocation

75. Understand SSH port tunnels (including X11 tunnels)

The following is a partial list of the used files, terms and utilities: ssh, ssh-keygen, ssh-agent, ssh-add, ~/.ssh/id_rsa and id_rsa.pub, ~/.ssh/id_dsa and id_dsa.pub, /etc/ssh/ssh_host_rsa_key and ssh_host_rsa_key.pub, /etc/ssh/ssh_host_dsa_key and ssh_host_dsa_key.pub, ~/.ssh/authorized_keys, /etc/ssh_known_hosts, gpg, and ~/.gnupg/*

Summary of Exam Objectives and Relevant Details

The following tables provide a summarized view of the exam objectives, chapters they are discussed in, associated weights, the number of questions to expect on the exam, and other useful information. This summary may be used as a quick and convenient reference.

Objective	Chapter(s)	Weight	LX0-103/ 101-400	LX0-104/ 102-400	Comments
PART ONE [Chapters 1 to 8]					
Topic 101: System Architecture (14%)					All objectives for exam LX0-103/ 101-400 are fully covered in Part ONE of the book. Some objectives are split into multiple chapters. Objectives 101.3 and 103.1 cover some Part TWO topics.
101.1	7	2	X		
101.2	6	3	X		
101.3	6	3	X	X	
Expect 8 questions from Topic 101 on the exam					
Topic 102: Linux Installation and Package Management (18%)					
102.1	8	2	X		
102.2	6	2	X		
102.3	5	1	X		
102.4	5	3	X		
102.5	5	3	X		
Expect 11 questions from Topic 102 on the exam					
Topic 103: GNU and Unix Commands (43%)					
103.1	1 and 4	4	X	X	
103.2	2 and 3	3	X		
103.3	1, 2, 4 and 8	4	X		
103.4	2 and 4	4	X		
103.5	1, 4 and 8	4	X		
103.6	4	2	X		
103.7	3	2	X		
103.8	3	3	X		
Expect 26 questions from Topic 103 on the exam					
Topic 104: Devices, Linux Filesystems, Filesystem Hierarchy Standard (25%)					
104.1	8	2	X		
104.2	8	2	X		
104.3	8	3	X		
104.4	8	1	X		
104.5	2	3	X		
104.6	2	2	X		
104.7	2	2	X		
Expect 15 questions from Topic 104 on the exam					

Objective	Chapter(s)	Weight	LX0-103/ 101-400	LX0-104/ 102-400	Comments
PART TWO [Chapters 9 to 15]					
Topic 105: Shells, Scripting and Data Management (17%)					With the exception of a handful of topics discussed in chapter 4 and chapter 6 of Part ONE, all other objectives for exam LX0-104/ 102-400 are fully covered in Part TWO of the book. Some objectives are split into multiple chapters.
105.1	4, 9 and 10	4		X	
105.2	9 and 15	4		X	
105.3	9	2		X	
Expect 10 questions from Topic 105 on the exam					
Topic 106: User Interface and Desktops (8%)					
106.1	13	2		X	
106.2	13	1		X	
106.3	13	1		X	
Expect 4 questions from Topic 106 on the exam					
Topic 107: Administrative Tasks (20%)					
107.1	10	5		X	
107.2	14	4		X	
107.3	12	3		X	
Expect 12 questions from Topic 107 on the exam					
Topic 108: Essential System Services (17%)					
108.1	12	3		X	
108.2	14	3		X	
108.3	15	3		X	
108.4	13	2		X	
Expect 11 questions from Topic 108 on the exam					
Topic 109: Networking Fundamentals (23%)					
109.1	11	4		X	
109.2	11 and 12	4		X	
109.3	11 and 12	4		X	
109.4	12	2		X	
Expect 14 questions from Topic 109 on the exam					
Topic 110: Security (15%)					
110.1	10, 11 and 15	3		X	
110.2	6, 10, 11 and 14	3		X	
110.3	15	3		X	
Expect 9 questions from Topic 110 on the exam					

Exam Fees and Registration Procedure

The fee for each of the two CompTIA Linux+ Powered by LPI/LPIC-1 certification exam is US$200 or equivalent in local currencies. To purchase an exam voucher, visit http://www.comptiastore.com/ProductDetails.asp?ProductCode=VWLNXLPI or http://www.lpimarketplace.com/categorys/1847.htm?searching=Y&sort=3&cat=1847&show=15&page=1&brand=LPI and follow the directions. To register for an exam, visit https://certification.comptia.org/testing/schedule-exam or http://www.vue.com/lpi/ and follow the instructions. The exams are administered by Pearson VUE.

About This Book

The focus of this book is to present the basics of Linux in an easy-to-understand manner while covering the objectives and preparing the readers for the certification exams. In order to study the nitty-gritties of Linux while preparing for the exams at the same time, I have provided guidance in chapter 1 on how to set up a lab environment. I have used CentOS 7.3, Ubuntu 14.04.5, and CentOS 5.11 for examples, demonstrations, and exercises throughout this book. I have chosen CentOS 7.3 to explain new concepts and additions, such as systemd and journald, introduced in the latest release of the official exam objectives; Ubuntu 14.04.5 to present Debian-specific tasks, such as APT package management system; and CentOS 5.11 to cover older stuff such as SysVinit and GRUB Legacy.

The book is organized in two parts. Each part covers the objectives for one exam. There are 15 chapters that are organized to learn and teach Linux in a progressive manner.

1. **Part ONE** (chapters 1 to 8) covers topics that will help readers learn Linux essentials and build certain system administration skills while preparing for exam LX0-103/101-400. Material presented includes CentOS and Ubuntu installations; general Linux concepts and basic commands; compression and archiving; online help; file system hierarchy concepts, and file and directory operations; file types, access permissions, and ownership; file linking, searching, and special permissions; text file editing and data manipulation with filter programs; regular expressions; Bash shell features and process manipulation; shared libraries, and Debian and rpm package administration; system boot and initialization; hardware management and kernel modules; disk partitioning and file system build and repair; and quota and swap administration.
2. **Part TWO** (chapters 9 to 15) covers additional topics on system administration and prepares readers for exam LX0-104/102-400. Material presented includes automation with shell scripts; SQL database management and query; users, groups, password aging, and shell startup files; networking fundamentals and network interface configuration; routing and Internet services; network connection testing and troubleshooting; Linux support for internationalization and localization; time synchronization and hostname resolution; X Window, desktops, and accessibility options; printer and print queue administration; task scheduling and local and remote message logging; TCP Wrappers and email; secure shell and GnuPG management; and miscellaneous topics on file searching for auditing, in-use file identification, and PID identification using a specific file.

Each chapter begins with highlights of major topics and relevant exam objectives

covered and ends with a summary followed by an at-a-glance chapter review. Throughout the book, figures, tables, and screenshots have been furnished to support explanation. This book includes more or less 400 practice questions and answers for each exam in the appendices.

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PART ONE

LX0-103/101-400

Chapter 1

Installing Linux and Using Basic Commands

This chapter describes the following major topics:

- Overview of Linux, open source, and popular Linux distributions
- Obtain CentOS Linux, Ubuntu Linux, and Oracle VirtualBox software
- Create virtual machines and install CentOS and Ubuntu
- Access the new systems
- Access the command prompt
- General Linux commands and how to execute them
- Use basic compression and archiving tools
- Get Linux online help

This chapter covers the following objectives for LX0-103/101-400 Exam:

103.1 Work on the command line [a part of this objective is described in this chapter and the rest in chapter 4]

36. Use single shell commands and one line command sequences to perform basic tasks on the command line

The following is a partial list of the used files, terms and utilities: pwd, man, and uname

103.3 Perform basic file management [most of this objective is described in chapter 2, a part in chapter 4, the dd command in chapter 8, and the tar/cpio commands in this chapter]

46. Usage of tar and cpio

The following is a partial list of the used files, terms and utilities: tar, cpio, gzip,

gunzip, bzip2, and xz

103.5 Create, monitor and kill processes [most of this objective is described in chapter 4, the uptime command in this chapter, and the free command in chapter 8]

The following is a partial list of the used files, terms and utilities: uptime

Linux has been around since 1991. It is a free operating system with source code that anyone—amateur and developers—can use for customization and redistribution. Companies such as Red Hat, SUSE, Canonical, and Oracle have tailored the source code and added features, enhancements, and bug fixes to make their Linux distributions stable, robust, and feature-rich for commercial use.

Linux distributions may be downloaded for learning as well as for practicing and preparing for Linux certification exams. This chapter sets up the foundation for learning the essentials of Linux and practicing the objectives for CompTIA Linux+ Powered by LPI/LPIC-1 certification exams as published on www.comptia.org and www.lpi.org.

Linux offers a variety of commands for users and system managers. User commands are general purpose that are intended for execution by any user on the system. However, system management commands require elevated privileges of the superuser. Knowledge of these tools is essential for productive usage and efficient administration of the system. This chapter provides an introduction to a number of user and administrative commands.

Users and administrators need help on command usage/syntax and on the format of configuration files. To assist users, Linux installs help in the form of manual pages, as part of software installation.

Linux and Open Source

Linux was originally developed in a collaborative effort by several developers who had the primary goal of creating a free, open-source operating system.

The term open source is referred to the software with source code that is available to the public for download, duplication, amendment, repackaging, and re-sharing. The open-source approach allows anyone to add enhancements and fix bugs for the larger global community benefit.

The development effort was called the GNU Project (GNU's Not Unix) and it included file system structure, tools, and utilities. In 1991, a piece of software called kernel, developed by Linus Torvalds, was integrated with the GNU software, which formed what is now referred to as GNU/Linux, Linux operating system, or simply Linux. Linux was initially released in 1991 under the GNU General Public License (GPL), which provided public access to its source code free of charge with full consent to amend and redistribute. The first major version 1.0 was released in 1994 followed by 2.0 in 1996, 3.0 in 2011, and the latest 4.0 in 2015. Each major version had plenty of minor releases. For instance, the 2.5 kernel had 75 minor releases, 2.6 had 39, 3.0 had 19, and 4.0 has had 9 so far. Each successive version/release saw bug fixes, new features, support for new hardware devices, enhancements, and security patches. At the time of this writing,

version 4.9 is the latest Linux kernel.

Linux runs on an extensive range of computer hardware platforms, from laptop and desktop computers to massive mainframe and supercomputers. Linux also runs as the base operating system on a variety of networking, mass storage, and mobile devices. Numerous vendors including Red Hat, SUSE, Canonical, IBM, HP, Oracle, and Dell offer commercial support to Linux users worldwide.

The functionality, adaptability, portability, and cost-effectiveness that Linux offers has made it the main alternative to proprietary UNIX and Windows operating systems.

Linux is largely used in government agencies, corporate businesses, academic institutions, and scientific organizations, as well as on home computers. Linux deployment and usage has grown tremendously over the years. A number of companies are planning or executing a migration or have already migrated from UNIX to the Linux platform.

Popular Linux Distributions

There are over a hundred distributions of Linux available from various vendors, organizations, and individuals; however, only a handful of them gained popularity and wide acceptance amid user, developer, and corporate communities. Among these distributions are Red Hat Enterprise Linux (RHEL), Oracle Linux, CentOS (Community Enterprise Operating System), Scientific Linux, Fedora, Debian Linux, Ubuntu Linux, SUSE Linux, and OpenSUSE Linux.

Enterprise Linux (Red Hat, Oracle Linux, CentOS, Scientific Linux, and Fedora)

Of the list provided above, Red Hat and Oracle Linux are targeted for enterprise use and require paid subscription for support. CentOS and Scientific Linux are available for free and may be used for home and business purposes but without any official support. Fedora is a community-based project initiated, sponsored, and sustained by Red Hat as their test-bed for the development and testing of new features, enhancements, and bug fixes for inclusion in subsequent releases of RHEL. Oracle Linux, CentOS, and Scientific Linux branch off their releases from versions of RHEL. At the time of this writing, the latest version of RHEL, Oracle Linux, and CentOS is 7.3, Scientific Linux is 7.0, and Fedora is 25.

Debian Linux

Debian made its debut in 1993 as a community-powered project. Debian supports a number of different vendor hardware architectures including Intel/AMD processors,

SPARC, PowerPC, and IBM mainframes.

Debian has three release types that are referred to as unstable, testing, and stable. An unstable release is the version that developers are currently working on, a testing release is in the testing phase, and a stable release is the one that is ready and available for use. At the time of this writing, the latest version of Debian Linux is 8.6.

