FOURTH EDITION

"First Sobell taught people how to use Linux... now he teaches you the power of Linux. A must-have book for anyone who wants to take Linux to the next level."

—**Jon "maddog" Hall,** Executive Director, Linux International

A Practical Guide to Linux®

Commands, Editors, and Shell Programming

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Mark G. Sobell

coauthored by **Matthew Helmke**

Utility Index

A light page number such as 456 indicates a brief mention. Page numbers followed by the letter **t** refer to tables.

Continued on inside back cover

Utility Index

Continued from inside front cover

Praise for Previous Editions of *A Practical Guide to Linux® Commands, Editors, and Shell Programming*

"This book is a very useful tool for anyone who wants to 'look under the hood' so to speak, and really start putting the power of Linux to work. What I find particularly frustrating about man pages is that they never include examples. Sobell, on the other hand, outlines very clearly what the command does and then gives several common, easy-to-understand examples that make it a breeze to start shell programming on one's own. As with Sobell's other works, this is simple, straight-forward, and easy to read. It's a great book and will stay on the shelf at easy arm's reach for a long time."

—*Ray Bartlett*
Travel Writer

"Overall I found this book to be quite excellent, and it has earned a spot on the very front of my bookshelf. It covers the real 'guts' of Linux— the command line and its utilities—and does so very well. Its strongest points are the outstanding use of examples, and the Command Reference section. Highly recommended for Linux users of all skill levels. Well done to Mark Sobell and Prentice Hall for this outstanding book!"

—*Dan Clough*
Electronics Engineer and
Slackware Linux User

"Totally unlike most Linux books, this book avoids discussing everything via GUI and jumps right into making the power of the command line your friend."

—*Bjorn Tipling*
Software Engineer
ask.com

"This book is the best distro-agnostic, foundational Linux reference I've ever seen, out of dozens of Linux-related books I've read. Finding this book was a real stroke of luck. If you want to really understand how to get things done at the command line, where the power and flexibility of free UNIX-like OSes really live, this book is among the best tools you'll find toward that end."

—*Chad Perrin*
Writer, TechRepublic

"I moved to Linux from Windows XP a couple of years ago, and after some distro hopping settled on Linux Mint. At age 69 I thought I might be biting off more than I could chew, but thanks to much reading and the help of a local LUG I am now quite at home with Linux at the GUI level.

"Now I want to learn more about the CLI and a few months ago bought your book: *A Practical Guide to Linux® Commands, Editors, and Shell Programming, Second Edition.*

"For me, this book is proving to be the foundation upon which my understanding of the CLI is being built. As a comparative 'newbie' to the Linux world, I find your book a wonderful, easy-to-follow guide that I highly recommend to other Linux users."

—John Nawell
CQLUG (Central Queensland
Linux User Group)

"I have the second edition of *A Practical Guide to Linux® Commands, Editors, and Shell Programming* and am a big fan. I used it while working as a Cisco support engineer. I plan to get the third edition as soon as it is released. We will be doing a ton of command-line work on literally 1000 boxes (IMS core nodes). I feel you have already given me a lot of tools with the second edition. I want to get your new book as soon as possible. The way you write works very well for my style of learning."

—Robert Lingenfelter
Support Engineer, VoIP/IMS

Praise for Other Books by Mark G. Sobell

"Since I'm in an educational environment, I found the content of Sobell's book to be right on target and very helpful for anyone managing Linux in the enterprise. His style of writing is very clear. He builds up to the chapter exercises, which I find to be relevant to real-world scenarios a user or admin would encounter. An IT/IS student would find this book a valuable complement to their education. The vast amount of information is extremely well balanced and Sobell manages to present the content without complicated asides and meandering prose. This is a 'must have' for anyone managing Linux systems in a networked environment or anyone running a Linux server. I would also highly recommend it to an experienced computer user who is moving to the Linux platform."

