

WILLIAM “BO” ROTHWELL

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LPIC-2

(201-400 and
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LPIC-2 Cert Guide

William “Bo” Rothwell

PEARSON

800 East 96th Street
Indianapolis, Indiana 46240 USA

LPIC-2 Cert Guide (201-400 and 202-400 exams)

William “Bo” Rothwell

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About the Author

William “Bo” Rothwell At the impressionable age of 14, Bo crossed paths with a TRS-80 Micro Computer System (affectionately known as a “Trash 80”). Soon after, the adults responsible for Bo made the mistake of leaving him alone with the TRS-80. He immediately dismantled it and held his first computer class, showing his friends what made this “computer thing” work.

Since that experience, Bo’s passion for understanding how computers work and sharing this knowledge with others has resulted in a rewarding career in IT training. His experience includes Linux, Unix, and programming languages such as Perl, Python, Tcl, and BASH. He is the founder and president of One Course Source, an IT training organization.

Dedication

To Sarah, my fiancée and best friend: You have the patience of a saint and without your support, I could never have written this book.

To Julia, my daughter: You didn’t deserve at least half the times I yelled at you. Thanks for putting up with your grumpy Dad.

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I feel like one of those actors who has been awarded an Oscar and tries to rattle off a bunch of names, trying to say thank you to everyone. I’m not limited to five minutes, but I am worried about missing someone!

To Sarah and Julia, my fiancée and daughter, thank you again for all your support, encouragement, and patience.

To my Dad, Richard Rothwell: I hated having to write and rewrite my papers growing up. I dreaded bringing you “draft #5” knowing there would have to be a “draft #6.” But those experiences allowed me to become a good writer, and I can’t thank you enough for that. (However, please don’t send me a marked-up copy of this book!)

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Finally, thank you very much Ross Brunson and Keith Wright for your hard work as technical reviewers for this book. Your feedback made this a much better publication than I could have managed alone.

About the Technical Reviewers

Ross Brunson Ross has more than 20 years of experience as a Linux and Open Source trainer, training manager, and technologist and is author of the popular *LPIC-1 Exam Cram* (Que Publishing), as well as the Pearson IT Certification *LPIC-1 Certification Guide*. Ross is currently senior training/certification engineer at SUSE and recently spent almost five years as the director of member services for the Linux Professional Institute, where he contributed to placing several LPI courses into the Cisco Networking Academy, conducted dozens of Train-the-Trainer sessions, and provided sales enablement support for the worldwide Master Affiliate network spanning 100+ countries. Ross holds a number of key IT certifications; is author of several successful technical books and dozens of technical courses for major organizations (including the first LPI Certification Bootcamps); and is skilled at both contributing to and building community around IT products. He lives in Paradise Valley, Montana, with his family and enjoys traveling, winter sports, and photography.

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We Want to Hear from You!

As the reader of this book, you are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

We welcome your comments. You can e-mail or write to let us know what you did or didn't like about this book—as well as what we can do to make our books better. Please note that we cannot help you with technical problems related to the topic of this book.

When you write, please be sure to include this book's title and author as well as your name and e-mail address. We will carefully review your comments and share them with the author and editors who worked on the book.

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Reader Services

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Introduction

Odds are you are reading this book because you have successfully passed the Linux+ or LPIC-1 certification exams and you are ready for the next challenge. This book focuses on one major goal: to help you prepare to pass the LPIC-2 exams (Exam 201 and Exam 202).

These are challenging exams because they cover a wide range of advanced Linux topics. In fact, some of these topics are large enough to be covered in books of their own.

It is important to realize that this book's primary goal is to help you prepare to pass the LPIC-2 exam. As a result, the depth of the topics is specifically limited to what is exam-testable.

The rest of this introduction focuses on two topics: the LPIC-2 exam and a description of this book.

The LPIC-2 Exam

The Linux Network Professional Certification (LPIC-2) was first introduced in November 2001. To earn this certification, you need to pass two exams: 201 and 202. You also need to have an active LPIC-1 certification to be eligible to earn the LPIC-2 certification. Make sure you take the LPIC-2 exams within five years of earning your LPIC-1 certification.

The primary focus of the LPIC-2 exam is the skills that a Linux administrator should have to manage small- to medium-sized network environments. You will find a bit of redundancy with the topics on the LPIC-1 certification exams, but you should also expect the exam questions to deal with a deeper level of knowledge. For example, both exams list SysV-init system startup as an exam objective, but the questions are more challenging on the LPIC-2 exam than on the LPIC-1 exam.

VERY IMPORTANT: The LPIC-2 exam has a “shelf life” of five years. While topics and techniques change (sometimes rapidly) in Linux, the LPIC-2 exam does not immediately change. As a result, some of the topics that you will be tested on are no longer the standard that you find in most modern Linux distributions. I have made a point throughout the book to highlight which topics are slightly older because this should have an impact on your study methods.

For example, one of the exam objectives is 202.1 Customizing SysV-init system startup. Most modern distributions of Linux now use a different startup system (either Upstart or SystemD). For the purposes of the exam, you want to focus your studies on SysV-init. In these situations, I provide a suggestion as to which Linux distribution you should use to practice.

Contents of the 201 and 202 Exams

Every student who takes an exam wants to know what's on the exam. As with all their exams, LPI publishes a set of exam topics. These exam topics give general guidance as to what's on the exam.

You can find the exam topics at www.lpi.org. The most memorable way to navigate is to go to <https://www.lpi.org/study-resources/> and look for the LPIC-2 201 Objectives and the LPIC-2 202 Objectives.

Table I-1 lists the topics on the 201 and 202 exams, with a reference to the chapter or chapters of this book that covers the topic.

Table I-1 201 and 202 Topics and Chapter References

Exam Section/Objective	Chapter Where Covered
Topic 200: Capacity Planning	
200.1 Measure and Troubleshoot Resource Usage	Chapter 1
200.2 Predict Future Resource Needs	Chapter 2
Topic 201: Linux Kernel	
201.1 Kernel Components	Chapter 3
201.2 Compiling a Kernel	Chapter 3
201.3 Kernel Runtime Management and Troubleshooting	Chapter 4
Topic 202: System Startup	
202.1 Customizing SysV-init System Startup	Chapter 5
202.2 System Recovery	Chapter 6
202.3 Alternate Boot loaders	Chapter 7
Topic 203: Filesystem and Devices	
203.1 Operating the Linux Filesystem	Chapter 8
203.2 Maintaining a Linux Filesystem	Chapter 9
203.3 Creating and Configuring Filesystem Options	Chapter 10
Topic 204: Advanced Storage Device Administration	
204.1 Configuring RAID	Chapter 11
204.2 Adjusting Storage Device Access	Chapter 12
204.3 Logical Volume Manager	Chapter 13
Topic 205: Network Configuration	
205.1 Basic Networking Configuration	Chapter 14
205.2 Advanced Network Configuration and Troubleshooting	Chapter 15
205.3 Troubleshooting Network Issues	Chapter 16
Topic 206: System Maintenance	
206.1 Make and Install Programs from Source	Chapter 17
206.2 Backup Operations	Chapter 18
206.3 Notify Users on System-Related Issues	Chapter 19