Ubuntu Linux

Ubuntu is a spin-off of Debian. Ubuntu has two release types that are referred to as Ubuntu Long Term Support (LTS) and Ubuntu standard. The LTS version is stable, updated every six months, released every two years, and supported for five years. As of this writing, the latest Ubuntu LTS version is 16.04.1; however, for the purpose of this book, we use 14.04.5.

On the contrary, Ubuntu standard is released between six to twelve months and comes with a nine-month support. As of the writing of this book, the latest version of Ubuntu non-LTS is 16.10.

Ubuntu in comparison to Debian is more user-friendly and easier to use.

SUSE and OpenSUSE Linux

SUSE Linux was first released in 1994 and it is now a popular choice in the commercial space. OpenSUSE, on the other hand, is a community-driven project started when Novell owned SUSE in 2003. SUSE Linux Enterprise has two main versions: SUSE Linux Enterprise Server (SLES) and SUSE Linux Enterprise Desktop (SLED). At the time of this writing, the latest version of SLES and SLED is 12.2, and that of OpenSUSE is 42.2.

LAB Setup for Practicing CompTIA Linux+ Powered by LPI/LPIC-1 Exam Objectives

Beginning in this chapter and throughout this book, several topics on Linux system, networking, and security will be introduced and discussed, along with procedures on how to implement, administer, and use them. A number of exercises will be performed and commands presented and executed to support the learning in a practical environment. In order for a smooth and effective learning experience, I have summarized the lab setup that I have used to support my writing and I want you to use the same, if possible, for yourselves to avoid issues that might arise due to dissimilarities. Here is what I have used:

Linux software:	ISO images for CentOS 7.3, Ubuntu 14.04.5, and CentOS 5.11 attached to their respective virtual machines. A complete procedure is provided to help you download the images.

Virtualization software:	Oracle VM VirtualBox 5.1.18 on MS Windows 10. A link is provided on where to download the O VM VirtualBox software.
Remote client connectivity software:	Binary SSH client file called putty.exe from https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html. Store this file on your Windows/M computer. You will need it to connect to the three Linux systems over the new network interfaces you'll configure in Chapter 11.
Laptop architecture:	64-bit laptop with Intel Core i7 processor and 8GB of memory
Network interface:	1 WiFi network interface
Number of VMs:	3
Guest OS in VM1:	CentOS 7.3. This new OS version is included to expound on the exam objectives that require the knowledge and understanding of new concepts and procedures. This VM and OS is stood up in Chapter 1 and used throughout the book.
Guest OS in VM2:	Ubuntu 14.04.5. This new OS version is included to explicate the exam objectives that require the knowledge and understanding of concepts and procedures specific to Debian-based Linux systems This VM and OS is stood up in Chapter 1 and used throughout the book.
Guest OS in VM3:	CentOS 5.11. This old OS version is included to support the exam objectives that require the knowledge and understanding of concepts and procedures specific to older Linux versions. This Li system is needed in Chapter 6 and beyond. You need to build it yourselves; a procedure is not prov
VM1:	Hostname centos73, 1 vCPU, 1024MB memory, 1 x 8GB virtual disk for CentOS 7.3, 3 x 200MB virtual disks for disk management exercises added and used in Chapter 8, and 1 virtual bridged net interface over WiFi with a DHCP-supplied IP address. A static IP address 192.168.0.100 will be applied to a new network interface in Chapter 11. Most tasks in the book are performed on this VI
VM2:	Hostname ubuntu14, 1 vCPU, 1024MB memory, 1 x 8GB virtual disk for Ubuntu 14.04.5, and 1 vi bridged network interface over WiFi with a DHCP-supplied IP address. A static IP address 192.168.0.101 will be applied to a new network interface in Chapter 11.
VM3:	Hostname centos511, 1 vCPU, 1024MB memory, 1 x 8GB virtual disk for CentOS 5.11, and 1 virtu bridged network interface over WiFi with a DHCP-supplied IP address. A static IP address 192.168.0.102 will be applied to a new network interface in Chapter 11.

If you prefer to continue to use IP addresses provided by your DHCP server (such as your home router) throughout this book, make sure that you keep a mapping between them and the ones provided above to avoid losing track.

Exercise 1-1: Installing CentOS Desktop

For the purpose of learning, practicing, and preparing for the exams, we have downloaded CentOS 7.3 to our MS Windows system and installed it in an Oracle VirtualBox virtual machine as directed in the following subsections. We use basic installation options, such as the default disk partitioning layout, and obtain IP assignments from the DHCP server that is running on our home router. We've named the system centos73.

Downloading CentOS 7.3

Installation images for CentOS are available in the ISO format for download on the official website at www.centos.org. Follow the instructions provided below to acquire a copy of the x86_64 version:

1. Go to www.centos.org and click "GET CENTOS" located at the top of the home page.

2. Click "DVD ISO" to list download locations for the image. The files should have 1611 version number embedded in their names.

3. Click any image from the list to download the software to your Windows desktop.

Creating a Virtual Machine

We use Oracle VirtualBox 5.1.10 to create a virtual machine (VM) to host CentOS. Download and install this software (or a closer version) from www.virtualbox.org on your Windows system. After the installation, launch the Oracle VM VirtualBox program and follow the steps provided below to create a VM:

1. Click New to begin the VM creation process.

2. Enter a name, such as centos 73, for the VM and ensure Linux Red Hat (64-bit) is selected. Click Next.

3. Allocate 1024MB as the amount of memory and click Next.

4. Select "Create a virtual disk now" and click Create.

5. Choose "VDI (VirtualBox Disk Image)" as the type of virtual disk and click Next.

6. Select "Dynamically allocated" and click Next.

7. Choose the default disk size of 8GB and click Create.

8. Click "[Optical Drive] Empty" under Storage on the VM's Details page and select "Choose disk image...".

9. Browse to select the CentOS 7.3 ISO image (CentOS-7-x86_64-DVD-1611) that you just downloaded and click Open to attach the image to the VM.

This completes the steps to create a VM and attach an ISO image to it. The Details page of the VM will look similar to what is shown in Figure 1-1.

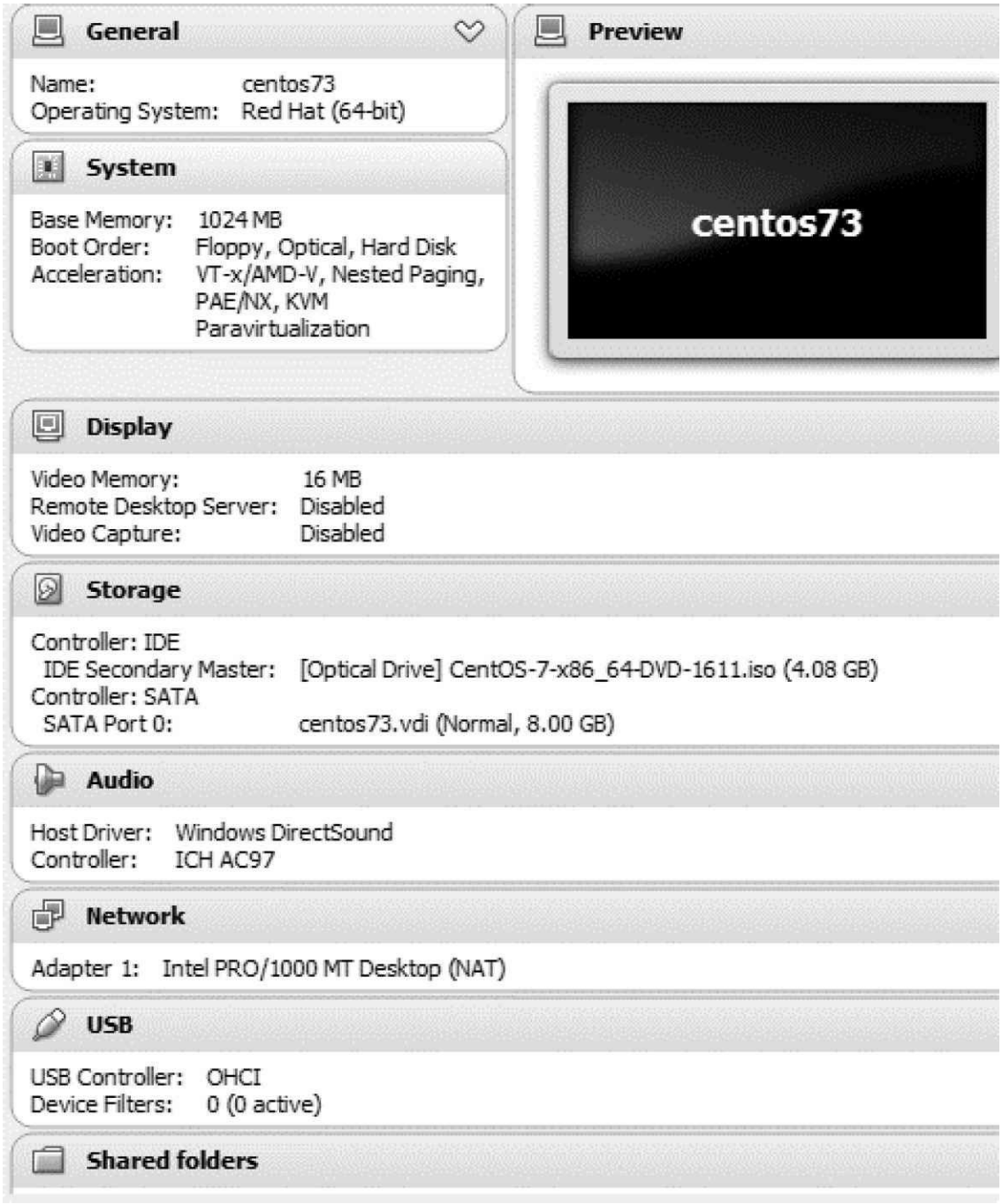

Figure 1-1 VM Details

You now have a VM ready for CentOS installation.

Initiating Installation

1. Power on the VM by highlighting it and then clicking Start. This will open a console window for the VM and start the boot program.

2. Highlight “Install CentOS Linux 7” and press Enter to begin installation.

Figure 1-2 Boot Menu

3. Click Continue on the next screen to select English as the language to be used during the installation process.

4. The “Installation Summary” screen appears next, as shown in Figure 1-3. This is when the Linux installer program called Anaconda is initiated and takes over the installation process. Prior to starting the installation, you can make necessary configuration changes to localization (date, time, time zone, keyboard, and language), software (installation source and what to install), and system settings (disk selection and partitioning, kernel dump, network & hostname assignments, and security policy). For this exercise, we use the defaults for localization, so there is no need to make changes there. The installation program auto-detects the presence of the attached ISO image as the local media, so there is no need to modify Installation Source under Software either. We also leave the kdump and security policy settings under System intact.

Figure 1-3 Installation Summary

Selecting Software for Installation

5. The default software selected for installation is “Minimal Install” as displayed under Software Selection; however, for this exercise, click Software Selection and choose “GNOME Desktop” (Figure 1-4). Click Done in the top left-hand corner to return to the Installation Summary page.


GNOME is the default graphical desktop in numerous Linux distributions and it stands for (GNU Network Object Model Environment).

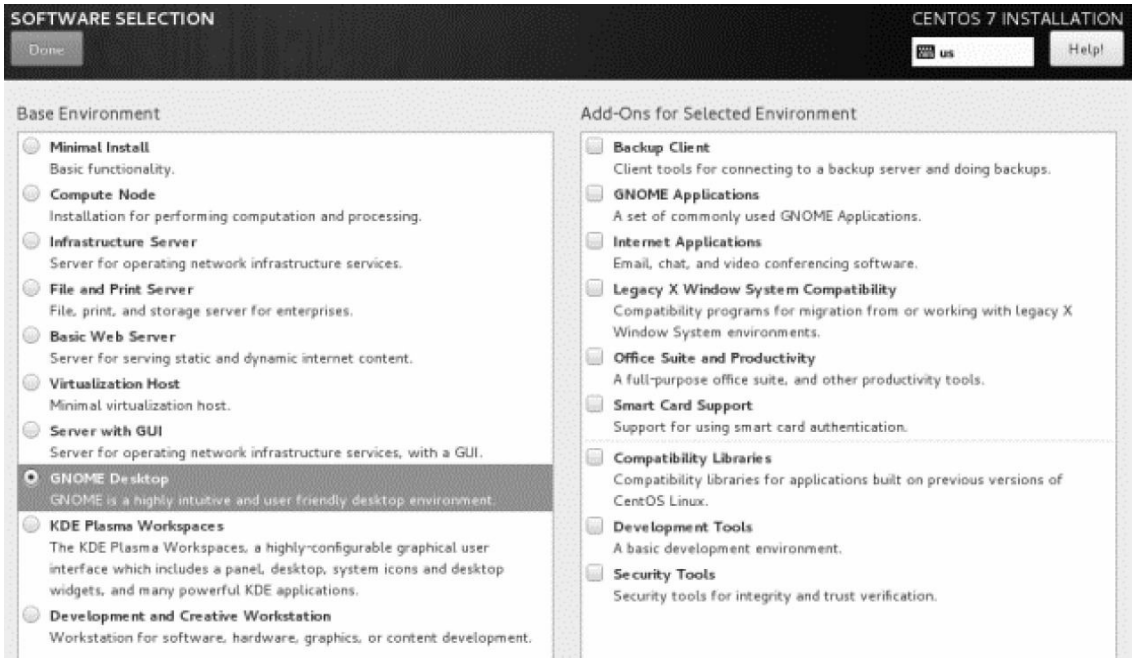

Figure 1-4 Installation Summary / Software Selection

Configuring Installation Destination

6. Choose a disk for installation and partitioning under Installation Destination. See Figure 1-5. By default, the installer selects “Automatic partitioning selected” as displayed on the Installation Summary page. However, you can either retain the automatic partitioning selection or configure your own scheme on the Installation Destination page. The 8GB disk that was added during the VM creation is visible here as sda.