—Mary Norbury
IT Director
Barbara Davis Center
University of Colorado at Denver
from a review posted on slashdot.org

"I had the chance to use your UNIX books when I when was in college years ago at Cal Poly, San Luis Obispo, CA. I have to say that your books are among the best! They're quality books that teach the theoretical aspects and applications of the operating system."

—Benton Chan
IS Engineer

"The book has more than lived up to my expectations from the many reviews I read, even though it targets FC2. I have found something very rare with your book: It doesn't read like the standard technical text, it reads more like a story. It's a pleasure to read and hard to put down. Did I say that?! :-)"

—David Hopkins
Business Process Architect

"Thanks for your work and for the book you wrote. There are really few books that can help people to become more efficient administrators of different workstations. We hope (in Russia) that you will continue bringing us a new level of understanding of Linux/UNIX systems."

—Anton Petukhov

"Mark Sobell has written a book as approachable as it is authoritative."

—*Jeffrey Bianchine*
Advocate, Author, Journalist

"Excellent reference book, well suited for the sysadmin of a Linux cluster, or the owner of a PC contemplating installing a recent stable Linux. Don't be put off by the daunting heft of the book. Sobell has striven to be as inclusive as possible, in trying to anticipate your system administration needs."

—*Wes Boudville*
Inventor

"*A Practical Guide to Red Hat® Linux®* is a brilliant book. Thank you Mark Sobell."

—*C. Pozrikidis*
University of California at San Diego

"This book presents the best overview of the Linux operating system that I have found. . . . [It] should be very helpful and understandable no matter what the reader's background: traditional UNIX user, new Linux devotee, or even Windows user. Each topic is presented in a clear, complete fashion and very few assumptions are made about what the reader knows. . . . The book is extremely useful as a reference, as it contains a 70-page glossary of terms and is very well indexed. It is organized in such a way that the reader can focus on simple tasks without having to wade through more advanced topics until they are ready."

—*Cam Marshall*
Marshall Information Service LLC
Member of Front Range UNIX
Users Group [FRUUG]
Boulder, Colorado

"Conclusively, this is THE book to get if you are a new Linux user and you just got into RH/Fedora world. There's no other book that discusses so many different topics and in such depth."

—*Eugenia Loli-Queru*
Editor in Chief
OSNews.com

"I currently own one of your books, *A Practical Guide to Linux®*. I believe this book is one of the most comprehensive and, as the title says, practical guides to Linux I have ever read. I consider myself a novice and I come back to this book over and over again."

—*Albert J. Nguyen*

"Thank you for writing a book to help me get away from Windows XP and to never touch Windows Vista. The book is great; I am learning a lot of new concepts and commands. Linux is definitely getting easier to use."

—*James Moritz*

"I am so impressed by how Mark Sobell can approach a complex topic in such an understandable manner. His command examples are especially useful in providing a novice (or even an advanced) administrator with a cookbook on how to accomplish real-world tasks on Linux. He is truly an inspired technical writer!"

—*George Vish II*
Senior Education Consultant
Hewlett-Packard Company

"Overall, I think it's a great, comprehensive Ubuntu book that'll be a valuable resource for people of all technical levels."

—*John Dong*
Ubuntu Forum Council Member
Backports Team Leader

"The JumpStart sections really offer a quick way to get things up and running, allowing you to dig into the details of the book later."

—*Scott Mann*
Aztek Networks

"I would so love to be able to use this book to teach a class about not just Ubuntu or Linux but about computers in general. It is thorough and well written with good illustrations that explain important concepts for computer usage."

—*Nathan Eckenrode*
New York Local Community Team

"Ubuntu is gaining popularity at the rate alcohol did during Prohibition, and it's great to see a well-known author write a book on the latest and greatest version. Not only does it contain Ubuntu-specific information, but it also touches on general computer-related topics, which will help the average computer user to better understand what's going on in the background. Great work, Mark!"

—Daniel R. Arfsten
Pro/ENGINEER Drafter/Designer

"I read a lot of Linux technical information every day, but I'm rarely impressed by tech books. I usually prefer online information sources instead. Mark Sobell's books are a notable exception. They're clearly written, technically accurate, comprehensive, and actually enjoyable to read."