Exam Section/Objective	Chapter Where Covered
Topic 207: Domain Name Server	
207.1 Basic DNS Server Configuration	Chapter 20
207.2 Create and Maintain DNS Zones	Chapter 21
207.3 Securing a DNS Server	Chapter 22
Topic 208: Web Services	
208.1 Implementing a Web Server	Chapter 23
208.2 Apache Configuration for HTTPS	Chapter 24
208.3 Implementing a Proxy Server	Chapter 25
208.4 Implementing Nginx as a Web Server and a Reverse Proxy	Chapter 25
Topic 209: File Sharing	
209.1 SAMBA Server Configuration	Chapter 26
209.2 NFS Server Configuration	Chapter 27
Topic 210: Network Client Management	
210.1 DHCP Configuration	Chapter 28
210.2 PAM Authentication	Chapter 29
210.3 LDAP Client Usage	Chapter 31
210.4 Configuring an OpenLDAP Server	Chapter 30
Topic 211: E-mail Services	
211.1 Using E-mail Servers	Chapter 32
211.2 Managing Local E-mail Delivery	Chapter 33
211.3 Managing Remote E-mail Delivery	Chapter 34
Topic 212: System Security	
212.1 Configuring a Router	Chapter 35
212.2 Securing FTP Servers	Chapter 36
212.3 Secure Shell (SSH)	Chapter 37
212.4 Security Tasks	Chapter 38
212.5 OpenVPN	Chapter 38

How to Take the LPIC-201 and LPIC-202 Exams

To take the LPIC-2 exams, start at lpi.org to get a member ID and a link to pearsonvue.com/lpi/ to schedule an exam.

Who Should Take This Exam and Read This Book?

This book is intended for anyone wanting to prepare for the LPIC-2 certification exams. The audience includes self-study readers—people who pass the test by studying 100% on their own.

This book is also an excellent primer for many topics that a Linux system administrator is responsible for handling. The information in this book can also be used as a reference for when the gray matter storage device between your ears fails to return the necessary information.

Book Organization

This book contains 39 chapters, plus a glossary and an appendix. The topics all focus in some way on LPIC-2 certification topics, making the topics somewhat focused, but with deep coverage on those topics.

The book organizes the topics into 14 major parts. The following list outlines the major part organization of this book:

- **Part I, “Capacity Planning”:** This part includes two chapters, which focus on tools designed to determine resource usage. Using this information, you can determine what additional resources may be needed in the future:
 - **Chapter 1, “Measuring and Troubleshooting Resource Usage”:** This chapter covers the tools and terms that you should know about when measuring the resources used by the system.
 - **Chapter 2, “Predict Future Resource Needs”:** This chapter covers the tools and techniques to predict what your system will need in the future, not only to help you avoid disasters, but also to provide you with the means to proactively maintain your system’s health.
- **Part II, “Managing the Kernel”:** The focus on this part is the kernel:
 - **Chapter 3, “Kernel Components and Compiling”:** In this chapter you learn about kernel parameters, discover kernel documentation that helps you understand these parameters, and learn how to create a custom kernel.
 - **Chapter 4, “Kernel Runtime Management and Troubleshooting”:** The focus of this chapter is to learn how to load LKMs, unload them from memory, and view information about the modules, not to memorize what the different modules do. You also learn how to fine-tune LKMs by adjusting module parameters.
- **Part III, “Managing System Startup”:** As an administrator you need to be able to administer how the system boots. This part focuses on how the boot process works and what changes you can make as an administrator:
 - **Chapter 5, “Customizing SysV-init System Startup”:** This chapter focuses on understanding the boot process of SysV-init systems as well as how to modify how these systems boot.

- **Chapter 6, “Administering System Recovery”**: In this chapter you learn the skills that enable you to recover a system that will not boot properly.
- **Chapter 7, “Alternate Boot loaders”**: In this chapter you learn how to configure LILO, the LInux LOader. You also learn about other boot loaders, including syslinux, extlinux, isolinux, and pxelinux.
- **Part IV, “Managing Filesystem and Devices”**: Local filesystems are stored on devices such as partitions. The ability to make partitions and place filesystems on these partitions is a critical component of the functions of a system administrator:
 - **Chapter 8, “Operating the Linux Filesystem”**: This chapter explains how the mounting process works.
 - **Chapter 9, “Maintaining a Linux Filesystem”**: In this chapter you learn about different Linux filesystems, including the family of ext-based filesystems and the xfs filesystem. You learn how to create these filesystems as well as how to maintain them. You also learn how to create swap devices and utilize SMART, a method of monitoring your hard disks.
 - **Chapter 10, “Creating and Configuring Filesystem Options”**: This chapter focuses on understanding the essentials about removable media filesystems, including ISO9660, HFS, and UDF. You also learn about encrypted filesystems and the autofs system.
- **Part V, “Administering Advanced Storage Device”**: In addition to regular partitions, you can use software RAID and LVM (Logical Volume Manager) devices to store files locally:
 - **Chapter 11, “Configuring RAID”**: This chapter focuses on how to set up and maintain software RAID devices on Linux distributions.
 - **Chapter 12, “Adjusting Storage Device Access”**: This chapter is somewhat of a hodgepodge chapter, covering a wide range of storage topics not covered in previous chapters. This includes covering iSCSI (a network-based implementation of SCSI), tools related to storage device system resources, as well as kernel parameters related to storage devices.
 - **Chapter 13, “Logical Volume Manager”**: This chapter covers Logical Volume Manager (LVM), a technology that can be used in place of traditional partitions.
- **Part VI, “Configuring the Network”**: This part focuses on configuring and troubleshooting network interfaces:
 - **Chapter 14, “Basic Networking Configuration”**: The focus of this chapter is basic networking commands, such as `ifconfig`, `arp`, and the `route` commands. The topic of wireless networking commands is also covered in this chapter.
 - **Chapter 15, “Advanced Network Configuration and Troubleshooting”**: The focus of this chapter is commands that gather network information, primarily to aid the process of troubleshooting problems. The topic includes commands that probe remote systems (the `ping` and `nmap` commands), display local network information (the `nc`, `netstat`, and `lsof` commands), and sniff local network packets (the `tcpdump` command).