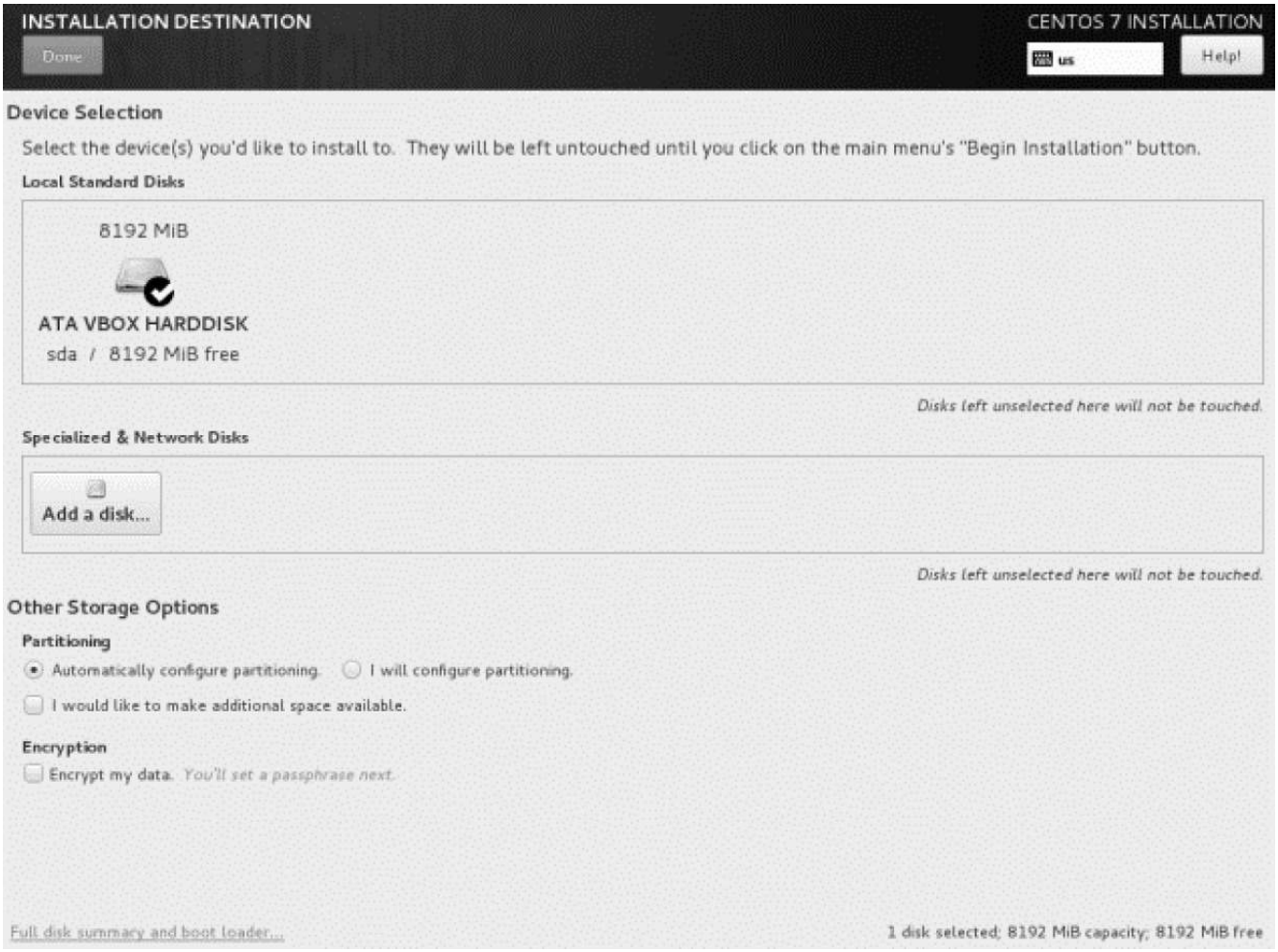

Figure 1-5 Installation Summary / Installation Destination

For this exercise, simply click the Done button to permit the installer to use the default automatic disk partitioning scheme. This will create a partition called /boot for storing kernel and boot configuration files, and an LVM (Logical Volume Manager) volume group with two partitions called / and swap. Together, the three partitions take up the entire disk capacity. Custom partitioning under the Other Storage Options by selecting "I will configure partitioning" will allow you to create separate partitions for /home, /usr, /var, and /opt with desired sizes.


LVM stands for Logical Volume Manager. It is a popular choice for disk partitioning and it is available in most Linux distributions. See Chapter 8 "Administering Partitions, File Systems, and Swap" for more details.


The installer program requires that three partitions: /boot, /, and swap be created at a minimum.


The /boot partition is created as a standard partition outside of LVM boundaries.

Configuring Network and Hostname

7. Assigning appropriate IP information and a hostname is essential for system functionality on the network. Click Network & Hostname on the Installation Summary page and a window similar to the one shown in Figure 1-6 will pop up. Anaconda automatically detects the network interface (represented as enp0s3 here; however, it might be different on your system) and shows it in the left windowpane. It also shows the default hostname as localhost.localdomain in the bottom left side. You need to modify these assignments so that your system is able to communicate with other systems on the network. For this exercise, simply slide the switch located in the top right-hand corner to enable getting IP assignments automatically from DHCP.

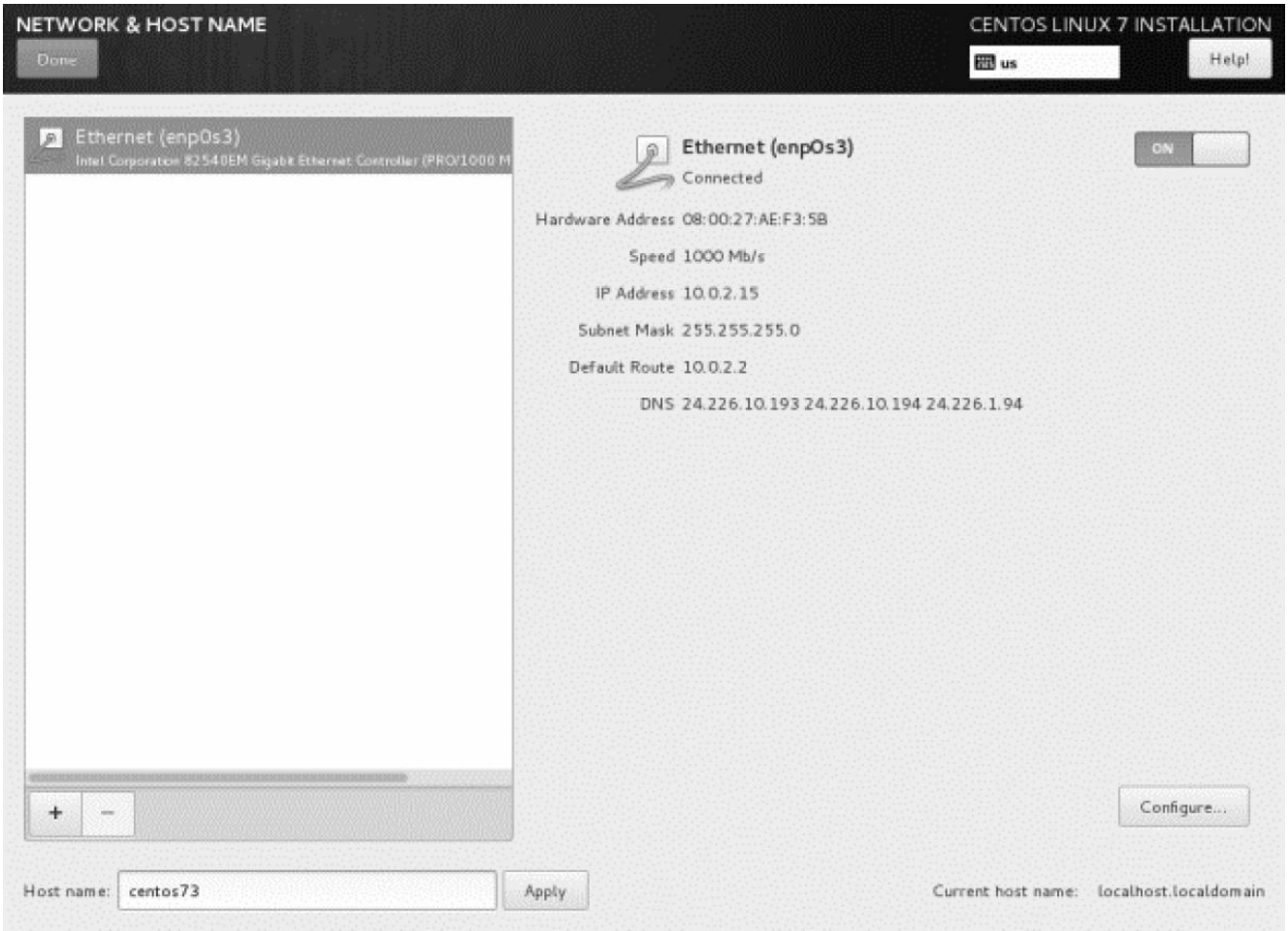

Figure 1-6 Installation Summary / Network & Hostname

Next, enter centos 73 in the Hostname field in the bottom left-hand corner and click Done to return to the Installation Summary page.

Beginning Installation

8. The Installation Summary page now looks like Figure 1-7. Click Begin Installation in the bottom right to begin the installation based on the configuration entered in the previous steps.

