Red Hat® RHCSA™/RHCE® 7
Cert Guide:
Red Hat Enterprise Linux 7
(EX200 and EX300)

Sander van Vugt
About the Author

Sander van Vugt is an independent Linux trainer, author, and consultant living in the Netherlands. Sander is the author of the best-selling Red Hat Certified System Administrator (RHCSA) Complete Video Course and also of the Red Hat Certified Engineer (RHCE) Complete Video Course. He has also written numerous books about different Linux-related topics, and many articles for Linux publications around the world. Sander has been teaching Red Hat, SUSE, and LPI Linux classes since 1994. As a consultant, he specializes in Linux high-availability solutions and performance optimization. You can find more information about Sander on his website at http://www.sandervanvugt.com.

For more information about RHAT certification and additional resources, visit the author’s Red Hat Certification page at http://www.rhatcert.com/.
About the Technical Reviewers

**Frederik Vos** is a senior technical trainer in Linux training and also in several virtualization solutions, such as VMware vSphere, XenServer, and KVM. For the past 8 years Frederik has working for XTG in Gouda, a training center specializing in virtualization solutions and Linux, as a teacher and Linux evangelist, responsible for the Linux portfolio at XTG.

He has specialized in data center infrastructures (several Linux distributions), hypervisors, networking, and storage solutions and cloud computing (Cloudstack, Cloudplatform, and OpenStack). He has a lot of knowledge as a teacher and also real-world experience as a system engineer and as a long-time (1997) Linux user.

**Ross Brunson** 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 LPIC-1 Certification Guide. Ross recently spent almost 5 years as the director of member services for the Linux Professional Institute, building the member program, conducting dozens of Train-the-Teacher sessions, and providing support for the worldwide Master Affiliate network spanning 100+ countries.

Ross holds a number of key IT certifications and is also author of several successful technical books, dozens of technical courses for major organizations (including the first LPI Certification Bootcamp). He is also skilled at both contributing to and building community around IT products.

He lives in Paradise Valley, Montana, with his family and enjoys traveling far and wide, winter sports, and photography.

**William “Bo” Rothwell**, at the impressionable age of 14, 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 TSR-80. He immediately dismantled it and held his first computer class, showing his friends what made this “computer thing” work.

Since this 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. Bo owns several IT certifications, including earning his original RHCE in 2003. He is a former RHCI (Red Hat Certified Instructor) and the founder and president of One Course Source, an IT training organization.
Dedication

This book is dedicated to my family: Florence, Franck, and Alex. Together we’ve made great accomplishments over the past year.

Acknowledgments

This book could not have been written without the help of all the people who contributed to it. To start, I want to thank the people at Pearson, Denise Lincoln and Ellie Bru in particular. We’ve worked a lot together over the past year, and this book is another milestone on our road to success!

Next I want to thank my technical proofreaders. What has made this book special is that the first round of technical proofreading was completely done by volunteers. We started with 10 volunteers, but just 1 made it all the way to the end. Many thanks to Giles, the man behind the great and very useful website certdepot.net, the only one who reviewed all the chapters.

I also want to thank Jaques Weewer, Rob Mokkink, and all the other volunteer technical reviewers. You made many suggestions without which the book would not have the high quality that it has right now.
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 email 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 email address. We will carefully review your comments and share them with the author and editors who worked on the book.

Email: feedback@pearsonitcertification.com

Mail: Pearson IT Certification
ATTN: Reader Feedback
800 East 96th Street
Indianapolis, IN 46240 USA

Reader Services

Visit our website and register this book at www.pearsonitcertification.com/register for convenient access to any updates, downloads, or errata that might be available for this book.
## Contents at a Glance