- **Chapter 16, “Troubleshooting Network Issues”:** This chapter focuses on files used to configure and troubleshoot network-related issues. You learn about the different configuration files that exist on Debian and Red Hat–based systems. Various troubleshooting tools are covered to provide you with the skills to fix network issues.
- **Part VII, “Performing System Maintenance”:** This part contains a collection of topics, including installing software via source code, backing up filesystems, and sending messages to users:
 - **Chapter 17, “Make and Install Programs from Source”:** In this chapter you learn where you can access source code. After downloading it to your system, you learn how to “unpack” and configure the source code. Finally, you learn how to install and patch the source code.
 - **Chapter 18, “Backup Operations”:** This chapter introduces some of the basics that you should know about when creating your backup strategy. You learn how to answer the questions of what should be backed up and what tools should be used. You also learn about some of the standard backup tools that come with Linux as well as some of the third-party tools available.
 - **Chapter 19, “Notify Users on System-Related Issues”:** In this chapter you learn how to display both pre-login messages and post-login messages. You also learn how to send broadcast messages to all users who are currently logged in to the system.
- **Part VIII, “Administering Domain Name Server”:** This part focuses on configuring and securing a DNS server:
 - **Chapter 20, “Basic DNS Server Configuration”:** This chapter focuses on understanding the essential concepts and terms of DNS as well as how to administer the primary BIND configuration file. You also are introduced to some of the essential commands that help you administer a DNS server.
 - **Chapter 21, “Create and Maintain DNS Zones”:** In this chapter you learn how to configure a DNS zone by modifying the `/etc/named.conf` file and creating zone files.
 - **Chapter 22, “Securing a DNS Server”:** The focus of this chapter is to make DNS more secure.
- **Part IX, “Configuring Web Services”:** This section focuses on configuring and securing web servers and proxy servers:
 - **Chapter 23, “Implementing a Web Server”:** This chapter introduces the Apache Web Server. You learn how to perform basic configuration changes to both its primary configuration files and “include” directory configuration files.
 - **Chapter 24, “Apache Configuration for HTTPS”:** This chapter focuses on HTTPS, the Hypertext Transfer Protocol with SSL (Secure Sockets Layer) for authentication and encryption. You learn about the concepts of SSL and how it can be used to allow a client system to authenticate an Apache Web Server.
 - **Chapter 25, “Implementing a Proxy Server”:** In this chapter you are introduced to the concept of proxy servers. You learn how to configure a proxy server, including how to limit access to the server.

- **Part X, “Administrating File Sharing”:** Files are typically shared between systems via either SAMBA or NFS. This part focuses on configuring these services:
 - **Chapter 26, “SAMBA Server Configuration”:** In this chapter you learn about the Samba server, including key configuration settings.
 - **Chapter 27, “NFS Server Configuration”:** In this chapter you learn how to set up an NFS server and connect to it from an NFS client. You also learn how to secure portmap, the service that grants access to NFS servers.
- **Part XI, “Managing Network Clients”:** This part covers a collection of services, including DHCP, PAM, and LDAP:
 - **Chapter 28, “DHCP Configuration”:** This chapter covers DHCP server configuration.
 - **Chapter 29, “PAM Authentication”:** This chapter covers PAM (pluggable authentication modules), a component of Linux designed to authorize and authenticate user accounts.
 - **Chapter 30, “Configuring an OpenLDAP Server”:** This chapter introduces LDAP (Lightweight Directory Access Protocol), a distributed directory service.
 - **Chapter 31, “LDAP Client Usage”:** This chapter focuses on the OpenLDAP database. You learn how to use the `ldapadd` and `ldapdelete` commands to make changes to the database.
- **Part XII: “Administrating E-mail Services”:** This section focuses on administrating various e-mail services:
 - **Chapter 32, “Using E-mail Servers”:** In this chapter you learn features such as configuration of e-mail addresses, implementing e-mail quotas, and managing virtual e-mail domains.
 - **Chapter 33, “Managing Local E-mail Delivery”:** In this chapter you learn how to set up procmail rules, both systemwide as an administrator and by individual user accounts.
 - **Chapter 34, “Managing Remote E-mail Delivery”:** You learn about the protocols used by the MDA: IMAP (Internet Message Access Protocol) and POP (Post Office Protocol) in this chapter. You also learn how to configure MDA services, including Dovecot and Courier.
- **Part XIII, “Administrating System Security”:** In this section several security features are introduced, including router configuration, FTP servers, SSH servers, and VPN:
 - **Chapter 35, “Configuring a Router”:** In this chapter you learn how to configure a Linux system as a router and protect the internal network using a firewall. You also learn how to allow an internal, private network to access the Internet via NAT.
 - **Chapter 36, “Securing FTP Servers”:** This chapter primarily focuses on how to set up a specific FTP server called the vsftpd server. You also learn some of the key command line options of the Pure-FTPd server.
 - **Chapter 37, “Secure Shell (SSH)”:** This chapter primarily focuses on setting up a Secure Shell server, including the concepts of how the protocol works and key con-

figuration options. The Secure Shell client utilities also are covered, including how to customize the behavior of the utilities by modifying the SSH client configuration file.

- **Chapter 38, “Security Tasks and OpenVPN”:** You first learn about some key security tools, such as nmap, nc, snort, and fail2ban. You also learn how to discover important security alerts from sources such as Bugtraq, CERT, CIAC, and others. This chapter also covers the LPIC-2 objective of OpenVPN (Open Virtual Private Network).
- **Part XIV, “Final Preparation”:** This part concludes the book with recommendations for exam preparation:
 - **Chapter 39, “Final Preparation”:** This nontechnical chapter identifies and explains how to use various exam preparation tools, followed by a step-by-step strategy for using this book to prepare for the LPIC-201 and LPIC-202 exams.

In addition to the core chapters, this book also has

- **Glossary:** The glossary contains definitions for all the terms listed in the “Define Key Terms” sections at the conclusions of Chapters 1 through 38.
- **Appendix A, “Answers to ‘Do I Know This Already?’ Quizzes and Review Questions:** Includes the answers to all the questions from Chapters 1 through 38.

Book Features and Exam Preparation Methods

This book uses several key methodologies to help you discover the exam topics on which you need more review, to help you fully understand and remember those details, and to help you prove to yourself that you have retained your knowledge of those topics. Therefore, this book does not try to help you pass the exams only by memorization but by truly learning and understanding the topics.

The book includes many features that provide different ways to study so you can be ready for the exam. If you understand a topic when you read it, but do not study it any further, you probably will not be ready to pass the exam with confidence. The features included in this book give you tools that help you determine what you know, review what you know, better learn what you don’t know, and be well prepared for the exam. These tools include

- **“Do I Know This Already?” Quizzes:** Each chapter begins with a quiz that helps you determine the amount of time you need to spend studying that chapter.
- **Foundation Topics:** These are the core sections of each chapter. They explain the protocols, concepts, and configuration for the topics in that chapter.
- **Exam Preparation Tasks:** These sections list a series of study activities that should be done after reading the Foundation Topics section. Each chapter includes the activities that make the most sense for studying the topics in that chapter. The activities include
 - **Key Topics Review:** The Key Topic icon appears next to the most important items in the Foundation Topics section of the chapter. The Key Topics Review activity lists the key topics from the chapter and their page numbers. Although the contents of the entire chapter could be on the exam, you should definitely know the information listed in each key topic. Review these topics carefully.