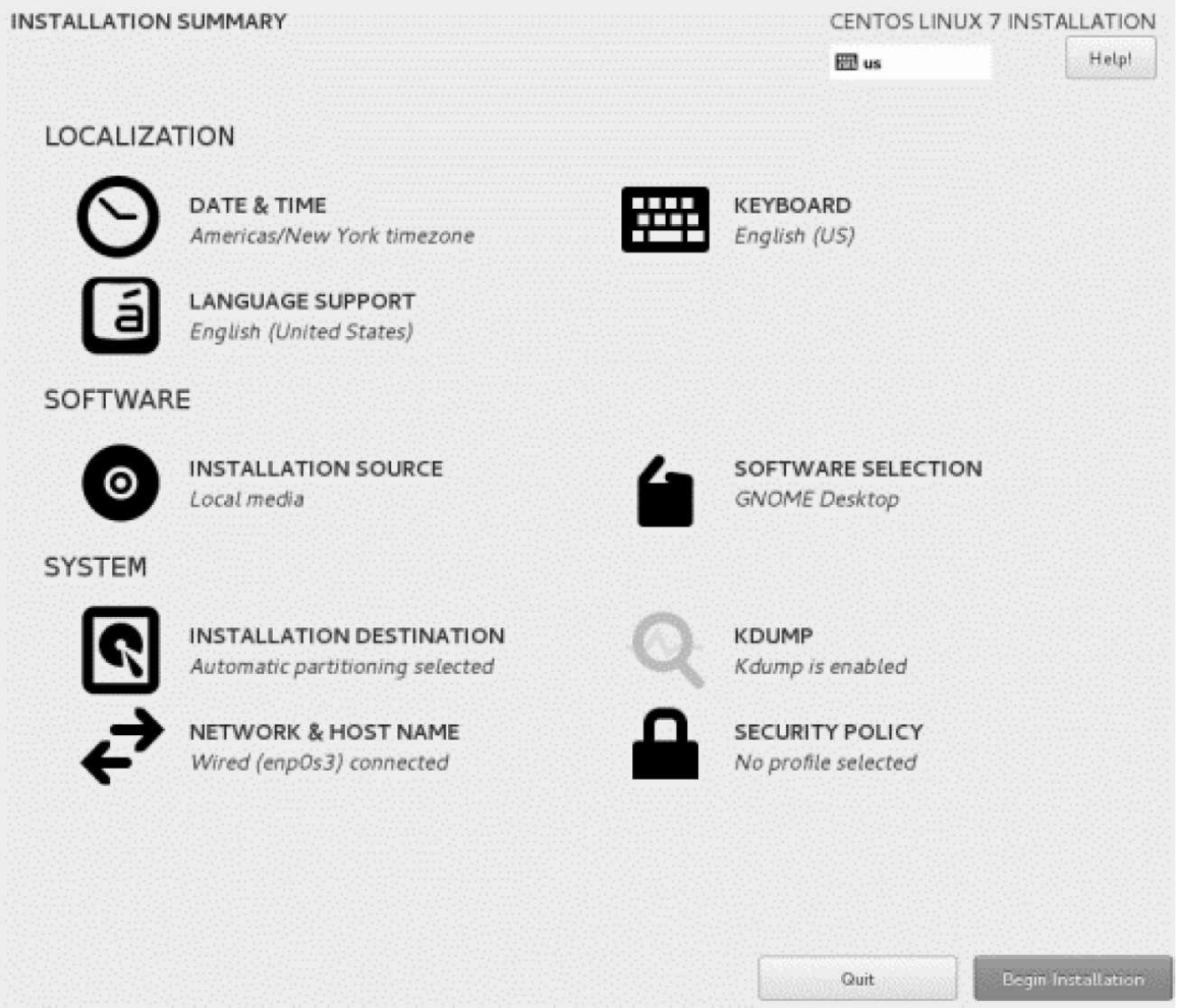

Figure 1-7 Installation Summary


The Begin Installation button is not visible until all required configuration is entered.

Setting root User Password and Creating a User Account

9. Once the installation has begun, a new screen appears that shows the installation progress. This screen also allows you to assign a password to the root user and create a normal user account.

10. While the installer continues with background configuration and software copy, click Root Password and enter a password for the root user. Click Done to return to the installation progress screen.

11. Next, click User Creation and create a user account called user1 and assign a password of your choice. See Figure 1-8. Click Done to return.

Finishing Installation

12. When all software packages are installed, the Reboot button becomes active in the bottom right-hand corner of the screen. Click this button to reboot the new system.

Figure 1-8 Configuration / Create User

Accepting the License

13. Following the reboot, the system shows you two options in the graphical console window: (1) License Information under Licensing, and (2) Network & Hostname under System. Click License Information and select “I accept the license agreement” in the bottom of the screen. Click Done to go back to the previous screen. There is no need to modify the network or hostname configuration at this point. Click Finish Configuration at the bottom right side to continue with the boot process.

Logging In

14. The login screen appears showing the user account (user1) created earlier. Click user1 and enter the password to sign in.

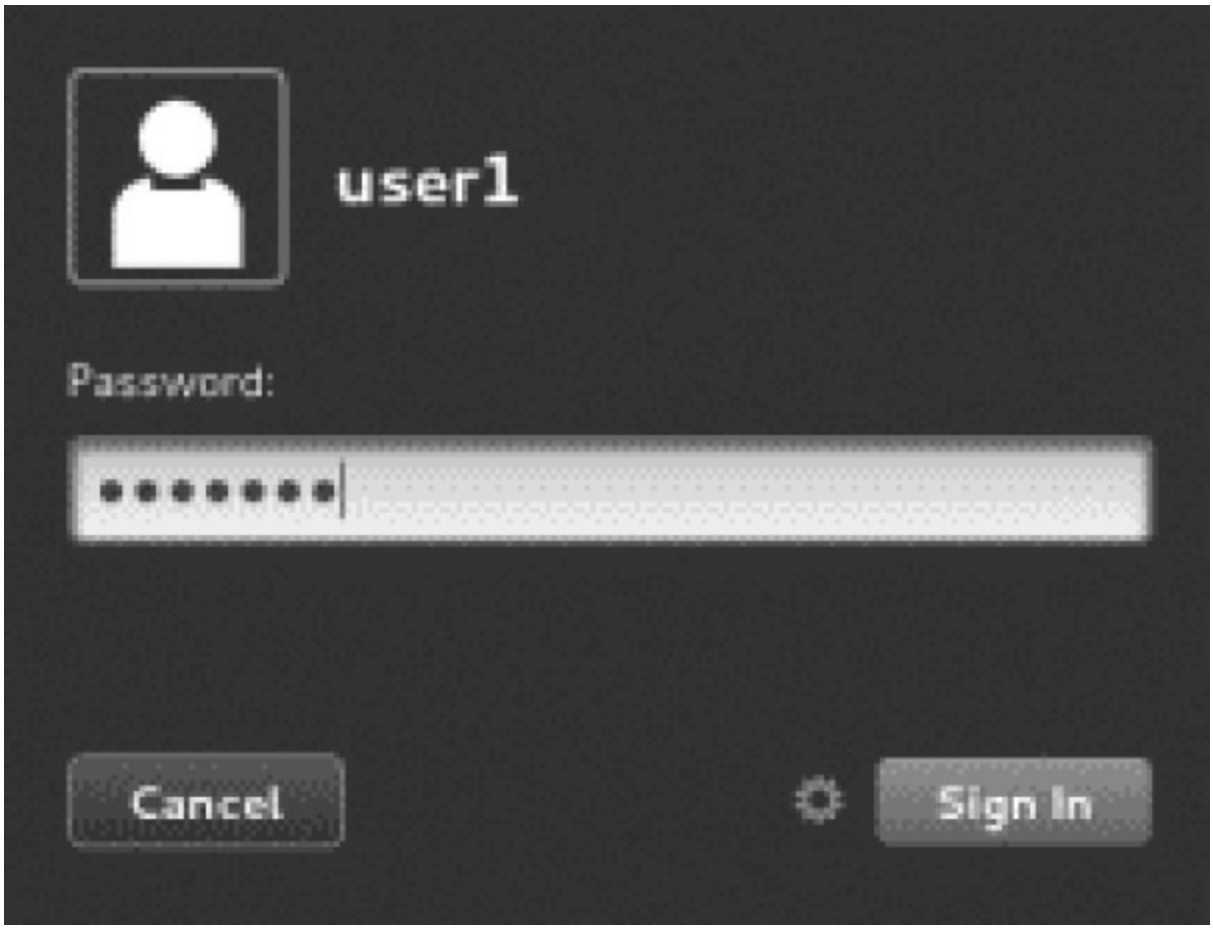

Figure 1-9 Sign In

15. Click Next on the Welcome screen and then click Next again to accept the selected keyboard layout.

16. Click Skip on Online Accounts and then click "Start using CentOS Linux."

17. Your system is now ready for use. The default graphical desktop called GNOME appears with Getting Started information (Figure 1-10). You should now be able to start using the system as user1.

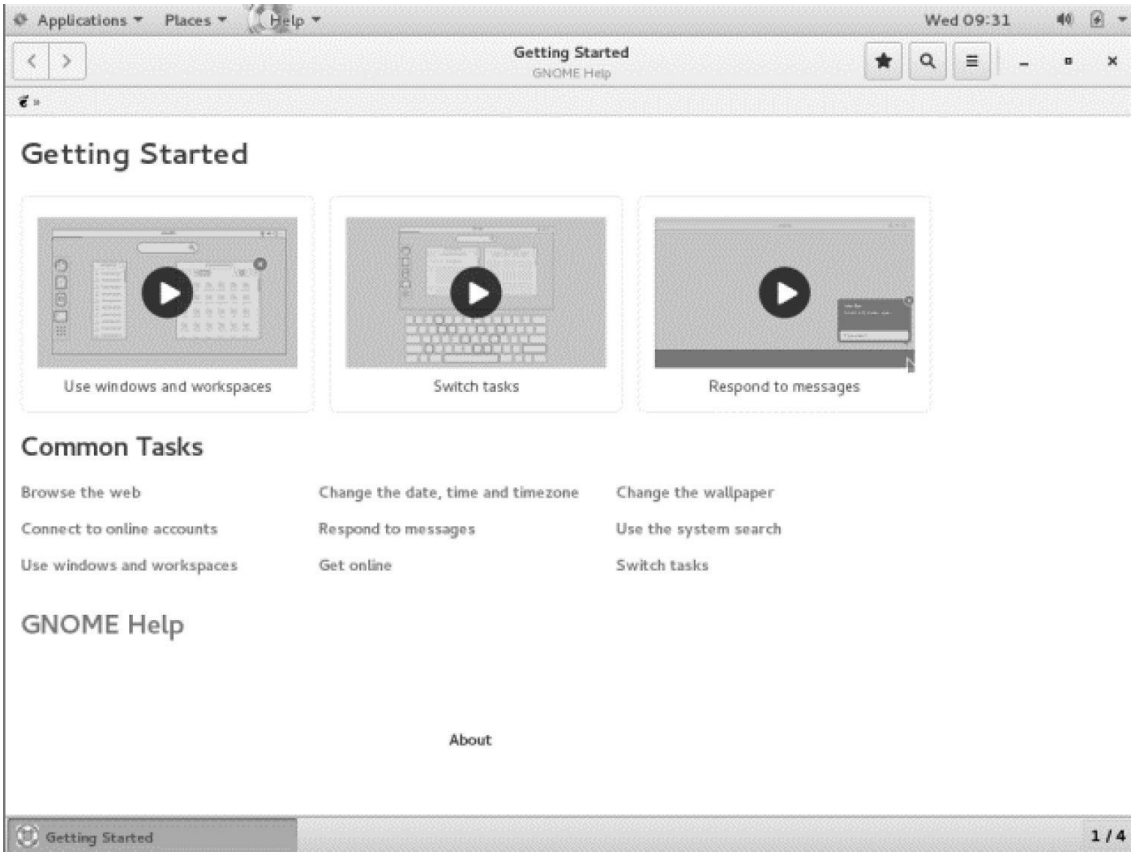

Figure 1-10 GNOME Desktop

Logging Out

18. After you are done navigating, click the down arrowhead at the top right-hand corner of the screen and then click the arrowhead beside user1. Click “Log Out” to log off the system.

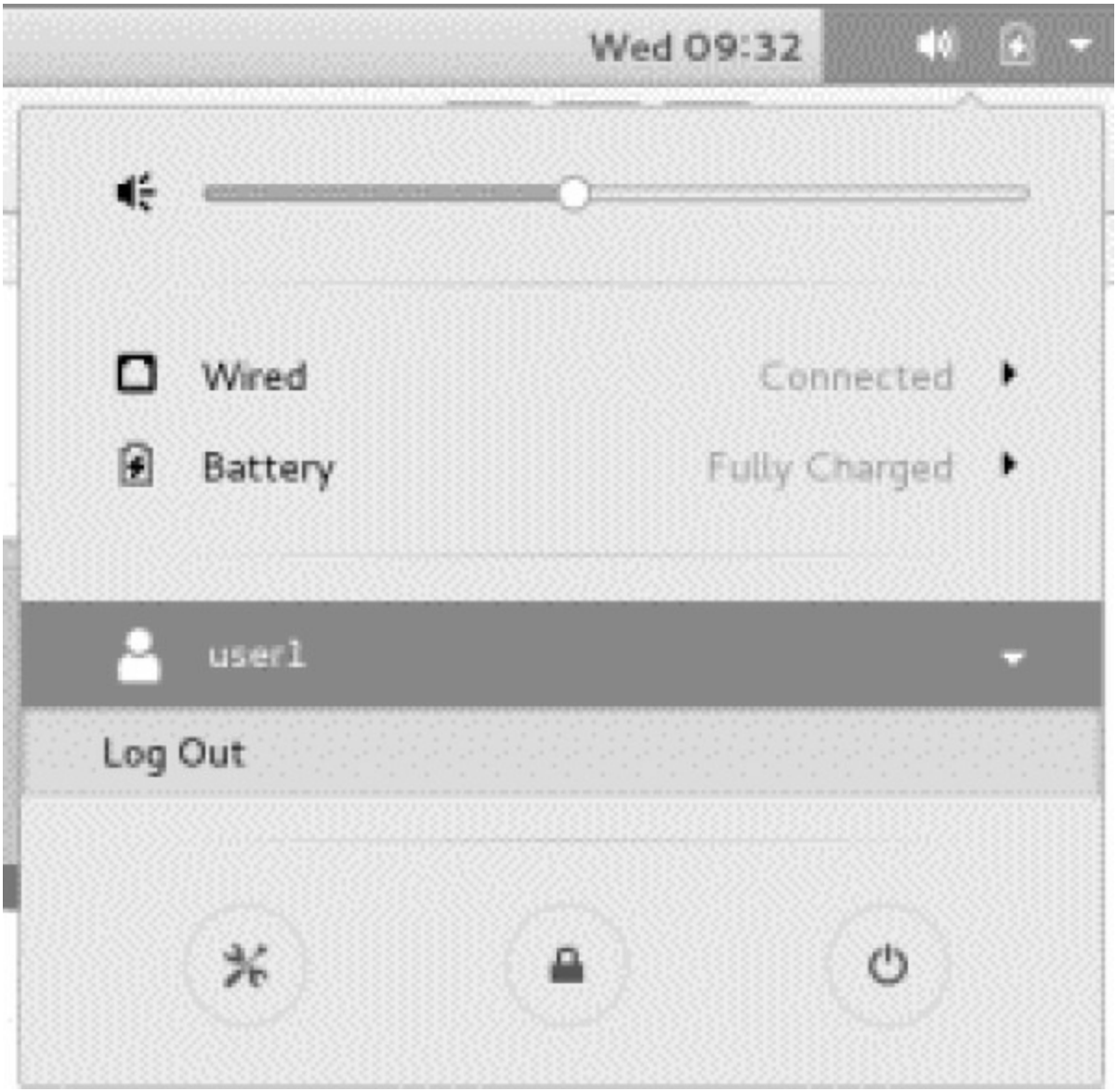

Figure 1-11 Log Out

This completes the step-by-step procedure for installing CentOS 7.3 Desktop using the ISO image in a virtual machine.