**Introduction**  xxxix

### Part 1: RHCSA  3

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installing Red Hat Enterprise Linux Server</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Using Essential Tools</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>Essential File Management Tools</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>Working with Text Files</td>
<td>85</td>
</tr>
<tr>
<td>5</td>
<td>Connecting to Red Hat Enterprise Linux 7</td>
<td>103</td>
</tr>
<tr>
<td>6</td>
<td>User and Group Management</td>
<td>123</td>
</tr>
<tr>
<td>7</td>
<td>Configuring Permissions</td>
<td>151</td>
</tr>
<tr>
<td>8</td>
<td>Configuring Networking</td>
<td>177</td>
</tr>
<tr>
<td>9</td>
<td>Managing Processes</td>
<td>205</td>
</tr>
<tr>
<td>10</td>
<td>Working with Virtual Machines</td>
<td>225</td>
</tr>
<tr>
<td>11</td>
<td>Managing Software</td>
<td>249</td>
</tr>
<tr>
<td>12</td>
<td>Scheduling Tasks</td>
<td>281</td>
</tr>
<tr>
<td>13</td>
<td>Configuring Logging</td>
<td>295</td>
</tr>
<tr>
<td>14</td>
<td>Managing Partitions</td>
<td>319</td>
</tr>
<tr>
<td>15</td>
<td>Managing LVM Logical Volumes</td>
<td>349</td>
</tr>
<tr>
<td>16</td>
<td>Basic Kernel Management</td>
<td>369</td>
</tr>
<tr>
<td>17</td>
<td>Configuring a Basic Apache Server</td>
<td>389</td>
</tr>
<tr>
<td>18</td>
<td>Managing and Understanding the Boot Procedure</td>
<td>405</td>
</tr>
<tr>
<td>19</td>
<td>Troubleshooting the Boot Procedure</td>
<td>429</td>
</tr>
<tr>
<td>20</td>
<td>Using Kickstart</td>
<td>451</td>
</tr>
<tr>
<td>21</td>
<td>Managing SE Linux</td>
<td>473</td>
</tr>
<tr>
<td>22</td>
<td>Configuring a Firewall</td>
<td>499</td>
</tr>
<tr>
<td>23</td>
<td>Configuring Remote Mounts and FTP</td>
<td>515</td>
</tr>
<tr>
<td>24</td>
<td>Configuring Time Services</td>
<td>539</td>
</tr>
</tbody>
</table>
Contents

Introduction xxxix

Part 1: RHCSA 3

Chapter 1 Installing Red Hat Enterprise Linux Server 7

“Do I Know This Already?” Quiz 7

Foundation Topics 11

Preparing to Install Red Hat Enterprise Linux 11

What Is Red Hat Enterprise Linux 7 Server? 11

Getting the Software 12

Using CentOS 12

Other Distributions 13

Understanding Access to Repositories 13

Understanding Red Hat Enterprise Linux 7 Server Variants and Add-Ons 14

Setup Requirements 15

Course Environment Description 16

Performing a Manual Installation 17

Summary 29

Exam Preparation Tasks 29

Review All Key Topics 29

Define Key Terms 30

Review Questions 30

End-of-Chapter Labs 30

Lab 1.1 31

Chapter 2 Using Essential Tools 33

“Do I Know This Already?” Quiz 33

Foundation Topics 36

Basic Shell Skills 36

Executing Commands 36

I/O Redirection 37

Using Pipes 39

History 40

Bash Completion 42
Contents

Using Links 73
  Understanding Hard Links 73
  Understanding Symbolic Links 74
  Creating Links 74
  Removing Links 75

Working with Archives and Compressed Files 76
  Managing Archives with tar 77
  Using Compression 78

Summary 80

Exam Preparation Tasks 80
  Review All Key Topics 80
  Complete Tables and Lists from Memory 81
  Define Key Terms 81

Review Questions 81

End-of-Chapter Labs 82
  Lab 3.1 82

Chapter 4 Working with Text Files 85

“Do I Know This Already?” Quiz 85

Foundation Topics 88
  Using Common Text File-Related Tools 88
      Doing More with Less 88
      Showing File Contents with cat 89
      Displaying the First or Last Lines of a File with head and tail 90
      Filtering Specific Columns with cut 91
      Sorting File Contents and Output with sort 91
      Counting Lines, Words, and Characters with wc 93

A Primer to Using Regular Expressions 93
  Using Line Anchors 94
  Using Escaping in Regular Expressions 95
  Using Wildcards and Multipliers 95

Using grep to Analyze Text 96

Working with Other Useful Text Processing Utilities 97

Summary 99

Exam Preparation Tasks 99
Chapter 5  Connecting to Red Hat Enterprise Linux 7  103