- **Definition of Key Terms:** Although certification exams might be unlikely to ask a question such as “Define this term,” the LPIC-201 and LPIC-202 exams require you to learn and know a lot of terminology. This section lists some of the most important terms from the chapter, asking you to write a short definition and compare your answer to the Glossary.
- **End of Chapter Review Questions:** Confirm that you understand the content that you just covered.

Companion Website

Register this book to get access to the Pearson IT Certification test engine and other study materials plus additional bonus content. Check this site regularly for new and updated postings written by the author that provide further insight into the more troublesome topics on the exam. Be sure to check the box that you would like to hear from us to receive exclusive discounts on future editions of this product or related products.

To access this companion website, follow these steps:

1. Go to www.pearsonITcertification.com/register and log in or create a new account.
2. Enter the ISBN: 9780789757142
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Note that many of our companion content files can be very large, especially image and video files.

If you are unable to locate the files for this title by following these steps, visit www.pearsonITcertification.com/contact and select the Site Problems/Comments option. Our customer service representatives will assist you.

Pearson IT Certification Practice Test Engine and Questions

The companion website includes the Pearson IT Certification Practice Test engine—software that displays and grades a set of exam-realistic multiple-choice questions. Using the Pearson IT Certification Practice Test engine, you can either study by going through the questions in Study Mode or take a simulated exam that mimics real exam conditions. You can also serve up questions in a Flash Card Mode, which displays just the question and no answer, challenging you to state the answer in your own words before checking the actual answer to verify your work.

The installation process requires two major steps: installing the software and then activating the exam. The website has a recent copy of the Pearson IT Certification Practice Test engine. The practice exam (the database of exam questions) is not on this site.

Note: The cardboard DVD sleeve in the back of this book includes a piece of paper. The paper lists the activation code for the practice exam associated with this book. Do not lose the activa-

tion code. Also included on the paper is a unique, one-time-use coupon code for the purchase of the Premium Edition eBook and Practice Test.

Install the Software

The Pearson IT Certification Practice Test is a Windows-only desktop application. You can run it on a Mac using a Windows virtual machine, but it was built specifically for the PC platform. The minimum system requirements are as follows:

- Windows XP (SP3), Windows Vista (SP2), Windows 7, or Windows 8
- Microsoft .NET Framework 4.0 Client
- Pentium-class 1 GHz processor (or equivalent)
- 512 MB RAM
- 650 MB disk space plus 50 MB for each downloaded practice exam
- Access to the Internet to register and download exam databases

The software installation process is routine as compared with other software installation processes. If you have already installed the Pearson IT Certification Practice Test software from another Pearson product, there is no need for you to reinstall the software. Simply launch the software on your desktop and proceed to activate the practice exam from this book by using the activation code included in the cardboard sleeve.

The following steps outline the installation process:

1. Download the exam practice test engine from the companion site.
2. Respond to Windows prompts as with any typical software installation process.

The installation process gives you the option to activate your exam with the activation code supplied on the paper in the cardboard sleeve. This process requires that you establish a Pearson website login. You need this login to activate the exam, so please do register when prompted. If you already have a Pearson website login, there is no need to register again. Just use your existing login.

Activate and Download the Practice Exam

Once the exam engine is installed, you should then activate the exam associated with this book (if you did not do so during the installation process) as follows:

1. Start the Pearson IT Certification Practice Test software from the Windows Start menu or from your desktop shortcut icon.
2. To activate and download the exam associated with this book, from the My Products or Tools tab, click the Activate Exam button.
3. At the next screen, enter the activation key from the paper inside the cardboard sleeve in the back of the book. Once entered, click the Activate button.
4. The activation process downloads the practice exam. Click Next, and then click Finish.

When the activation process completes, the My Products tab should list your new exam. If you do not see the exam, make sure that you have selected the My Products tab on the menu. At this point, the software and practice exam are ready to use. Simply select the exam and click the Open Exam button.

To update a particular exam you have already activated and downloaded, display the Tools tab and click the Update Products button. Updating your exams ensures that you have the latest changes and updates to the exam data.

If you want to check for updates to the Pearson Certification Practice Test exam engine software, display the Tools tab and click the Update Application button. You can then ensure that you are running the latest version of the software engine.

Activating Other Exams

The exam software installation process and the registration process, only have to happen once. Then, for each new exam, only a few steps are required. For instance, if you buy another Pearson IT Certification Cert Guide, extract the activation code from the cardboard sleeve in the back of that book; you do not even need the exam engine at this point. From there, all you have to do is start the exam engine (if not still up and running) and perform steps 2 through 4 from the previous list.

Assessing Exam Readiness

Exam candidates never really know whether they are adequately prepared for the exam until they have completed about 30% of the questions. At that point, if you are not prepared, it is too late. The best way to determine your readiness is to work through the “Do I Know This Already?” quizzes at the beginning of each chapter and review the foundation and key topics presented in each chapter. It is best to work your way through the entire book unless you can complete each subject without having to do any research or look up any answers.

Premium Edition eBook and Practice Tests

This book also includes an exclusive offer for 70% off the Premium Edition eBook and Practice Tests edition of this title. See the coupon code included with the cardboard sleeve for information on how to purchase the Premium Edition.

LPIC-2 Exam Updates

Over time, reader feedback allows Pearson to gauge which topics give our readers the most problems when taking the exams. Additionally, LPIC does occasionally make minor updates to the LPIC-2 exam. We address that all in Appendix B “LPIC-2 Exam Updates.”

To assist readers with keeping up to date, the author might create new materials clarifying and expanding on those troublesome exam topics as well as changes to the LPIC-2 exams. This material can be found at <http://www.pearsonitcertification.com/title/9780789757142>. Alternatively this material can also be found at <http://www.OneCourseSource.com/LPIC-2-book>.



This chapter covers the following topics:

- How to access source code
- How to unpack and build source code
- How to patch source code

This chapter covers the following objective:

- 206.1 Make and Install Programs from Source



This chapter covers the following topics:

- How to develop a backup strategy
- How to use standard backup tools
- Third-party backup tools

This chapter covers the following objective:

- 206.2 Backup Operations

Backup Operations

Almost every seasoned system administrator, as well as many end users, has horror stories that revolve around lost data. Millions of dollars have been lost and heads have rolled because either no backup strategy was put in place or the backup strategy wasn't followed.