You need to press the right Ctrl key to release the mouse cursor.

Exercise 1-2: Installing Ubuntu Desktop

For the purpose of learning, practicing, and preparing for the exams, we have downloaded Ubuntu 14.04.5 Desktop to our MS Windows system and installed it in an Oracle VirtualBox virtual machine as directed in the following subsections. We use basic installation options such as the default disk partitioning layout and acquiring IP assignments from the DHCP server running on our home router. We've named the system

ubuntu14.

Downloading Ubuntu 14.04.5 Desktop

Installation images for Ubuntu Linux are available in ISO format for download on the official website at www.ubuntu.com. Follow the instructions below to obtain a copy of the x86_64 version:

1. Go to releases. ubuntu.com and click "Ubuntu 14.04.5 LTS (Trusty Tahr)" under "Ubuntu Releases."

2. Click "64-bit PC (AMD64) desktop image" to download the image to your system.

Creating a Virtual Machine

Follow the instructions outlined in Exercise 1-1 to create a virtual machine (VM) using Oracle VirtualBox to host Ubuntu. Name the VM ubuntu14 and attach the Ubuntu ISO image to the VM.

Initiating Installation

1. Power on the virtual machine by highlighting it and then clicking Start. This will open a console window and start the boot program.

2. Click "Install Ubuntu" on the Welcome screen to initiate the installation.

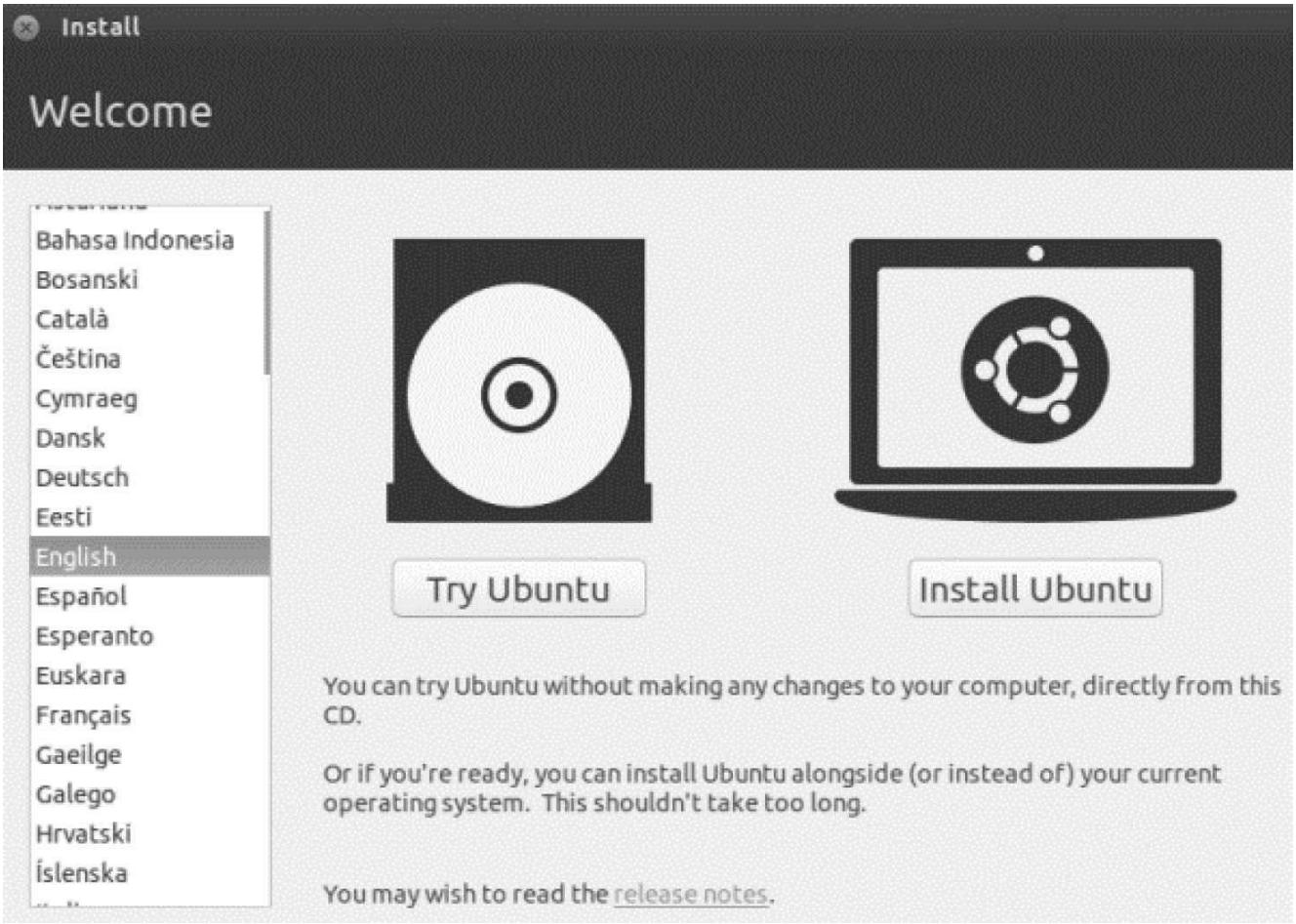

Figure 1-12 Welcome Screen

Preparing for Installation

3. The “Preparing to install Ubuntu” screen appears next, as shown in Figure 1-13.

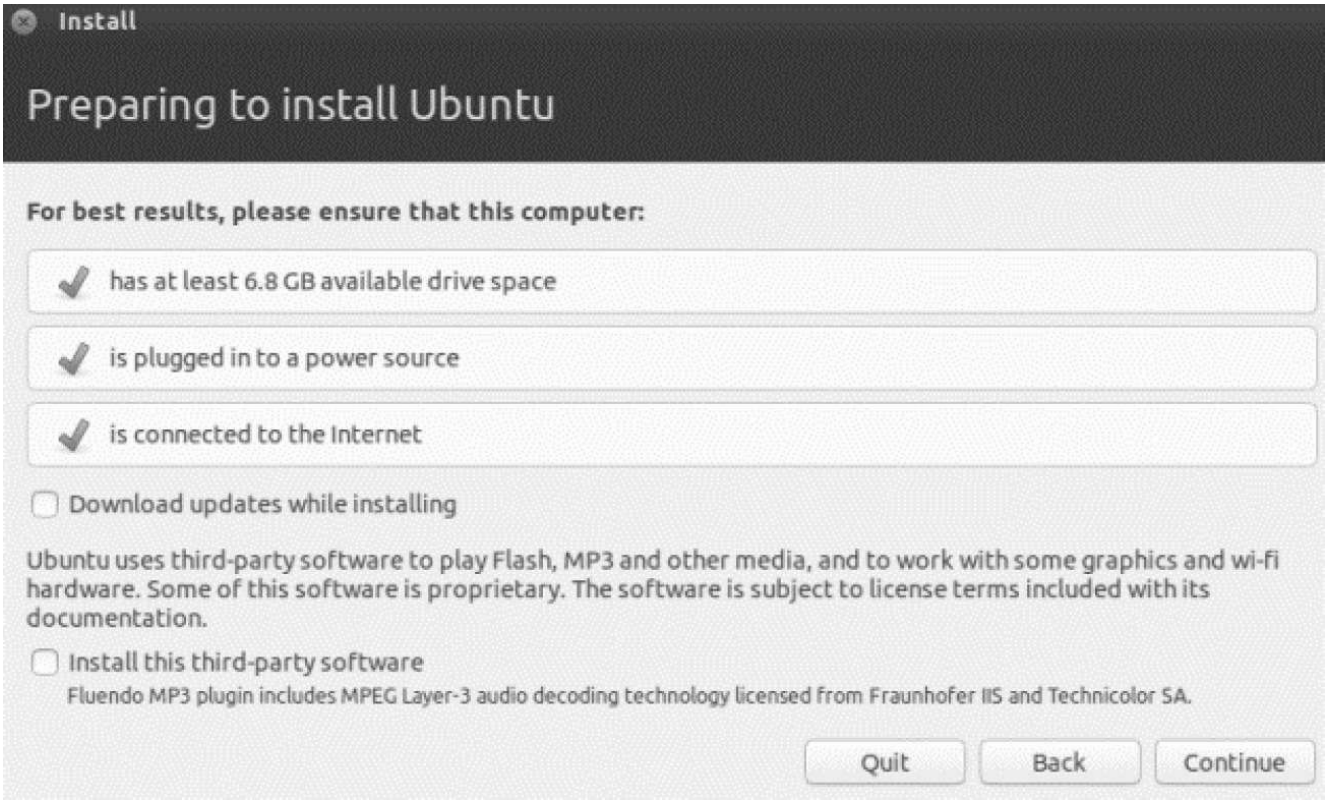

Figure 1-13 Install Preparation

The installer program shows the available drive space and whether the computer is plugged in to a power source. Click Continue while leaving the "Download updates while installing" and "Install this third-party software" options unselected.

Selecting an Installation Type

4. The installer detects the presence of the empty disk that had been added at the time of the VM creation and selects the option to erase the disk and use it for installing Ubuntu. For partitioning, choose "Use LVM with the new Ubuntu installation." Click "Install Now" to continue with the installation.