“Do I Know This Already?” Quiz  103

Foundation Topics  106

Working on Local Consoles  106

Logging In to a Local Console  106

Switching Between Terminals in a Graphical Environment  107

Working with Multiple Terminals in a Nongraphical Environment  108

Understanding Pseudo Terminal Devices  109

Booting, Rebooting, and Shutting Down Systems  110

Using SSH and Related Utilities  112

Accessing Remote Systems Using SSH  112

Using Graphical Applications in an SSH Environment  114

Securely Transferring Files Between Systems  115

Configuring Key-Based Authentication for SSH  116

Using Passphrases or Not?  117

Using the screen Command  118

Summary  119

Exam Preparation Tasks  120

Review All Key Topics  120

Define Key Terms  120

Review Questions  120

End-of-Chapter Labs  121

Lab 5.1  121

Chapter 6  User and Group Management  123

“Do I Know This Already?” Quiz  123

Foundation Topics  126
Contents xiii

Different User Types 126
  Users on Linux 126
  Working as Root 126
  Using su 127
  sudo 128
  PolicyKit 128

Managing User Accounts 129
  System and Normal Accounts 129
  Creating Users 132
  Managing User Properties 134
  Configuration Files for User Management Defaults 134
  Managing Password Properties 135
  Creating a User Environment 136

Creating and Managing Group Accounts 137
  Understanding Linux Groups 137
  Creating Groups 138
  Managing Group Properties 139

Logging In Through an External Authentication Service 140
  Understanding LDAP 140
  Making the Authentication Platform Available 142
  Configuring RHEL 7 for LDAP Authentication 142
  Managing nslcd 143
  Managing sssd 144

Summary 146

Exam Preparation Tasks 146
  Review All Key Topics 146
  Complete Tables and Lists from Memory 147
  Define Key Terms 147

Review Questions 147

End-of-Chapter Labs 148
  Lab 6.1 148
  Lab 6.2 148
Chapter 7  Configuring Permissions  151

“Do I Know This Already?” Quiz  151

Foundation Topics  155

Managing File Ownership  155
  Displaying Ownership  155
  Changing User Ownership  156
  Changing Group Ownership  156
  Understanding Default Ownership  157

Managing Basic Permissions  158
  Understanding Read, Write, and Execute Permissions  158
  Applying Read, Write, and Execute Permissions  159

Managing Advanced Permissions  161
  Understanding Advanced Permissions  161
  Applying Advanced Permissions  164

Managing ACLs  165
  Understanding ACLs  166
  Preparing Your File System for ACLs  166
  Changing and Viewing ACL Settings with setfacl and getfacl  166
  Working with Default ACLs  168

Setting Default Permissions with umask  169

Working with User Extended Attributes  170

Summary  172

Exam Preparation Tasks  172
  Review All Key Topics  172
  Define Key Terms  173

Review Questions  173

End-of-Chapter Labs  173
  Lab 7.1  173

Chapter 8  Configuring Networking  177

“Do I Know This Already?” Quiz  177

Foundation Topics  180

Networking Fundamentals  180
  IP Addresses  180
  IPv6 Addresses  181
Network Masks 181
Binary Notation 182
MAC Addresses 183
Protocol and Ports 183
Managing Network Addresses and Interfaces 183
Validating Network Configuration 184
  Validating Network Address Configuration 185
  Validating Routing 187
  Validating the Availability of Ports and Services 187
Configuring Network Configuration with nmtui and nmcli 189
  Configuring the Network with nmcli 189
  Configuring the Network with nmtui 193
Working on Network Configuration Files 194
Setting Up Hostname and Name Resolution 196
  Hostnames 196
  DNS Resolving 198
Summary 200
Exam Prep Tasks 200
  Review All Key Topics 200
  Complete Tables and Lists from Memory 201
  Define Key Terms 201
Review Questions 201
End-of-Chapter Labs 201
  Lab 8.1 202

Chapter 9 Managing Processes 205
“Do I Know This Already?” Quiz 205
Foundation Topics 208
Introduction to Process Management 208
Managing Shell Jobs 208
  Running Jobs in the Foreground and Background 208
  Managing Shell Jobs 209
  Managing Parent Child Relations 211
  Understanding Processes and Threads  211
  Using ps to Get Process Information  212
  Adjusting Process Priority with nice  214
  Sending Signals to Processes with kill, killall, and pkill  216
  Using top to Manage Processes  218