Data is a serious business, and you don't want to be the one, hat in hand, explaining why critical company data has been lost forever. You must create a solid backup strategy and make sure it is implemented correctly.

This chapter introduces some of the basics that you should know when creating your backup strategy. You learn to answer the questions of what should be backed up and what tools should be used. You also learn about some of the standard backup tools that come with Linux as well as some of the third-party tools that are available.

“Do I Know This Already?” Quiz

The “Do I Know This Already?” quiz enables you to assess whether you should read this entire chapter or simply jump to the “Exam Preparation Tasks” section for review. If you are in doubt, read the entire chapter. Table 18-1 outlines the major headings in this chapter and the corresponding “Do I Know This Already?” quiz questions. You can find the answers in Appendix A, “Answers to the ‘Do I Know This Already?’ Quizzes.”

Table 18-1 “Do I Know This Already?” Foundation Topics Section-to-Question Mapping

Foundation Topics Section	Questions Covered in This Section
Backup Strategy	1
Standard Backup Utilities	2, 3
Third-Party Backup Utilities	4

1. Which directory cannot be placed in a separate filesystem from the root filesystem?
 - a. **/boot**
 - b. **/etc**
 - c. **/var**
 - d. None of the above

2. The ____ command is designed to back up the contents of entire disk drives, regardless of the data on the disk drive.
 - a. **zip**
 - b. **tar**
 - c. **dd**
 - d. **rsync**

3. To specify the block size, use the ____ option to the **dd** command.

4. Which of the following is considered a third-party backup utility available for the Linux operating system.
 - a. BackLinuxUp
 - b. CompleteBackup
 - c. Amanda
 - d. Rebecca

Foundation Topics

Backup Strategy

As an administrator, it is your responsibility to develop a solid backup strategy. To create this strategy, you need to answer the following questions:

- **What needs to be backed up?**—This is a critical question because it has an impact on the answers to the rest of the questions. While answering this question, you should consider breaking down your filesystem into smaller components to create a more efficient backup strategy.
- **How often?**—Several factors come into play when answering this question. If you have broken down your filesystem into smaller components, you are really going to answer this question for each component, as the answer varies depending on what is being backed up.
- **Full or incremental?**—A full backup is when everything is backed up, regardless of whether any changes have been made since the last backup. An incremental backup is when a backup is performed only on the files that have changed since a previous backup. Some backup utilities allow for complex backup strategies based on several different levels of incremental backups.
- **Where will the backup be stored?**—Will you use tape devices, optical devices (CD-ROMS/DVDs), external storage devices (USB drives), or network-accessible storage locations? Each storage location has inherent advantages and disadvantages.
- **What backup tool will be used?**—The decision that you make regarding the backup tool has a significant impact on the process of backing up and restoring data. Most Linux distributions come with several tools installed by default, such as the **dd** and **tar** commands. In many cases, additional tools are freely available; you just need to install them from the distribution repository. In addition to the tools that come with the distribution, you may want to consider exploring third-party tools, which typically offer more robust solutions.

What Needs to Be Backed Up?



One of the reasons why administrators tend to use multiple partitions (or logical volumes) when installing the operating system is that this lends to developing good backup strategies. Certain directories change more often than others. By making these separate filesystems, you can make use of filesystem features to perform the backup.

For example, it is normally a good idea to back up data not actively being modified. This can pose challenges when backing up users' home directories. By making **/home** a separate partition, the partition can then be unmounted and a backup can be performed directly from the partitions. Even better: Make the **/home** filesystem on a logical volume and use LVM snapshots to create a "frozen" view of the filesystem in the **/home** directory. This allows users to continue to work on the filesystem while you back up the data.

This doesn't mean that you will always make separate filesystems for each directory structure that you want to back up. In fact, in some cases, like the **/etc** directory, this isn't even possible (**/etc** must be in the same filesystem as the **/** filesystem). However, whenever possible, it is generally a good idea to create separate filesystems for directory structures that you are incorporating in your backup strategy.

Note: You will see that I tend to use the terms "directory" and "filesystem" interchangeably in this chapter. As you know, not all directories represent entire filesystems, just the ones that are mount points. However, because I am strongly suggesting that the directories in Table 18-2 be mount points for filesystems, I decided to use the terms "directory," "directory structure," and "filesystem" interchangeably when I am discussing these sorts of directories.

So, what directories/filesystems should you consider including in your backup strategy? Table 18-2 highlights the ones that are commonly part of a backup strategy.

Table 18-2 Directories/Filesystems to Consider Including in Your Backup Strategy

Directory/Filesystem	Why You Should Consider
/home	If your system has any regular users, this directory structure is certain to be a part of your backup strategy. On servers with no regular users, however, this directory is normally ignored when developing the backup strategy.
/usr	The /usr directory rarely changes as this is the location of most of the system's commands, documentation, and programs. This directory structure normally only changes when new software is added to the system or when existing software is updated. Some administrators argue not to ever back up /usr because if something goes wrong, you can always just reinstall the software. The flaw in this reasoning is that few administrators keep a list of all the software installed on all the systems they administer. So, you should include this directory in your backup strategy.

Directory/Filesystem	Why You Should Consider
/bin	If you back up the /usr directory, consider including the /bin directory as some of the operating system software is installed in this directory structure.
/sbin	If you back up the /usr directory, consider including the /sbin directory as some of the operating system software is installed in this directory structure.
/opt	If you have a lot of third-party software installed on your system, you may consider backing up this directory. This isn't typically the case in most Linux distributions.
/var	The primary data stored in the /var directory structure includes log files, the incoming email queue, and the print queue. The print queue should not need backing up, but log files and the email queue may be important, depending on the function of the system. Typically this filesystem is backed up on servers, but often ignored on desktop systems.
/boot	The kernel is located in this directory structure. If you install a new kernel, consider backing up this directory structure. Typically it is not backed up on a regular basis.
/lib and /lib64	If you back up the /usr directory, consider including the /lib and /lib64 directories as the operating system libraries are installed in these directory structures. As software is added to the system, new libraries are sometimes added as well.
/etc	This directory structure is often overlooked in the backup strategy, but it is also often the directory that changes most frequently. Regular system administration tasks, such as administering software configuration files and managing user/group accounts, result in changes in the /etc directory structure. On an active system, this directory should be backed up on a regular basis. Important note: The /etc directory must be a part of the / filesystem; it cannot be a separate filesystem.

Which directories/filesystems should you never back up? The following directories either are not stored on the hard drive or contain temporary information that never needs to be backed up:

- **/dev**
- **/media**
- **/mnt**
- **/net**

- **/proc**
- **/srv**
- **/sys**
- **/var/tmp**

How Often?

There is no exact rule that tells you how often to perform backups. To determine how often to perform backups, determine which directories/filesystems you are going to back up and then get an idea of how often data changes on each of them.