—Matthew Miller
Senior Systems Analyst/Administrator
BU Linux Project
Boston University Office
of Information Technology

"This is well-written, clear, comprehensive information for the Linux user of any type, whether trying Ubuntu on for the first time and wanting to know a little about it, or using the book as a very good reference when doing something more complicated like setting up a server. This book's value goes well beyond its purchase price and it'll make a great addition to the Linux section of your bookshelf."

—Linc Fessenden
Host of The LinuxLink TechShow
tllts.org

"The author has done a very good job at clarifying such a detail-oriented operating system. I have extensive Unix and Windows experience and this text does an excellent job at bridging the gaps between Linux, Windows, and Unix. I highly recommend this book to both 'newbs' and experienced users. Great job!"

—Mark Polczynski
Information Technology Consultant

"Your text, *A Practical Guide to Ubuntu Linux®, Third Edition,* is a well constructed, informative, superbly written text. You deserve an award for outstanding talent; unfortunately my name is not Pulitzer."

—Harrison Donnelly
Physician

"When I first started working with Linux just a short ten years or so ago, it was a little more difficult than now to get going. . . . Now, someone new to the community has a vast array of resources available on the web, or if they are inclined to begin with Ubuntu, they can literally find almost every single thing they will need in the single volume of Mark Sobell's *A Practical Guide to Ubuntu Linux®*.

"I'm sure this sounds a bit like hyperbole. Everything a person would need to know? Obviously not everything, but this book, weighing in at just under 1200 pages, covers so much so thoroughly that there won't be much left out. From install to admin, networking, security, shell scripting, package management, and a host of other topics, it is all there. GUI and command-line tools are covered. There is not really any wasted space or fluff, just a huge amount of information. There are screen shots when appropriate but they do not take up an inordinate amount of space. This book is information-dense."

—JR Peck
Editor
GeekBook.org

"I have been wanting to make the jump to Linux but did not have the guts to do so—until I saw your familiarly titled *A Practical Guide to Red Hat® Linux®* at the bookstore. I picked up a copy and am eagerly looking forward to regaining my freedom."

—Carmine Stoffo
Machine and Process Designer
to pharmaceutical industry

"I am currently reading *A Practical Guide to Red Hat® Linux®* and am finally understanding the true power of the command line. I am new to Linux and your book is a treasure."

—Juan Gonzalez

"Overall, *A Practical Guide to Ubuntu Linux®* by Mark G. Sobell provides all of the information a beginner to intermediate user of Linux would need to be productive. The inclusion of the Live DVD of the Gutsy Gibbon release of Ubuntu makes it easy for the user to test-drive Linux without affecting his installed OS. I have no doubts that you will consider this book money well spent."

—Ray Lodato
Slashdot contributor
www.slashdot.org

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A Practical Guide to Linux® Commands, Editors, and Shell Programming

FOURTH EDITION

Mark G. Sobell
coauthored by Matthew Helmke

Addison-Wesley

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For Sandra,
Sage, Sedona, Philip, and Evan.
Love you tons!

—Matthew Helmke

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Brief Contents

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PREFACE

Linux

A Practical Guide to Linux® Commands, Editors, and Shell Programming, Fourth Edition, explains how to work with the Linux operating system from the command line. The first few chapters of this book build a foundation for learning about Linux. The rest of the book covers more advanced topics and goes into more detail. This book does not describe a particular release or distribution of Linux but rather pertains to all recent versions of Linux.

macOS

This book also explains how to work with the UNIX/Linux foundation of macOS. It looks "under the hood," past the traditional GUI (graphical user interface) that most people associate with the Macintosh, and explains how to use the powerful command-line interface (CLI) that connects you directly to macOS. Where this book refers to Linux, it implicitly refers to macOS as well and makes note of differences between the two operating systems.

Command-line interface (CLI)

In the beginning there was the command-line (textual) interface, which enabled a user to give Linux commands from the command line. There was no mouse to point with or icons to drag and drop. Some programs, such as emacs, implemented rudimentary windows using the very minimal graphics available in the ASCII character set. Reverse video helped separate areas of the screen.