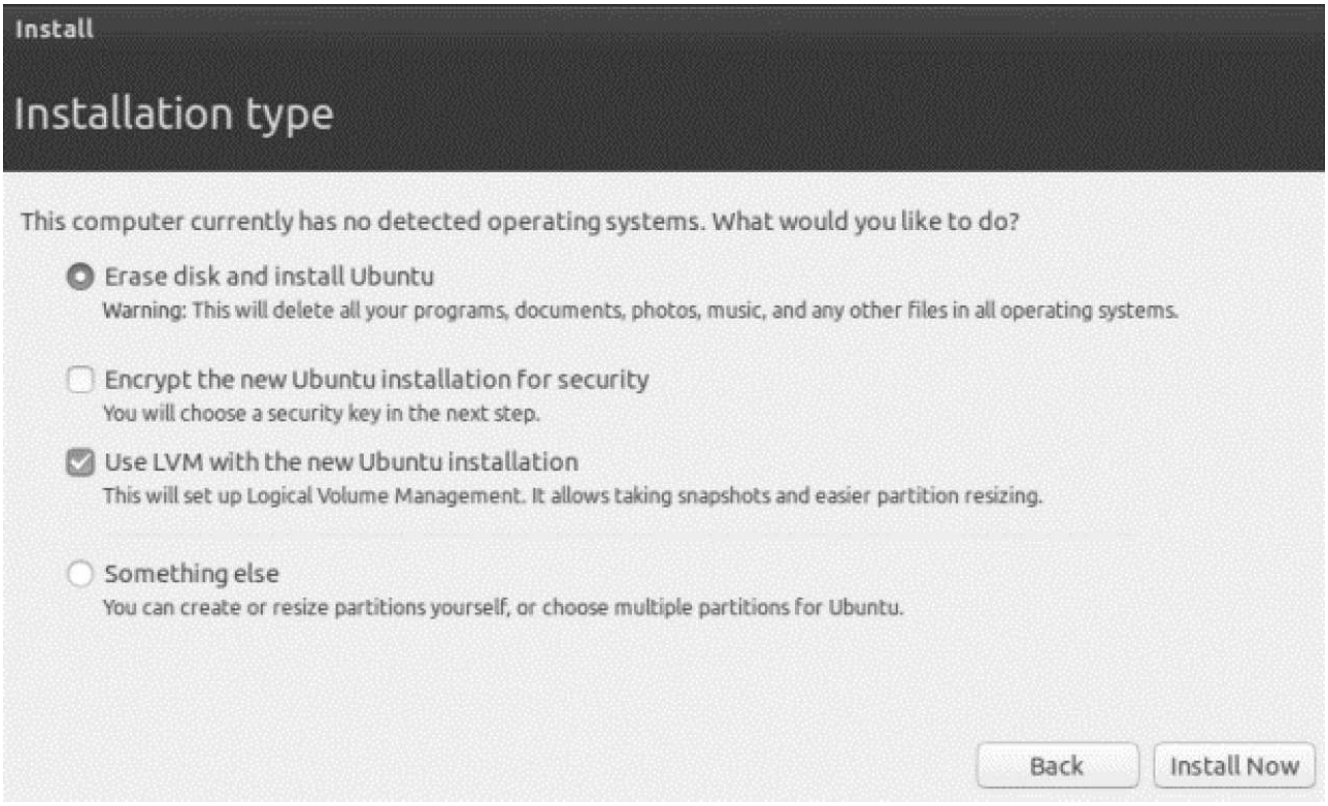

Figure 1-14 Installation Type

5. A pop-up screen prompts for confirmation to write the changes to the disk. Click Continue to confirm and proceed.

Configuring Locale

6. Type the name of your time zone (e.g., Eastern Standard Time; Mountain Time) and select an appropriate time zone from available choices. Click Continue.

7. On the next screen, click Continue to select the “English (US)” as the keyboard layout for your system. Choose a different value if you wish to.

Creating a User Account and Setting a Hostname

8. Enter credentials to create an account for user user1. Also, enter ubuntu14 as the hostname for your computer.

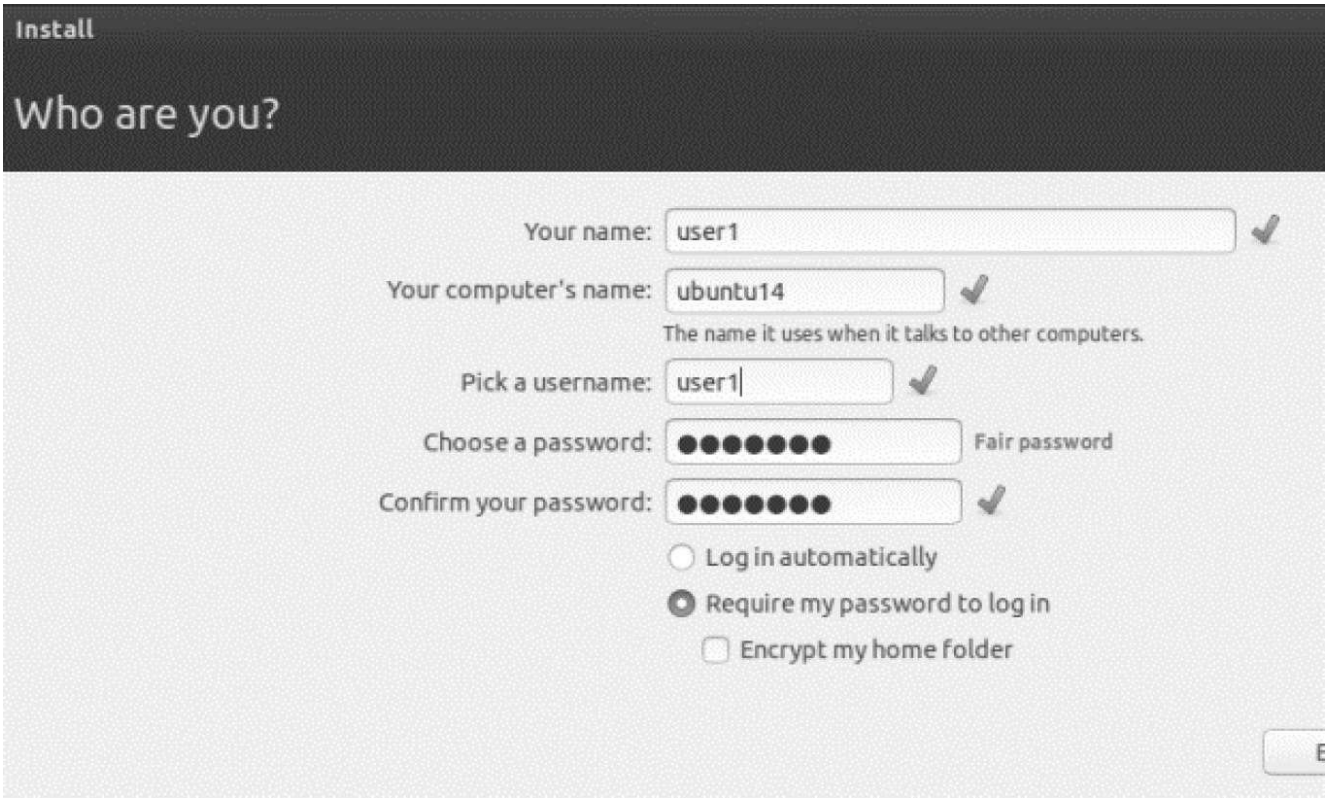

Figure 1-15 User Creation and Hostname Setting

Click Continue to complete the configuration steps and proceed with the installation.

Finishing Installation

9. When the configuration is done and software packages are installed, a message pops up on the screen marking completion of the installation. Click “Restart Now” to reboot the new system.

Logging In

10. Following the reboot, the system presents the login screen for user1. Enter the password for user1 to log in.

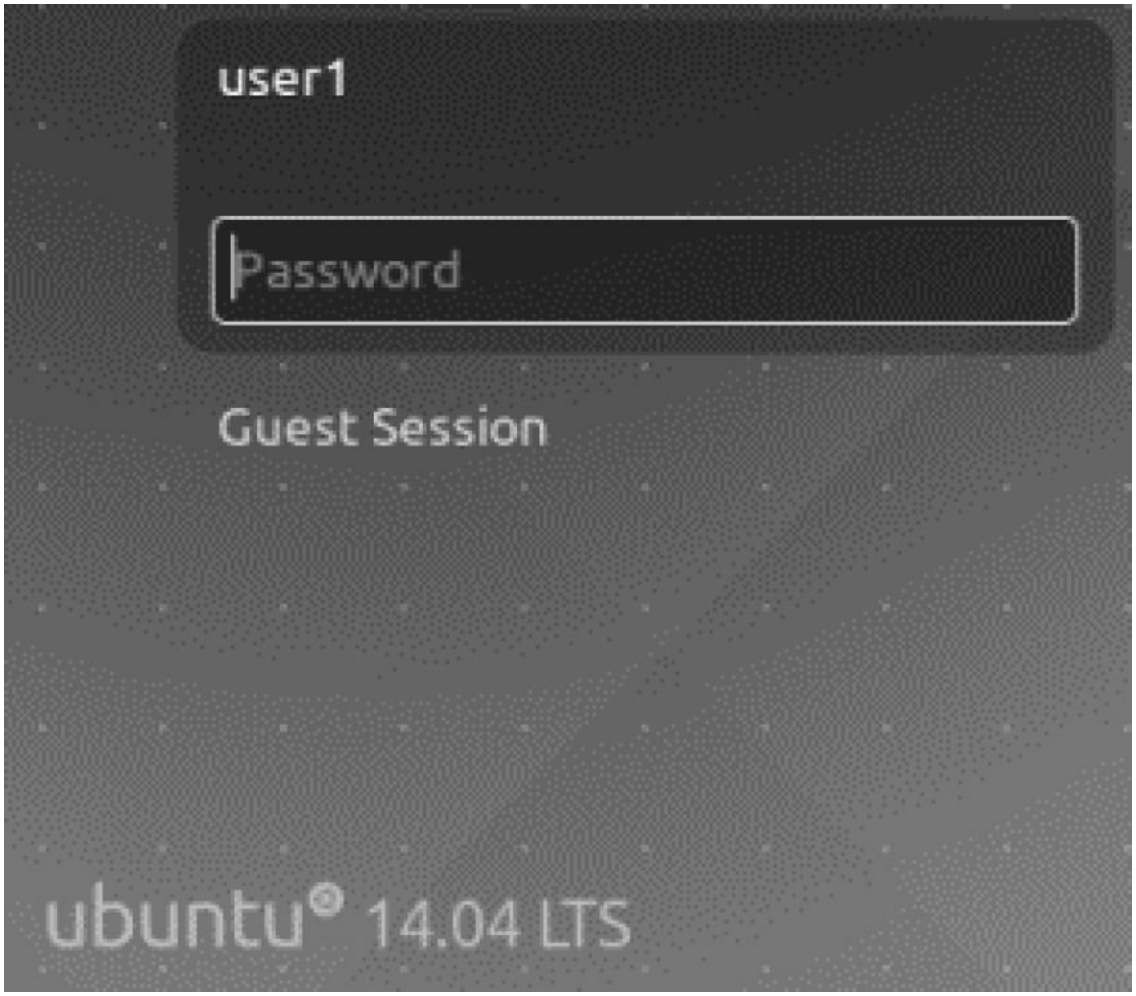

Figure 1-16 Login Screen

11. The default graphical desktop environment called Unity appears, allowing you to use the system as user1.

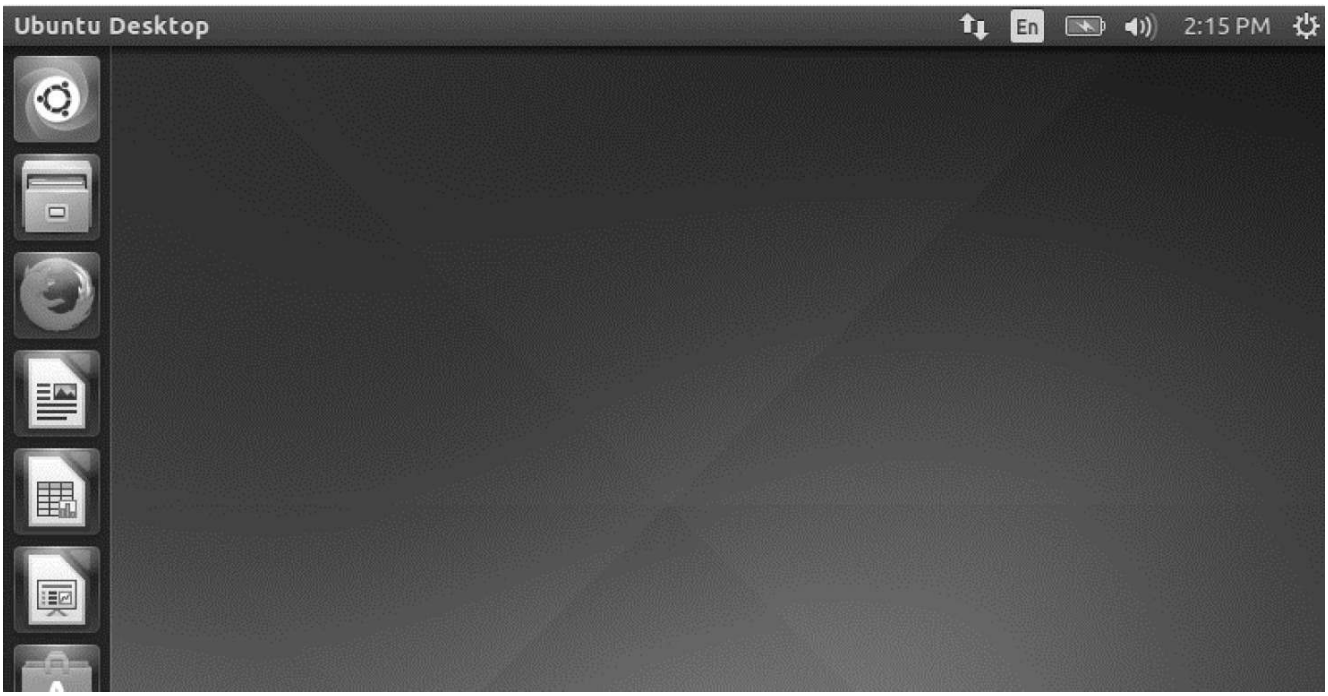

Figure 1-17 Unity Desktop Environment

Logging Out

12. After you are done navigating the system, click the little wheel icon at the top right-hand corner of the screen and choose Log Out to log off the system as user1.