Based on your observations, you should be able to determine how often to perform backups. It will likely be a different schedule for different directories, and you also need to consider how often to perform full versus incremental backups.

Full or Incremental?

Not all software tools provide the flexibility to perform incremental backups. But if you are using one that does provide this feature, consider including it in your backup strategy.

If the backup tool does provide incremental backups, there are probably several different levels available. For example:

- A level 0 backup would be a full backup.
- A level 1 backup would back up all files that have changed since the last lower backup (level 0).
- A level 2 backup would back up all files that have changed since the last lower backup (level 0 or 1).

Typically these incremental backups would include the values 1–9. So level 9 backup would back up all files that have changed since the last lower backup (which could be level 0, level 1, level 2, etc.).

To better understand incremental backups, first look at Figure 18-1.

**Key
Topic**

Week 1	Sun 0	Mon 2	Tue 3	Wed 4	Thur 5	Fri 6	Sat 7
Week 2	Sun 1	Mon 2	Tue 3	Wed 4	Thur 5	Fri 6	Sat 7
Week 3	Sun 1	Mon 2	Tue 3	Wed 4	Thur 5	Fri 6	Sat 7
Week 4	Sun 1	Mon 2	Tue 3	Wed 4	Thur 5	Fri 6	Sat 7

Figure 18-1 Backup strategy #1

The strategy in Figure 18-1 demonstrates a four-week backup period. Every four weeks this cycle repeats. On the first day of the period, a full (level 0) backup is performed. The next day, Monday, a level 2 backup is performed. This backs up everything that changed since the last lower number backup (level 0), essentially one day's worth of changes.

On Tuesday, a level 3 backup is performed. This backs up everything that has changed since the last lower number backup, the level 2 performed on Monday. Each day during the week, a backup is performed that backs up the last 24 hours of changes to the directory/filesystem.

The following Sunday, a level 1 backup is performed. This backs up all changes since the last lower backup, the level 0 performed at the beginning of the cycle. Essentially, this backs up a week's worth of changes.

The advantage of this backup plan is that the backups each night take comparatively little time. Sunday's backups take longer each week, but the rest of the week is a relatively small backup.

The disadvantage of this backup plan is in the recovery. If the filesystem must be restored because the data was lost on Friday of the third week, then the following restores must be performed in order:

- The level 0 backup
- The level 1 backup performed on Sunday of week 3
- The level 2 backup performed on Monday of week 3
- The level 3 backup performed on Tuesday of week 3

- The level 4 backup performed on Wednesday of week 3
- The level 5 backup performed on Thursday of week 3

Now compare the previous backup strategy from Figure 18-1 with the backup strategy in Figure 18-2.

Week 1	Sun 0	Mon 5	Tue 5	Wed 5	Thur 5	Fri 5	Sat 5
Week 2	Sun 1	Mon 5	Tue 5	Wed 5	Thur 5	Fri 5	Sat 5
Week 3	Sun 1	Mon 5	Tue 5	Wed 5	Thur 5	Fri 5	Sat 5
Week 4	Sun 1	Mon 5	Tue 5	Wed 5	Thur 5	Fri 5	Sat 5

Figure 18-2 Backup strategy #2

With the backup strategy in Figure 18-2, you also perform a full backup on the first day of the cycle. The backups performed Monday through Saturday back up all files that have changed since Sunday. The backup performed on the following Sunday includes all files that have changed since the first backup of the cycle.

The disadvantage of this method is each backup takes more time as the week progresses. The advantage is the recovery process is easier and quicker. If the filesystem must be restored because the data was lost on Friday of the third week, then the following restores must be performed in order:

- The level 0 backup
- The level 1 backup performed on Sunday of week 3
- The level 5 backup performed on Thursday of week 3

There are many other backup strategies, including the famous Tower of Hanoi, which is based on a mathematical puzzle game. The important thing to remember is that you should research the different methods and find the one that is right for your situation.

Where Will the Backup Be Stored?

Note: Consider following the 3-2-1 rule: Store three copies of all important backup data. Use at least two types of media for the backups. Make sure at least one backup is offsite.

Key Topic

There are four primary locations where you can store backup data. Table 18-3 describes each and provides some of the advantages and disadvantages that you should consider.

Table 18-3 Backup Storage Locations

Location	Advantage	Disadvantage
Tape	Low cost	Slow
	Medium shelf life	Requires special hardware
		Requires a lot of maintenance
Disk	Fast	Not portable
	Easily available	
Remote	Normally easily available	Depends on network access
	Easy to have data secured offsite	Could be expensive
		Could be slow
Optical media	Decent speed	Low storage capacity
	Low cost	Most often “once write,” can’t be reused
	Hardware easy to obtain and affordable	

What Backup Tool Will Be Used?

The rest of this chapter explores different backup tools. The following tools are explored as they are all LPIC-2 exam objectives:

- **dd**
- **tar**
- **rsync**
- Amanda
- Bacula
- BackupPC

In addition to these backup tools, you should be aware of a few other tools used for creating and restoring files:

- **dump/restore**—Not used as often as in the past, these tools were designed to back up and restore entire filesystems. They do support both full and incremental backups, which makes them one of the few standard backup tools that have this feature.
- **cpio**—Similar to the **tar** command, the **cpio** command can be used to merge files from multiple locations into a single archive.
- **gzip/gunzip**—While the **gzip** command doesn't provide an essential feature that you want a backup tool to provide (namely, it doesn't merge files together), it does compress files. As a result, it could be used to compress a backup file.
- **bzip2/bunzip2**—While the **bgzip2** command doesn't provide an essential feature that you want a backup tool to provide (namely, it doesn't merge files together), it does compress files. As a result, it could be used to compress a backup file.
- **zip/unzip**—An advantage of this tool is not only does it merge files together and compress them, but it uses a standard compression technique used on multiple operating systems, including many non-Linux operating systems.

Note: These utilities are not part of the LPIC-2 exam objectives, but they are important ones to consider when you are deciding which backup utility to use.

Standard Backup Utilities

These utilities are considered standard as you can expect them to be on just about every distribution of Linux. The advantage of this is that not only can you use the tools to perform a backup on just about every system, but even more importantly, you can view and restore the backups on just about every system. It is frustrating and time-consuming to deal with an esoteric backup file that you lack the software for to even determine what is in the backup.

The dd Command

Key Topic

The **dd** command is useful to back up entire devices, either entire hard disks, individual partitions, or logical volumes. For example, to back up an entire hard disk to a second hard disk, execute a command like the following:

```
[root@localhost ~]# dd if=/dev/sda of=/dev/sdb
```

The **if** option is used to specify the input device. The **of** option is used to specify the output device. Make sure when you execute this command that the **/dev/sdb** hard disk is at least as large as the **/dev/sda** hard disk.