Linux was born and raised in this environment, so naturally all the original Linux tools were invoked from the command line. The real power of Linux still lies in this environment, which explains why many Linux professionals work *exclusively* from the command line. Using clear descriptions and many examples, this book shows you how to get the most out of your Linux system using the command-line interface.

Linux distributions

A Linux distribution comprises the Linux kernel, utilities, and application programs. Many distributions are available, including Ubuntu, Fedora, openSUSE, Red Hat, Debian, Mageia, Arch, CentOS, Solus, and Mint. Although the distributions differ

from one another in various ways, all of them rely on the Linux kernel, utilities, and applications. This book is based on the code that is common to most distributions. As a consequence you can use it regardless of which distribution you are running.

Overlap If you read one of Mark Sobell's other books, *A Practical Guide to Fedora™ and Red Hat® Enterprise Linux*, or *A Practical Guide to Ubuntu Linux®*, or Matthew Helmke's *Ubuntu Unleashed* or *The Official Ubuntu Book*, you will notice some overlap between those books and the one you are reading now. The books cover similar information, presented from different perspectives and at different levels of depth depending on the intended audience for each book.

Audience This book is designed for a wide range of readers. It does not require programming experience, although some experience using a computer is helpful. It is appropriate for the following readers:

- **Students** taking a class in which they use Linux or macOS
- **Power users** who want to explore the power of Linux or macOS from the command line
- **Professionals** who use Linux or macOS at work
- **Beginning Macintosh users** who want to know what UNIX/Linux is, why everyone keeps saying it is important, and how to take advantage of it
- **Experienced Macintosh users** who want to know how to take advantage of the power of UNIX/Linux that underlies macOS
- **UNIX users** who want to adapt their UNIX skills to the Linux or macOS environment
- **System administrators** who need a deeper understanding of Linux or macOS and the tools that are available to them, including the bash, Perl, and Python scripting languages
- **Web developers** who need to understand Linux inside and out, including Perl and Python
- **Computer science students** who are studying the Linux or macOS operating system
- **Programmers** who need to understand the Linux or macOS programming environment
- **Technical executives** who want to get a grounding in Linux or macOS

Benefits *A Practical Guide to Linux® Commands, Editors, and Shell Programming, Fourth Edition,* gives you a broad understanding of how to use Linux and macOS from the command line. Regardless of your background, it offers the knowledge you need to get on with your work: You will come away from this book with an understanding of how to use Linux/macOS, and this text will remain a valuable reference for years to come.

A large amount of free software has always been available for Macintosh systems. In addition, the Macintosh shareware community is very active. By introducing the UNIX/Linux aspects of macOS, this book throws open to Macintosh users the vast store of free and low-cost software available for Linux and other UNIX-like systems.

In this book, *Linux* refers to *Linux* and *macOS*

tip The UNIX operating system is the common ancestor of Linux and macOS. Although the GUIs (graphical user interfaces) of these two operating systems differ significantly, the command-line interfaces (CLIs) are very similar and in many cases identical. This book describes the CLIs of both Linux and macOS. To make the content more readable, this book uses the term *Linux* to refer to both *Linux* and *macOS*. It makes explicit note of where the two operating systems differ.

FEATURES OF THIS BOOK

This book is organized for ease of use in different situations. For example, you can read it from cover to cover to learn command-line Linux from the ground up. Alternatively, once you are comfortable using Linux, you can use this book as a reference: Look up a topic of interest in the table of contents or index and read about it. Or refer to one of the utilities covered in Part VI, "Command Reference." You can also think of this book as a catalog of Linux topics: Flip through the pages until a topic catches your eye. The book also includes many pointers to Web sites where you can obtain additional information: Consider the Internet to be an extension of this book.