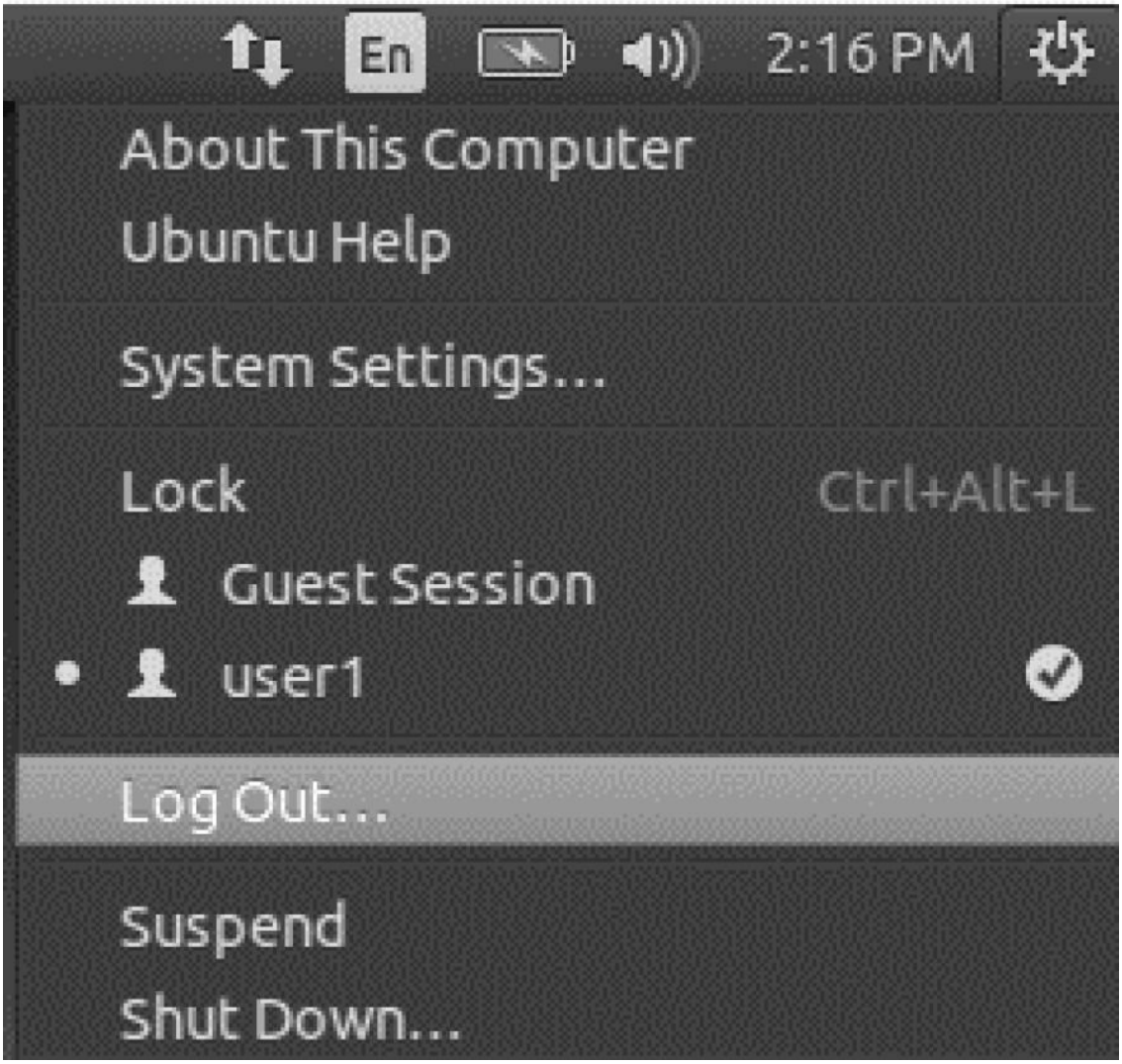

Figure 1-18 Log Out

This completes the step-by-step procedure for installing Ubuntu Desktop 14.04.5 in a virtual machine using the ISO image.

Accessing the Linux Command Prompt

To interact with the Linux shell and issue Linux commands, we must access the Linux command prompt. We can access the command prompt by re-logging as user1 to both centos 73 and ubuntu14. Open a terminal session on centos 73 by clicking Applications in the top left-hand corner of the desktop screen and then selecting Favorites→Terminal. See Figure 1-19.

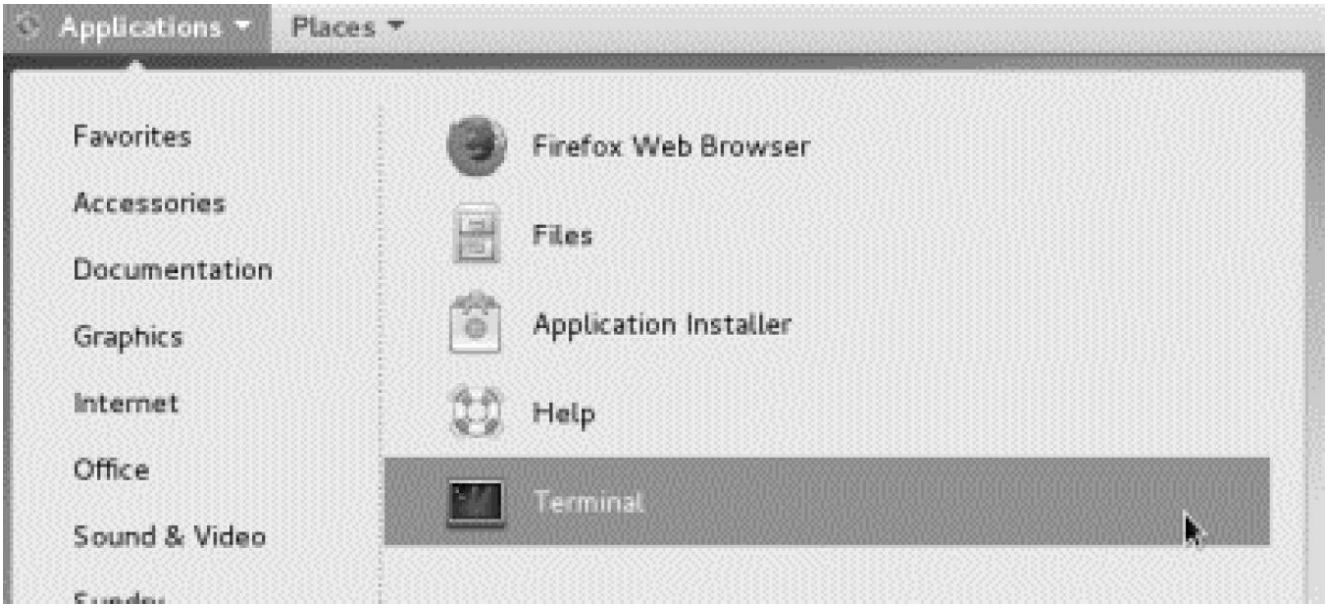

Figure 1-19 Access Command Prompt (CentOS)

The command prompt for user1 will look similar to the following in the terminal window:

```
[user1@centos73 ~]$
```

On Ubuntu (Figure 1-20), click the Search icon at the top left-hand corner of the screen and type “terminal” in the search window that appears. Click the Terminal icon to get the command prompt.

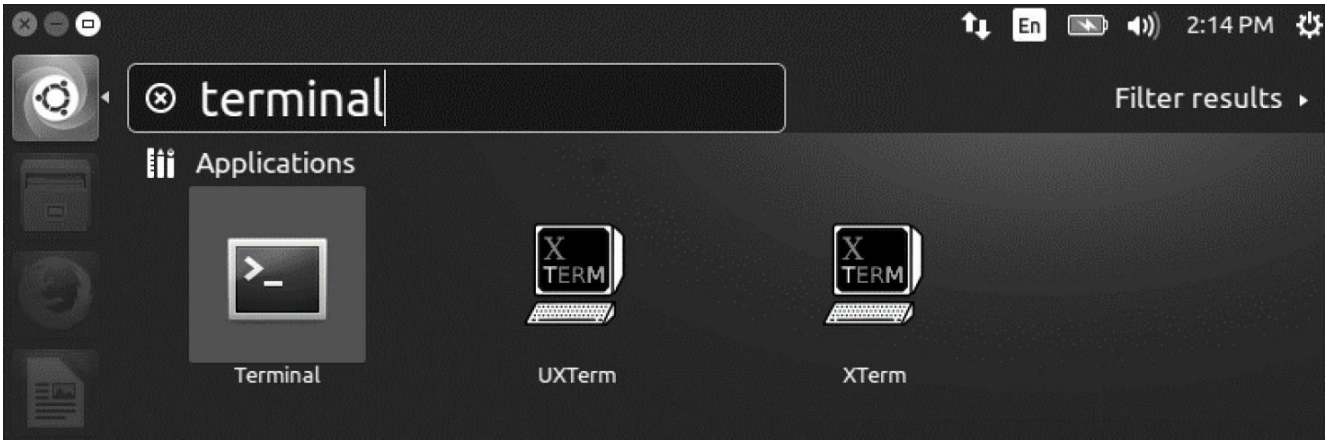

Figure 1-20 Access Command Prompt (Ubuntu)

The command prompt for user1 will look similar to the following in the terminal window:

```
user1@ubuntu14:~$
```

 The font I have used for the command prompt is Consolas, and this representation is used throughout this book.

Notice the inclusion of the username and the Linux system name in the command prompts. The ~ (tilde) sign represents the user's home directory, and the $ sign is the default shell sign that identifies user1 as a regular user. The CentOS command prompt appears slightly different because it is enclosed within square brackets ([]).

Common Linux Commands

Linux offers hundreds of commands for both privileged and non-privileged use. Privileged commands are for system management and intended solely for privileged users. Non-privileged commands do not require extra rights for execution and can be run with regular user rights.

These commands range from simple to complicated ones. Some of the commands only offer a few options, while others have as many as 70 options or more, which can be used to produce outputs of your choice. Knowledge of these commands is essential for proper use and efficient administration of the system. This section sheds some light on command syntax and then demonstrates the use of some common commands. Please note: the examples are run on centos 73 unless stated otherwise. In addition, we will show the output of a command where it's necessary for clarity. You should run each command and observe the output.

Understanding the Command Syntax

To practice the commands provided in this chapter, log in as user1 on centos 73 and ubuntu14 desktop consoles, run the commands, and observe their outputs. In most cases, the commands will yield the same or similar result on both Linux distributions.

The basic syntax of the Linux command is:

command option argument

You can specify zero or more options and arguments with a command. Some commands have default options and arguments that are used when executed, so you do not need to specify them. Other commands require at least one option or argument in order to work. An option (a.k.a. a switch or flag, and often preceded by the hyphen (-) character), modifies the behavior of the command, and an argument supplies a target on which to perform the command action. The following examples show some command structures. The text on the right states the number of options and arguments supplied:

$ **ls** (no option, no argument; the default argument is the current directory name)

$ **ls -l**	(one option, no argument; the default argument is the current directory name)
$ **ls directory_name**	(no option, one argument)
$ **ls -la directory_name**	(two options, one argument)

Listing Files and Directories

The ls (list) command produces a list of files and directories and displays it on the screen. It supports several options such as -a, -h, -l, -d, -R, -t, and -r. The following examples describe the function of these options.

To list files in the current directory with the assumption that you are in the home directory /home/user1 for user1:

```
[user1@centos73 ~]$ ls
Desktop Documents Downloads Music Pictures Public Templates Videos
```

To list files in the current directory with detailed information:

```
[user1@centos73 ~]$ ls -l total 0
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Desktop
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Documents
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Downloads
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Music
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Pictures
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Public
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Templates
drwxr-xr-x. 2 user1 user1 6 Dec 21 09:28 Videos
```

As an alternative to using **ls -l**, you may use its shortcut **ll** to get the same result.