What if you don't have a spare hard disk, but you have enough room on a device (such as an external USB hard disk)? In this case, place the output into an image file:

```
[root@localhost ~]# dd if=/dev/sda of=/mnt/hda.img
```

You can also use the **dd** command to back up the contents of a CD-ROM or DVD into an ISO image:

```
[root@localhost ~]# dd if=/dev/cdrom of=cdrom.iso
```

The ISO image file can be used to create more CD-ROMs. Or it can be shared via the network to make the contents of the CD-ROM easily available (rather than passing the CD-ROM disc around the office).

It is also helpful to know that both image and ISO files can be treated as regular file-systems in the sense they can be mounted and explored:

```
[root@localhost ~]# mkdir /test
[root@localhost ~]# mount -o loop /mnt/had.img /test
```

One of the advantages of the **dd** command is that it can back up anything on the hard disk, not just files and directories. For example at the beginning of each disk is an area called the MBR (master boot record). For the boot disk the MBR contains the boot loader (GRUB) and a copy of the partition table. It can be useful to have a backup of this data:

```
[root@localhost ~]# dd if=/dev/sda of=/root/mbr.img bs=512 count=1
```

The **bs** option indicates the block size, and the **count** indicates how many blocks to back up. The values of 512 and 1 make sense because the MBR size is 512 bytes.

I would suggest storing the MBR image on an external device. If the system fails to boot because of a corrupted MBR, you can boot off a recovery CD and restore the MBR with a single command:

```
[root@localhost ~]# dd if=mbr.img of=/dev/sda
```

The tar Command



The **tape archive** command was originally designed to back up filesystems to tape devices. While many people now use the **tar** command to back up to nontape devices, you should be aware of how to use tape devices as well.

Tape device names in Linux follow the **/dev/st*** and **/dev/nst*** convention. The first tape device name is assigned the device name of **/dev/st0**, and the second tape device is accessible via the **/dev/st1** device name.

The name `/dev/nst0` also refers to the first tape device, but it sends a no rewind signal to the tape device. This is important for when you need to write multiple volumes to the tape. The default behavior of the tape drive is to automatically rewind when the backup is complete. If you wrote another backup to the same tape, you would end up overwriting the first backup unless you used the `/dev/nst0` device name when performing the first backup.

If you are working with tape devices, you should be aware of the `mt` command. This command is designed to allow you to directly manipulate the tape devices, including moving from one volume to another and deleting the contents of a tape. Some common examples:

```
[root@localhost ~]# mt -f /dev/nst0 fsf 1           #skip forward one file
(AKA, volume)
[root@localhost ~]# mt -f /dev/st0 rewind           #rewinds the tape
[root@localhost ~]# mt -f /dev/st0 status           #prints information about
tape device
[root@localhost ~]# mt -f /dev/st0 erase           #erases tape in tape
drive
```

Note: For the following examples I am going to assume that you don't have a tape drive in your system. The examples provided for the `tar` command place the tar ball in a regular file; however, if you have a tape drive, you can just replace the filename with your tape device file.

To create a backup (AKA, a tar ball) with the `tar` utility, use the `-c` (create) option in conjunction with the `-f` (filename) option:

```
[root@localhost ~]# tar -cf /tmp/xinet.tar /etc/xinet.d
tar: Removing leading '/' from member names
```

The leading `/` characters are removed from the filenames, so instead of backing up absolute pathnames, the pathnames are relative. This makes it easier to specify where the files are restored. Having the leading `/` would result in files always being stored in the exact same location.

To see the contents of a tar ball, use the `-t` (table of contents) option in conjunction with the `-f` option, as shown in Example 18-1.

Example 18-1 Contents of a tar Ball Using `tar -tf`

```
[root@localhost ~]# tar -tf /tmp/xinet.tar
etc/xinet.d/
etc/xinet.d/rsync
```



```

etc/xinetd.d/discard-stream
etc/xinetd.d/discard-dgram
etc/xinetd.d/time-dgram
etc/xinetd.d/echo-dgram
etc/xinetd.d/daytime-stream
etc/xinetd.d/chargen-stream
etc/xinetd.d/daytime-dgram
etc/xinetd.d/chargen-dgram
etc/xinetd.d/time-stream
etc/xinetd.d/telnet
etc/xinetd.d/echo-stream
etc/xinetd.d/tcpmux-server

```

You often want to see detailed information when listing the contents of the tar ball. Include the `-v` (verbose) option to see additional information, as shown in Example 18-2.

Example 18-2 The `-v` Option to See Details of the tar Ball

```

[root@localhost ~]# tar -tvf /tmp/xinet.tar
drwxr-xr-x root/root          0 2015-11-02 11:52 etc/xinetd.d/
-rw-r--r-- root/root         332 2014-03-28 03:54 etc/xinetd.d/rsync
-rw----- root/root        1159 2013-10-07 10:35 etc/xinetd.d/discard-stream
-rw----- root/root        1157 2013-10-07 10:35 etc/xinetd.d/discard-dgram
-rw----- root/root        1149 2013-10-07 10:35 etc/xinetd.d/time-dgram
-rw----- root/root        1148 2013-10-07 10:35 etc/xinetd.d/echo-dgram
-rw----- root/root        1159 2013-10-07 10:35 etc/xinetd.d/daytime-stream
-rw----- root/root        1159 2013-10-07 10:35 etc/xinetd.d/chargen-stream
-rw----- root/root        1157 2013-10-07 10:35 etc/xinetd.d/daytime-dgram
-rw----- root/root        1157 2013-10-07 10:35 etc/xinetd.d/chargen-dgram
-rw----- root/root        1150 2013-10-07 10:35 etc/xinetd.d/time-stream
-rw----- root/root          302 2015-11-02 11:52 etc/xinetd.d/telnet
-rw----- root/root        1150 2013-10-07 10:35 etc/xinetd.d/echo-stream
-rw----- root/root        1212 2013-10-07 10:35 etc/xinetd.d/tcpmux-server

```

To extract all the contents of the tar ball into the current directory, use the `-x` (extract) option in conjunction with the `-f` option, as shown in Example 18-3.

Example 18-3 Using `tar -xf` for Extracting Contents from the tar Ball

```

[root@localhost ~]# cd /tmp
[root@localhost tmp]# tar -xf xinet.tar
[root@localhost tmp]# ls

```

```

backup          pulse-iqQ3aLCZD30z  virtual-root.MLN2pc  virtual-root.zAkrYZ
etc             pulse-lZAnjZ6xlqVu  virtual-root.o6Mepr  xinet.tar
keyring-9D6mpL source             virtual-root.vtPUaj  zip-3.0-1.el6.src.rpm
orbit-gdm       virtual-root.7AHBKz  virtual-root.y6Q4gw
orbit-root      virtual-root.EaUiye  virtual-root.Ye1rtc
[root@localhost tmp]# ls etc
xinetd.d
[root@localhost tmp]# ls etc/xinetd.d
chargen-dgram  daytime-stream  echo-dgram  tcpmux-server  time-stream
chargen-stream discard-dgram   echo-stream telnet
daytime-dgram  discard-stream  rsync       time-dgram

```

Suppose your tar ball contains thousands of files and you only need a few files. You can list the filenames at the end of the **tar** command to perform this partial restore:

```

[root@localhost tmp]# tar -xf xinet.tar etc/xinetd.d/rsync
[root@localhost tmp]# ls etc/xinetd.d
rsync

```

There are many options to the **tar** command; consult Table 18-4 to learn about some of the more useful options (including those already covered, which are listed in **bold**).