Summary  220

Exam Preparation Tasks  220
  Review All Key Topics  220
  Complete Tables and Lists from Memory  221
  Define Key Terms  221

Review Questions  221

End-of-Chapter Labs  222
  Lab 9.1  222

**Chapter 10 Working with Virtual Machines**  225

“Do I Know This Already?” Quiz  225

Foundation Topics  228
  Understanding RHEL 7 Virtualization  228
    Understanding KVM Virtualization  228
    Understanding QEMU  228
    Red Hat Beyond KVM  229
    Understanding the Role of Libvirtd  229
  Making Your Server a KVM Host  231
    Checking Host Requirements  231
    Installing the KVM Software  232
    Understanding KVM Host Networking  233

Managing Virtual Machines  234
  Installing Virtual Machines  234
  Using KVM Virtual Machines  240
  Accessing Virtual Machines from a Text-Only Console  241
  Managing Virtual Machine Properties  242
  Managing Virtual Machines from the Command Line  243
  Monitoring Virtual Machine Activity from Top  244
Chapter 11 Managing Software 249

“Do I Know This Already?” Quiz 249

Foundation Topics 252

Managing Software Packages with yum 252
  Understanding the Role of Repositories 252
  Specifying Which Repository to Use 253
  Understanding Repository Security 256
  Creating Your Own Repository 259
  Using yum 260
  Using yum to Find Software Packages 261
  Getting More Information About Packages 262
  Installing and Removing Software Packages 263
  Showing Lists of Packages 265
  Updating Packages 267
  Working with yum Package Groups 268
  Using yum History 270

Managing Software Packages with rpm 271
  Understanding RPM Filenames 272
  Querying the RPM Database 273
  Querying RPM Package Files 273
  Using repoquery 275

Summary 276

Exam Preparation Tasks 276
  Review All Key Topics 276
  Complete Tables and Lists from Memory 277
  Define Key Terms 277
Chapter 12  Scheduling Tasks  281

“Do I Know This Already?” Quiz  281
Configuring cron to Automate Recurring Tasks  284
  Managing the cron Service  284
  Understanding cron Timing  285
  Managing cron Configuration Files  286
  Understanding the Purpose of anacron  288
  Managing cron Security  289
Configuring at to Schedule Future Tasks  290
Summary  291
Exam Preparation Tasks  291
  Review All Key Topics  291
  Define Key Terms  292
Review Questions  292
End-of-Chapter Labs  293
  Lab 12.1  293

Chapter 13  Configuring Logging  295

“Do I Know This Already?” Quiz  295
Foundation Topics  298
Understanding System Logging  298
  Understanding the Role of rsyslogd and journald  298
Reading Log Files  300
Understanding Log File Contents  300
Live Log File Monitoring  302
Using logger  302
Configuring rsyslogd  303
  Understanding rsyslogd Configuration Files  303
  Understanding rsyslog.conf Sections  304
  Understanding Facilities, Priorities, and Log Destinations  304
Rotating Log Files  308
Chapter 14 Managing Partitions 319

"Do I Know This Already?" Quiz 319
Understanding MBR and GPT Partitions 322
  Understanding the MBR Partitioning Scheme 322
  Understanding the Need for GPT Partitioning 323
  Understanding Storage Measurement Units 324
Managing Partitions and File Systems 324
  Creating MBR Partitions with fdisk 325
  Using Extended and Logical Partitions on MBR 329
  Creating GPT Partitions with gdisk 330
  Creating File Systems 334
  Changing File System Properties 336
  Adding Swap Partitions 338
  Adding Swap Files 339
Mounting File Systems 339
  Manually Mounting File Systems 340
  Using Device Names, UUIDs, or Disk Labels 340
  Automating File System Mounts Through /etc/fstab 341
Summary 344
Exam Preparation Tasks 344
  Review All Key Topics 344
  Complete Tables and Lists from Memory 345
  Define Key Terms 345
Chapter 17 Configuring a Basic Apache Server 389