A Practical Guide to Linux® Commands, Editors, and Shell Programming, Fourth Edition, offers the following features:

- **Optional sections** allow you to read the book at different levels, returning to more difficult material when you are ready to tackle it.
- **Caution boxes** highlight procedures that can easily go wrong, giving you guidance *before* you run into trouble.
- **Tip boxes** highlight places in the text where you can save time by doing something differently or when it might be useful or just interesting to have additional information.
- **Security boxes** point out ways you can make a system more secure.
- Each chapter starts with a list of **chapter objectives**—a list of important tasks you should be able to perform after reading the chapter.
- Concepts are illustrated by **practical examples** found throughout the book.
- The many useful **URLs** (Internet addresses) identify sites where you can obtain software and information.
- **Main, File Tree, and Utility indexes** help you find what you are looking for quickly; for easy access, the Utility index is reproduced on the insides of the front and back covers.

- **Chapter summaries** review the important points covered in each chapter.
- **Review exercises** are included at the end of each chapter for readers who want to hone their skills. Answers to even-numbered exercises are posted at www.sobell.com.
- Important **GNU tools**, including gcc, GNU Configure and Build System, make, gzip, and many others, are described in detail.
- Pointers throughout the book provide help in obtaining **online documentation** from many sources, including the local system and the Internet.
- Important command-line utilities that were developed by Apple specifically for macOS are covered in detail, including diskutil, ditto, dscl, GetFileInfo, launchctl, otool, plutil, and SetFile.
- Descriptions of macOS **extended attributes** include **file forks**, **file attributes**, **attribute flags**, and **Access Control Lists** (**ACLs**).
- Appendix D, "macOS Notes," lists some differences between macOS and Linux.

CONTENTS

This section describes the information that each chapter covers and explains how that information can help you take advantage of the power of Linux. You might want to review the table of contents for more detail.

- **Chapter 1—Welcome to Linux and macOS**
  Presents background information on Linux and macOS. This chapter covers the **history of Linux**, profiles the macOS **Mach kernel**, explains how the GNU Project helped Linux get started, and discusses some of the **important features of Linux** that distinguish it from other operating systems.

PART I: THE LINUX AND MACOS OPERATING SYSTEMS

Experienced users might want to skim Part I

tip If you have used a UNIX/Linux system before, you might want to skim or skip some or all of the chapters in Part I. All readers should take a look at "Conventions Used in This Book" (page 24), which explains the typographic conventions that this book uses, and "Where to Find Documentation" (page 33), which points you toward both local and remote sources of Linux documentation.

Part I introduces Linux and gets you started using it.

- **Chapter 2—Getting Started**
  Explains the **typographic conventions** this book uses to make explanations clearer and easier to read. This chapter provides basic information and

explains how to log in, **change your password**, give Linux commands using the shell, and **find system documentation**.

- **Chapter 3—The Utilities**
  Explains the **command-line interface** (CLI) and briefly introduces **more than 30 command-line utilities**. Working through this chapter gives you a feel for Linux and introduces some of the tools you will use day in, day out. Deeper discussion of utilities is reserved for Part VI. The utilities covered in this chapter include
  - grep, which **searches through files** for strings of characters;
  - unix2dos, which **converts Linux text files** to Windows format;
  - tar, which **creates archive files** that can hold many other files;
  - bzip2 and gzip, which **compress files** so that they take up less space on disk and allow you to transfer them over a network more quickly; and
  - diff, which **displays the differences** between two text files.
- **Chapter 4—The Filesystem**
  Discusses the Linux hierarchical filesystem, covering files, filenames, **pathnames**, working with directories, **access permissions**, and hard and **symbolic links**. Understanding the filesystem allows you to **organize your data** so that you can find information quickly. It also enables you to **share some of your files** with other users while **keeping other files private**.
- **Chapter 5—The Shell**
  Explains how to use shell features to make your work faster and easier. All of the features covered in this chapter work with both bash and tcsh. This chapter discusses
  - Using **command-line options** to modify the way a command works;
  - Making minor changes in a command line to **redirect input** to a command so that it comes from a file instead of the keyboard;
  - **Redirecting output** from a command to go to a file instead of the screen;
  - Using **pipelines** to send the output of one utility directly to another utility so you can solve problems right on the command line;
  - Running programs in the **background** so you can work on one task while Linux is working on a different one; and
  - Using the shell to **generate filenames** to save time spent on typing and help you when you do not remember the exact name of a file.