Table 18-4 Useful **tar** Options

Option	Description
-A	Append to an existing tar ball.
-c	Create a tar ball.
-C	Set the current directory.
-d	Display the difference between an existing tar ball and what is currently on the filesystem.
--delete	Delete files from tar ball; not possible on tapes.
-j	Compress tar ball with the bzip2 command.
-t	List the table of contents of the tar ball.
-x	Extract the contents of the tar ball.
-z	Compress tar ball with the gzip command.
-W	Attempt to verify after writing. Note: One of the objectives on the exam is to verify the integrity of backup files, so you may be asked a question regarding this option.

The rsync Command

Key Topic

The **rsync** command provides a different set of backup features than those provided by the **tar** and **dd** commands. It is designed to back up files to a remote system. It can communicate via SSH, making the backup process secure. Additionally, it only backs up files that have changed since the last backup.

For example, the command shown in Example 18-4 performs a recursive backup of the **/etc/xinetd.d** directory to the **/backup** directory of the **server1** machine.

Example 18-4 The rsync Command

```
[root@localhost ~]# rsync -av -e ssh /etc/xinetd.d server1:/backup
root@server1's password:
sending incremental file list
xinetd.d/
xinetd.d/chargen-dgram
xinetd.d/chargen-stream
xinetd.d/daytime-dgram
xinetd.d/daytime-stream
xinetd.d/discard-dgram
xinetd.d/discard-stream
xinetd.d/echo-dgram
xinetd.d/echo-stream
xinetd.d/rsync
xinetd.d/tcpmux-server
xinetd.d/telnet
xinetd.d/time-dgram
xinetd.d/time-stream

sent 14235 bytes  received 263 bytes  1159.84 bytes/sec
total size is 13391  speedup is 0.92
```

The options used from the previous command: **-v** = verbose, **-a** = archive, **-e ssh** = execute via ssh. The first argument is what to copy, and the second argument is where to copy it.

Suppose a change takes place to one of the files in the **/etc/xinetd.d** directory:

```
[root@localhost ~]# chkconfig telnet off    #changes /etc/xinetd.d/telnet
```

Note that when the **rsync** command is executed again, only the modified file is transferred:

```
[root@localhost ~]# rsync -av -e ssh /etc/xinetd.d server1:/backup
root@server1's password:
```

```

sending incremental file list
xinetd.d/
xinetd.d/telnet

sent 631 bytes  received 41 bytes  192.00 bytes/sec
total size is 13392  speedup is 19.93

```

Third-Party Backup Utilities

Key Topic

Many third-party backup utilities are available for Linux. If you are studying for the LPIC-2 certification exam, you should realize that the exam objective states “Awareness of network backup solutions such as Amanda, Bacula, and BackupPC.” This means you should understand what these solutions provide, but don’t need to know any details.

Amanda

The Advanced Maryland Automatic Network Disk Archiver (AMANDA) is an open source software tool popular on both UNIX and Linux distributions. While there is a freely available community version, there is also an enterprise version that provides support (for a fee, of course).

Amanda provides a scheduler, making it easier for a system administrator to automate the backup process. It also supports writing to either tape device or hard disk.

Bacula

Bacula is an open source product that supports clients from different platforms, including Linux, Microsoft Windows, OS X, and UNIX. One of the compelling features of Bacula is the capability to automate backup, freeing the system administrator from this routine task.

Configuration of Bacula on the server side can be accomplished via a web interface, GUI-based tools, or command line tools.

One disadvantage of Bacula is that the format of the backup data is not compatible with other backup formats, such as the **tar** command’s format. This makes it difficult to deal with the backup data unless you have the Bacula tools installed on the system.

BackupPC

The BackupPC software provides a disk-to-disk solution that includes a web-based front end. Because it runs through a web interface, no client software needs to be installed. The server software provides the web interface to perform the backup.

Another advantage of BackupPC is that the server runs on many different Linux distributions as well as on several UNIX systems. The software also supports several standard protocols to transfer the data, including NFS, SSH, rsync, and SMB (Server Message Blocks, a Microsoft Windows protocol). This provides you with flexibility in backing up data from different client systems.

Exam Preparation Tasks

Review All Key Topics

Review the most important topics in this chapter, noted with the Key Topics icon in the outer margin of the page. Table 18-5 lists a reference of these key topics and the page numbers on which each is found.



Table 18-5 Key Topics for Chapter 18

Key Topic Element	Description	Page Number
Paragraph	What should be backed up	361
Figure 18-1	Incremental backups	365
Paragraph	Storage solutions	367
Paragraph	The dd command	368
Paragraph	The tar command	369
Paragraph	The rsync command	373
Paragraph	Third-party backup utilities	374

Define Key Terms

Define the following key terms from this chapter and check your answers in the glossary:

Tower of Hanoi, tape device, tar ball, Amanda, Bacula, BackupPC

Review Questions

The answers to these review questions are in Appendix A.

1. For tools that use numbers to specify full and incremental backups, what number specifies a full backup?
2. Which of the following directories do not need to be backed up? (Choose two.)
 - a. `/etc`
 - b. `/var`
 - c. `/dev`
 - d. `/sys`
3. Which of the following directories do not need to be backed up? (Choose two.)
 - a. `/usr`
 - b. `/tmp`
 - c. `/proc`
 - d. `/boot`
4. The ____ command is used to remotely back up data; by default it only backs up data that has changed since the last time the command was used.
5. Which of the following backup storage locations is likely to be the fastest?
 - a. CD-ROM
 - b. Tape
 - c. Hard disk
 - d. Remote network location
6. Which option to the **dd** command specifies the device that you are backing up?
 - a. `count=`
 - b. `bs=`
 - c. `of=`
 - d. `if=`
7. Fill in the following to mount the `test.iso` file under the `/mnt` directory:
`mount -o _____ test.iso /mnt.`
8. The “no rewind” device name for the first tape device on the system is `/dev/_____`.

9. Which option to the **tar** command is used to extract data from a tar ball?
 - a. **-a**
 - b. **-x**
 - c. **-e**
 - d. **-X**

10. The ___ option to the rsync command is used to enable data transfer via SSH.

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