“Do I Know This Already?” Quiz 389

Foundation Topics 392

Configuring a Basic Apache Server 392

Installing the Required Software 392

Identifying the Main Configuration File 392

Creating Web Server Content 395

Understanding Apache Configuration Files 397

Creating Apache Virtual Hosts 398

Summary 400

Exam Preparation Tasks 401

Review All Key Topics 401

Define Key Terms 401

Review Questions 401

End-of-Chapter Labs 402

Lab 17.1 402

Chapter 18 Managing and Understanding the Boot Procedure 405

“Do I Know This Already?” Quiz 405

Foundation Topics 408

Working with Systemd 408

Understanding Systemd 408

Managing Units Through Systemd 413
Chapter 19 Troubleshooting the Boot Procedure 429

“Do I Know This Already?” Quiz 429

Foundation Topics 432

Understanding the RHEL 7 Boot Procedure 432

Passing Kernel Boot Arguments 434

Accessing the Boot Prompt 434

Starting a Troubleshooting Target 435

Using a Rescue Disk 436

Restoring System Access Using a Rescue Disk 436

Reinstalling GRUB Using a Rescue Disk 439

Re-Creating the Initramfs Using a Rescue Disk 439

Fixing Common Issues 441

Reinstalling GRUB 2 441

Fixing the Initramfs 442

Recovering from File System Issues 442

Resetting the Root Password 443

Recovering Access to a Virtual Machine 444

Summary 446

Exam Prep Tasks 446

Review All Key Topics 446

Complete Tables and Lists from Memory 446

Define Key Terms 447
Chapter 20  Using Kickstart  451

“Do I Know This Already?” Quiz  451

Foundation Topics  454

Setting Up an Installation Server  454
  Configuring a Network Server as Installation Server  454

Setting Up a TFTP and DHCP Server for PXE Boot  455
  Installing the TFTP Server  456
  Configuring DHCP for PXE Boot  457
  Creating the TFTP PXE Server Content  458

Creating a Kickstart File  462
  Using a Kickstart File to Perform an Automated Installation  462
  Modifying the Kickstart File with system-config-kickstart  464
  Making Manual Modifications to the Kickstart File  467

Summary  469

Exam Preparation Tasks  470
  Review All Key Topics  470
  Define Key Terms  470

Review Questions  470

End-of-Chapter Labs  471
  Lab 20.1  471

Chapter 21  Managing SELinux  473

“Do I Know This Already?” Quiz  474

Foundation Topics  477

Understanding SELinux Working and Modes  477

Understanding Context Settings and the Policy  481
  Monitoring Current Context Labels  481
  Setting Context Types  483
  Finding the Context Type You Need  486

Restoring Default File Contexts  487

Using Boolean Settings to Modify SELinux Settings  489
Diagnosing and Addressing SELinux Policy Violations  491
  Making SELinux Analyzing Easier  492
Summary  494
Exam Prep Tasks  494
  Review All Key Topics  494
  Complete Tables and Lists from Memory  495
  Define Key Terms  495
Review Questions  495
End-of-Chapter Labs  496
  Lab 21.1  496

Chapter 22  Configuring a Firewall  499
  “Do I Know This Already?” Quiz  499
Foundation Topics  502
  Understanding Linux Firewalls  502
    Understanding Previous Solutions  502
    Understanding Firewall  502
    Understanding Firewalld Zones  503
    Understanding Firewalld Services  504
  Working with Firewalld  505
    Working with firewall-cmd  506
    Working with Firewall-config  508
Summary  511
Exam Prep Tasks  511
Key Topics  511
  Define Key Terms  512
  Complete Tables and Lists from Memory  512
Review Questions  512
End-of-Chapter Labs  513

Chapter 23  Configuring Remote Mounts and FTP  515
  “Do I Know This Already?” Quiz  515
Foundation Topics  519
  Mounting NFS Shares  519
    Understanding NFS Security Options  519
    Understanding Kerberos Requirements  520
Chapter 25  Configuring External Authentication and Authorization  557