PART II: THE EDITORS

Part II covers two classic, powerful Linux command-line text editors. Most Linux distributions include the vim text editor, an "improved" version of the widely used vi

editor, as well as the popular GNU emacs editor. Text editors enable you to create and modify text files that can hold programs, shell scripts, memos, and input to text formatting programs. Because Linux system administration involves editing text-based configuration files, skilled Linux administrators are adept at using text editors.

- **Chapter 6—The vim Editor**
  Starts with a **tutorial** on vim and then explains how to use many of the **advanced features** of vim, including special characters in search strings, the General-Purpose and Named buffers, parameters, markers, and execution of commands from within vim. The chapter concludes with a **summary of vim commands**.

- **Chapter 7—The emacs Editor**
  Opens with a **tutorial** and then explains many of the features of the emacs editor, as well as how to use the META, ALT, and ESCAPE keys. In addition, this chapter covers key bindings, buffers, and **incremental and complete searching** for both character strings and regular expressions. It details the relationship between Point, the cursor, Mark, and Region. It also explains how to take advantage of the extensive **online help** facilities available from emacs. Other topics covered include cutting and pasting, using multiple windows and frames, and working with emacs modes—specifically **C mode**, which aids programmers in writing and debugging C code. Chapter 7 concludes with a **summary of emacs commands**.

PART III: THE SHELLS

Part III goes into more detail about bash and introduces the TC Shell (tcsh).

- **Chapter 8—The Bourne Again Shell** (bash)
  Picks up where Chapter 5 left off, covering more advanced aspects of working with a shell. For examples it uses the Bourne Again Shell—bash, the shell used almost exclusively for system shell scripts. Chapter 8 describes how to
  - Use shell **startup files**, shell options, and shell features to **customize the shell**;
  - Use **job control** to stop jobs and move jobs from the foreground to the background, and vice versa;
  - Modify and reexecute commands using the **shell history** list;
  - Create **aliases** to customize commands;
  - Work with **user-created and keyword variables** in shell scripts;
  - Implement localization including discussions of the locale utility, the **LC_** variables, and internationalization;
  - Set up **functions**, which are similar to shell scripts but are executed more quickly;

- Write and execute simple **shell scripts**; and
- **Redirect error messages** so they go to a file instead of the screen.

- **Chapter 9—The TC Shell** (tcsh)
  Describes tcsh and covers features common to and different between bash and tcsh. This chapter explains how to
  - Run tcsh and **change your default shell** to tcsh;
  - **Redirect error messages** so they go to files instead of the screen;
  - Use **control structures** to alter the flow of control within shell scripts;
  - Work with tcsh **array and numeric variables**; and
  - Use shell **builtin commands**.

PART IV: PROGRAMMING TOOLS

Part IV covers important programming tools that are used extensively in Linux and macOS system administration and general-purpose programming.

- **Chapter 10—Programming the Bourne Again Shell** (bash)
  Continues where Chapter 8 left off, going into greater depth about advanced shell programming using bash, with the discussion enhanced by extensive examples. This chapter discusses
  - **Control structures** including **if...then...else** and **case**;
  - **Variables**, with discussions of attributes, expanding null and unset variables, array variables, and variables in functions;
  - **Environment**, including environment versus local variables, inheritance, and process locality;
  - **Arithmetic and logical** (**Boolean**) **expressions**; and
  - Some of the most useful **shell builtin commands**, including exec, trap, and getopts.

  Once you have mastered the basics of Linux, you can use your knowledge to build more complex and specialized programs, using the shell as a programming language.

  Chapter 10 poses two complete **shell programming problems** and then shows you how to solve them step by step. The first problem uses **recursion** to create a hierarchy of directories. The second problem develops a quiz program, shows you how to set up a shell script that **interacts with a user**, and explains how the script processes data. (The examples in Part VI also demonstrate many features of the utilities you can use in shell scripts.)