To list files under /home/user1 with hidden files and detailed information, use either **ll -a** or the following:

```
[user1@centos73 ~]$ ls -la
```

To list the listing of the Desktop directory without showing its contents:

```
[user1@centos73 ~]$ ls -ld Desktop
```

To list a file such as /etc/group:

```
[user1@centos73 ~]$ ls -l /etc/group
```

To list files in the /boot directory with detailed information and their sizes in human-readable format:

```
[user1@centos73 ~]$ ls -lh /boot
```

Replace -h with -t in the above example to list files sorted by date and time with the newest file first:

```
[user1@centos73 ~]$ ls -lt /boot
```

Add the -r option to the above command to list files in reverse chronological order:

```
[user1@centos73 ~]$ ls -ltr /boot
```

To list contents of the /etc directory recursively:

```
[user1@centos73 ~]$ ls -R /etc
```

Printing Working Directory

The pwd (print working directory) command displays a user's current location in the directory tree. The following example shows that user1 is presently in /home/user1:

```
[user1@centos73 ~]$ pwd
/home/user1
```

Changing Directories

The cd (change directory) command is used to navigate the directory tree. Use the pwd command after each execution of cd to confirm the directory switch.

To change directory to /usr/bin:

```
[user1@centos73 ~]$ cd /usr/bin
[user1@centos73 ~]$ pwd
/usr/bin
```

To go to the Desktop directory under the home directory of user1:

```
[user1@centos73 ~]$ cd ~/Desktop
```


tilde (~) is used as an alternative to a user's home directory path.

To return to the home directory of user1, run either **cd** or **cd ~**.

To go to the home directory of user sshd from anywhere in the directory structure, use the ~ (tilde) character and specify the login name:

```
[user1@centos73 ~]$ cd ~sshd
[user1@centos73 ~]$ pwd
```

```
/var/empty/sshd
```

To go to the root directory, use the forward slash (/) character:

```
[user1@centos73 ~]$ cd /
```

To switch between the current and the previous directory, issue the cd command with a hyphen (-):

```
[user1@centos73 ~]$ cd -
```

To move one directory up to the parent directory, use the period (.) character twice:

```
[user1@centos73 ~]$ cd ..
```

Showing the Terminal File

This command displays the terminal name we are currently running the commands in:

```
[user1@centos73 ~]$ tty
/dev/pts/0
```

Inspecting the System's Uptime

The uptime command shows the system's current time, how long it has been up for, the number of users currently logged in, and the average number of processes over the past 1, 5, and 15 minutes:

```
[user1@centos73 ~]$ uptime
17:32:18 up 1:24, 4 users, load average: 0.00, 0.01, 0.05
```

The above output shows that the current system time is 5:32 p.m.; the system has been up for 1 hour and 24 minutes; there are four users currently logged in; and the system load averages over the past 1, 5, and 15 minutes are 0.00, 0.01, and 0.05, respectively.

Viewing User Login Name

The whoami (who am i) command displays the effective username of the person executing this command:

```
[user1@centos73 ~]$ whoami
user1
```

The logname (login name) command shows the name of the real user who originally logged in to the system:

```
[user1@centos73 ~]$ logname
user1
```

Examining User and Group Information

The id (identifier) command displays a user's UID (user identifier), username, GID (group identifier), group name, all secondary groups the user is a member of, and SELinux security context:

```
[user1@centos73 ~]$ id
uid=1000(user1) gid=1000(user1) groups=1000(user1)
context=unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```


Each user and group has a corresponding number (called UID and GID) for identification purposes. If you specify a username with the id command, the SELinux information will not be printed.

The groups command lists all groups a user is a member of:

```
[user1@centos73 ~]$ groups
user1
```

In case a user has membership of multiple groups, the first group listed will be the user's primary group and the rest will be the user's secondary (or supplementary) groups.

Viewing System Information

The uname command produces elementary information about the system and running kernel. The output will be different for different hardware types and Linux distributions and versions. Without any options, this command only displays the operating system name. You may use the -a option for details.

```
[user1@centos73 ~]$ uname
Linux
[user1@centos73 ~]$ uname -a
Linux centos73 3.10.0-514.el7.x86_64 #1 SMP Tue Nov 22 16:42:41 UTC 2016
x86_64 x86_64 x86_64
GNU/Linux
```

The information returned by the second command is:

Linux	Kernel name
Centos73	Hostname (or node name) of this system

3.10.0-514.el7.x86_64	Kernel release
#1 SMP Tue Nov 22 UTC 2016	Date and time of this kernel built
x86_64	Machine's hardware name
x86_64	Processor type
x86_64	Hardware platform
GNU/Linux	Operating system name

Try running this command with the -s (kernel name), -n (node name), -r (kernel release), -v (kernel build date), -m (hardware name), -p (processor type), -i (hardware platform), and -o (OS name) options separately to view specific information. Also run this command on ubuntu14.

Displaying Hostname

The hostname command can be used to view the system hostname. Run this command without any options to view the hostname of the system:

```
[user1@centos73 ~]$ hostname
centos73
```

Clearing the Screen

The clear command clears the terminal screen and places the cursor at the beginning of the screen. We can alternatively use the Ctrl+l key combination for this purpose.

```
[user1@centos73 ~]$ clear
```

Compression Tools

Compression tools are used to compress one or more files to conserve space. They may be used with archive commands, such as tar, to create a single compressed archive of hundreds of files and directories. Archiving is discussed in the next section. A compressed archive can then be copied to a remote system faster than a non-compressed archive. Linux offers a number of compression tools such as gzip (gunzip), bzip2 (bunzip2), and xz that we can use for this purpose.

Using gzip and gunzip

The gzip/gunzip compression utility pair has been available in Linux for over two decades. The gzip command is used to create a compressed file of each of the specified files and it adds the .gz extension to each one of them for identification. This tool can be used with the -r option to compress an entire directory tree, and with the -l option to display compression information about a gzipped file. The -l option also instructs the command to display the filename that will be given to the file when it is uncompressed.

To compress the file fstab located in the /etc directory, copy this file in user1's home directory using the cp command and confirm with ls:

```
[user1@centos73 ~]$ pwd
/home/user1
[user1@centos73 ~]$ cp /etc/fstab .
[user1@centos73 ~]$ ls -l fstab
-rw-r--r--. 1 user1 user1 465 Dec 22 08:53 fstab
```

Now use the gzip command to compress this file and ls to confirm:

```
[user1@centos73 ~]$ gzip fstab
[user1@centos73 ~]$ ls -l fstab.gz
-rw-r--r--. 1 user1 user1 284 Dec 22 08:53 fstab.gz
```

Notice that the original file is compressed and it now has the .gz extension added to it. If you wish to view compression information for the file, run the command again with the -l option:

```
[user1@centos73 ~]$ gzip -l fstab.gz
 Compressed                uncompressed  ratio uncompressed_name
                  284                 465 44.1% fstab
```

To decompress this file, use the gunzip command. You may alternatively use the gzip command with the -d (decompress) option. Both will produce an identical result.

```
[user1@centos73 ~]$ gunzip fstab.gz
```

Check the file after the decompression with the ls command. It will be the exact same file with the exact same timestamp and other attributes.

Using bzip2 and bunzip2

The bzip2/bunzip2 compression pair has been available in Linux for almost two decades. The bzip2 command creates a compressed file of each of the specified files and it adds the .bz2 extension to each one for identification.

To compress the fstab file again but this time with bzip2, issue the following and confirm with ls:

```
[user1@centos73 ~]$ bzip2 fstab
[user1@centos73 ~]$ ls -l fstab.bz2
-rw-r--r--. 1 user1 user1 318 Dec 22 08:53 fstab
```

Notice that the original file is compressed and it now has the .bz2 extension added to it. To decompress this file, use the bunzip2 command. You may alternatively use the bzip2

command with the -d option. Both will produce an identical result.

```
[user1@centos73 ~]$ bunzip2 fstab.bz2
```

Check the file after the decompression with the ls command. It will be the exact same file with the exact same timestamp and other attributes.

Differences between gzip and bzip2

The function of both gzip and bzip2 is the same: to compress and decompress files. However, in terms of compression and decompression rate, gzip is faster with a compression ratio (smaller target file size) but not as good as bzip2's. These differences are evident on fairly large files; on small files, you can use either gzip or bzip2. Both commands support several identical options.

Using xz and unxz

The xz/unxz compression pair may be used in place of gzip and bzip2. This tool is relatively new. It delivers a better compression ratio, but it is slower than gzip and bzip2. It adds the .xz extension to the compressed file for identification. You can use the -l option with the command to display compression information for an xz-compressed file. To uncompress, use either the unxz command or the -d option with xz.
To compress the fstab file again but this time with xz, issue the following and confirm with ls:

```
[user1@centos73 ~]$ xz fstab

[user1@centos73 ~]$ ls -l fstab.xz
-rw-r--r--. 1 user1 user1 340 Dec 22 09:27 fstab.xz
```

Notice that the original file is compressed and it now has the .xz extension added to it. If you wish to view compression information for the file, run the command again with the -l option:

```
[user1@centos73 ~]$ xz -l fstab.xz
Strms  Blocks   Compressed Uncompressed  Ratio  Check   Filename
    1       1      340 B      465 B     0.731  CRC64   fstab.xz
```

To decompress this file, use the unxz command. You may alternatively use the xz command with the -d option. Both will produce an identical result.

```
[user1@centos73 ~]$ unxz fstab.xz
```

Check the file after the decompression with the ls command. It will be the same exact file with the exact same timestamp and other attributes.

Archiving Tools

Linux offers plenty of native tools that can be utilized to archive files for storage or distribution. These tools include tar and cpio, and both have the ability to preserve general file attributes such as ownership, owning group, and timestamp. The following subsections discuss the tools in detail.

Using tar

The tar (tape archive) command is used to create, append, update, list, and extract files or an entire directory tree to and from a single file, which is called a tarball or a tar file. This command can be instructed to also compress the tarball after it has been created.

tar supports several options such as those described in Table 1-1:

Option	Description
-c	Creates a tarball.
-f	Specifies the name of a tarball.
-r	Appends more files to an extant tarball.
-t	Lists contents of a tarball.
-u	Appends more files to an extant tarball provided the files being added are newer.
-v	Verbose mode.
-x	Extracts or restores from a tarball.

Table 1-1 tar Command Options

The -r and -u options do not support adding files to an existing compressed tarball.

A few examples are provided below to elucidate the use of tar. Note that the use of the hyphen (-) character with an option is not compulsory. Pay special attention to the syntax and options used in each command and observe the output.

To create a tarball called /tmp/home.tar of the entire /home directory, use the -v option for verbosity and the -f option to specify the name of the archive file with the command:

```
[user1@centos73 ~]$ tar -cvf /tmp/home.tar /home
tar: Removing leading `/' from member names
/home/
/home/user1/
/home/user/.mozilla/
. . . . . .
```

The resulting tarball will not include the leading forward slash (/) in the file paths as

indicated on the first line of the output even though we supplied the full path of /home for archival. This is the default behavior of the tar command, which gives us the flexibility to restore the files at any location of our choice without having to worry about the full pathnames. Use the -P option at the creation time to reverse this behavior.

To create a tarball called /tmp/files.tar containing only a select few files (three files in this example) from the /etc directory:

```
[user1@centos73 ~]$ tar -cvf /tmp/files.tar /etc/passwd /etc/yum.conf
```

To append files located in the /etc/yum.repos.d directory to the existing tarball /tmp/home.tar:

```
[user1@centos73 ~]$ tar -rvf /tmp/home.tar /etc/yum.repos.d
```

To list what files are included in the home. tar tarball:

```
[user1@centos73 ~]$ tar -tvf /tmp/home.tar
```

To restore all files from /tmp/files.tar in /home/user1 and confirm the output with the ls command:

```
[user1@centos73 ~]$ cd
[user1@centos73 ~]$ tar -xvf /tmp/files.tar
[user1@centos73 ~]$ ls -l etc
```

tar also supports options to directly compress the target file while being archived using the gzip, bzip2, or xz command. These options are described in Table 1-2.

Option	Description
-J	Compresses a tarball with xz command.
-j	Compresses a tarball with bzip2 command.
-z	Compresses a tarball with gzip command.

Table 1-2 tar with Compression Options

Let's use these options in the following examples.

To create a tarball called /tmp/home.tar.gz of the /home directory and compress it with gzip:

```
[user1@centos73 ~]$ tar -czvf /tmp/home.tar.gz /home
```

To create a tarball called /tmp/home.tar.bz2 of the /home directory and compress it with bzip2:

```
[user1@centos73 ~]$ tar -cvjf /tmp/home.tar.bz2 /home
```