- **Chapter 11—The Perl Scripting Language**
  Introduces the popular, feature-rich Perl programming language. This chapter covers
  - Perl **help tools**, including perldoc;
  - Perl **variables** and **control structures**;
  - **File handling**;
  - **Regular expressions**; and
  - Installation and use of **CPAN modules**.

  Many Linux administration scripts are written in Perl. After reading Chapter 11 you will be able to better understand these scripts and start writing your own. This chapter includes many examples of Perl scripts.
- **Chapter 12—The Python Programming Language**
  Introduces the flexible and friendly Python programming language. This chapter covers
  - Python **lists** and **dictionaries**;
  - Python functions and methods you can use to **write to and read from files**;
  - Using **pickle** to store an object on disk;
  - Importing and using **libraries**;
  - Defining and using **functions**, including regular and **Lambda functions**;
  - **Regular expressions**; and
  - Using **list comprehensions**.

  Many Linux tools are written in Python. Chapter 12 introduces Python, including some basic object-oriented concepts, so you can read and understand Python programs and write your own. This chapter includes many examples of Python programs.
- **Chapter 13—The MariaDB SQL Database Management System**
  Introduces the widely used MariaDB/MySQL relational database management system (RDBMS). This chapter covers
  - Relational database **terminology**;
  - **Installing** the MariaDB client and server;
  - **Creating a database**;
  - **Adding a user**;
  - Creating and modifying **tables**;
  - **Adding data** to a database; and
  - **Backing up** and restoring a database.

- **Chapter 14—The AWK Pattern Processing Language**
  Explains how to use the powerful AWK language to write programs that filter data, **write reports**, and **retrieve data from the Internet**. The advanced programming section describes how to set up **two-way communication** with another program using a **coprocess** and how to obtain input over a network instead of from a local file.
- **Chapter 15—The sed Editor**
  Describes sed, the **noninteractive stream editor** that finds many applications as a filter within shell scripts. This chapter discusses how to use sed's buffers to write **simple yet powerful programs** and includes many examples.

PART V: SECURE NETWORK UTILITIES

Part V describes two utilities you can use to work on a remote system and copy files across a network securely.

- **Chapter 16—The rsync Secure Copy Utility**
  Covers rsync, a secure utility that **copies** an ordinary file or **directory hierarchy** locally or between the local system and **a remote system**. As you write programs, you can use this utility to back them up to another system.
- **Chapter 17—The OpenSSH Secure Communication Utilities**
  Explains how to use the ssh, scp, and sftp utilities to communicate securely over the Internet. This chapter covers the use of authorized keys that allow you to log in on a remote system securely without a password, ssh-agent that can hold your **private keys** while you are working, and **forwarding X11** so you can run graphical programs remotely.

PART VI: COMMAND REFERENCE

Linux includes hundreds of utilities. Chapters 14, 15, 16, and 17 as well as Part VI provide extensive examples of the use of over 100 of the **most important utilities** with which you can solve problems without resorting to programming in C. If you are already familiar with UNIX/Linux, this part of the book will be a valuable, **easy-to-use reference**. If you are not an experienced user, it will serve as a useful supplement while you are mastering the earlier sections of the book.

Although the descriptions of the utilities in Chapters 14, 15, 16, and 17 and Part VI are presented in a format similar to that used by the Linux manual (man) pages, they are much easier to read and understand. These utilities are included because you will work with them **day in, day out** (for example, ls and cp), because they are **powerful tools** that are especially useful in shell scripts (sort, paste, and test), because they help you **work with a Linux system** (ps, kill, and fsck), or because they enable you to **communicate with other systems** (ssh, scp, and ftp). Each utility description includes complete explanations of its most useful options, differentiating between options supported under macOS and those supported under Linux. The "Discussion" and "Notes" sections present **tips and tricks** for taking full advantage of the utility's power. The "**Examples**" **sections** demon-

strate how to use these utilities in real life, alone and together with other utilities, to generate reports, summarize data, and extract information. Take a look at the "Examples" sections for find (page 826), ftp (page 841), and sort (page 971) to see how extensive these sections are. Some utilities, such as Midnight Commander (mc; page 902) and screen (page 958), include extensive discussion sections and tutorials.

PART VII: APPENDIXES

Part VII includes the appendixes, the glossary, and three indexes.

- **Appendix A—Regular Expressions**
  Explains how to use **regular expressions** to take advantage of the **hidden power of Linux**. Many utilities, including grep, sed, vim, AWK, Perl, and Python, accept regular expressions in place of simple strings of characters. A single regular expression can match many simple strings.
- **Appendix B—Help**
  Details the steps typically used to **solve the problems** you might encounter when using a Linux system.
- **Appendix C—Keeping the System Up-to-Date**
  Describes how to use tools to download software and **keep a system current**. This appendix includes information on
  - dnf—Downloads software from the Internet, keeping a system up-to-date and **resolving dependencies** as it goes.
  - apt-get—An alternative to dnf for keeping a system current.
  - **BitTorrent**—Good for distributing large amounts of data such as Linux installation CDs and DVDs.
- **Appendix D—macOS Notes**
  A brief guide to macOS features and quirks that might be unfamiliar to users who have been using Linux or other UNIX-like systems.
- **Glossary**
  Defines more than 500 terms that pertain to the use of Linux and macOS.
- **Indexes**
  Three indexes that make it easier to find what you are looking for quickly. These indexes indicate where you can locate tables (page numbers followed by the letter t) and definitions (*italic* page numbers). They also differentiate between light and comprehensive coverage (page numbers in light and standard fonts, respectively).
  - **File Tree Index**—Lists, in hierarchical fashion, most files mentioned in this book. These files are also listed in the Main index.
  - **Utility Index**—Locates all utilities mentioned in this book. A page number in a light font indicates a brief mention of the utility; use of

the regular font indicates more substantial coverage. The Utility index is reproduced on the insides of the front and back covers.

- **Main Index**—Helps you find the information you want quickly.

SUPPLEMENTS

The author's home page (www.sobell.com) contains downloadable listings of the longer programs from this book as well as pointers to many interesting and useful Linux- and macOS-related sites on the World Wide Web; a list of corrections to the book; answers to even numbered exercises; and a solicitation for corrections, comments, and suggestions.

Register your copy of *A Practical Guide to Linux® Commands, Editors, and Shell Programming, Fourth Edition*, at informit.com/register for convenient access to downloads, updates, and/or corrections as they become available (you must log in or create a new account). Enter the product ISBN (9780134774602) and click Submit. Once the process is complete, you will find any available bonus content under Registered Products. If you would like to be notified of exclusive offers on new editions and updates, please check the box to receive email from us.

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I take responsibility for any errors and omissions in this book. If you find one or just have a comment, let me know (matthew@matthewhelmke.com), and I will fix it in the next printing. I inherited a fabulous amount of well-vetted content, and I have tested what is here while updating the text for this edition, but it is possible I have not done so perfectly and am happy to receive your kind assistance and corrections where needed.

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Matthew Helmke
North Liberty, Iowa

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I take responsibility for any errors and omissions in this book. If you find one or just have a comment, let me know (mgs@sobell.com), and I will fix it in the next printing. My home page (www.sobell.com) contains a list of errors and credits those who found them. It also offers copies of the longer scripts from the book and pointers to interesting Linux pages on the Internet. You can follow me on Twitter at twitter.com/marksobell.

Mark G. Sobell
San Francisco, California

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Welcome to Linux and macOS

In This Chapter

Objectives

After reading this chapter you should be able to:

- Discuss the history of UNIX, Linux, and the GNU project
- Explain what is meant by "free software" and list characteristics of the GNU General Public License
- List characteristics of Linux and reasons the Linux operating system is so popular
- Discuss three benefits of virtual machines over single physical machines