“Do I Know This Already?” Quiz  557

Foundation Topics  560

Understanding Remote Authentication  560

Understanding Kerberos Basics  561

Understanding Kerberos Authentication  561

Understanding Kerberos Principals  563

Configuring LDAP Authentication with Kerberos Authorization  564

Using nslcd or sssd as the Authentication Backend Service  568

Setting Up External Authentication  569

Using an IPA Server or Active Directory  572

Summary  572

Exam Preparation Tasks  573

Review All Key Topics  573

Complete Tables and Lists from Memory  573

Define Key Terms  573

Review Questions  573

End-of-Chapter Labs  574

Lab 25.1  574

Chapter 26  Configuring an iSCSI SAN  577

“Do I Know This Already” Quiz  578

Foundation Topics  581

Understanding iSCSI  581
Using iostat, vmstat, and pidstat 616
Using iostat 617
Using vmstat 618
Using pidstat 620
Configuring sar 621
Summary 622
Exam Preparation Tasks 622
Review All Key Topics 622
Complete Tables and Lists from Memory 623
Define Key Terms 623
Review Questions 623
End-of-Chapter Labs 624

Chapter 28 System Optimization Basics 627
“Do I Know This Already?” Quiz 627
Foundation Topics 630
Understanding System Optimization Basics 630
Understanding the /proc File System 631
Using /proc to Analyze Performance 631
Using /proc/sys to Tune Linux Performance 633
Using sysctl to Automate System Optimization Parameters 635
Summary 637
Exam Preparation Tasks 638
Review All Key Topics 638
Complete Tables and Lists from Memory 638
Define Key Terms 638
Review Questions 639
End-of-Chapter Labs 639
Lab 28.1 639

Chapter 29 Configuring Advanced Log Features 641
“Do I Know This Already?” Quiz 641
Foundation Topics 644
Understanding rsyslogd Modules 644
Understanding the Need for Modules 644
Using Modules in rsyslog Configuration 645
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 31 An Introduction to Bash Shell Scripting</td>
<td>683</td>
</tr>
<tr>
<td>“Do I Know This Already?” Quiz</td>
<td>683</td>
</tr>
<tr>
<td>Foundation Topics</td>
<td>686</td>
</tr>
<tr>
<td>Understanding Shell Scripting Core Elements</td>
<td>686</td>
</tr>
<tr>
<td>Using Variables and Input</td>
<td>687</td>
</tr>
<tr>
<td>Using Positional Parameters</td>
<td>688</td>
</tr>
<tr>
<td>Working with Variables</td>
<td>689</td>
</tr>
<tr>
<td>Using Conditional Loops</td>
<td>691</td>
</tr>
<tr>
<td>Working with if then else</td>
<td>692</td>
</tr>
<tr>
<td>Using</td>
<td></td>
</tr>
<tr>
<td>Applying for</td>
<td>693</td>
</tr>
<tr>
<td>Understanding while and until</td>
<td>695</td>
</tr>
<tr>
<td>Understanding case</td>
<td>696</td>
</tr>
<tr>
<td>Bash Shell Script Debugging</td>
<td>697</td>
</tr>
<tr>
<td>Summary</td>
<td>698</td>
</tr>
<tr>
<td>Exam Preparation Tasks</td>
<td>698</td>
</tr>
<tr>
<td>Review All Key Topics</td>
<td>698</td>
</tr>
<tr>
<td>Define Key Terms</td>
<td>699</td>
</tr>
<tr>
<td>Review Questions</td>
<td>699</td>
</tr>
<tr>
<td>End-of-Chapter Labs</td>
<td>699</td>
</tr>
<tr>
<td>Lab 31.1</td>
<td>699</td>
</tr>
<tr>
<td>Chapter 32 Advanced Firewall Configuration</td>
<td>701</td>
</tr>
<tr>
<td>“Do I Know This Already?” Quiz</td>
<td>701</td>
</tr>
<tr>
<td>Foundation Topics</td>
<td>705</td>
</tr>
<tr>
<td>Excluding Iptables Services</td>
<td>705</td>
</tr>
<tr>
<td>Creating Firewalld Services</td>
<td>706</td>
</tr>
<tr>
<td>Configuring Firewalld Rich Rules</td>
<td>708</td>
</tr>
<tr>
<td>Rich Rule Syntax</td>
<td>708</td>
</tr>
<tr>
<td>Ordering</td>
<td>709</td>
</tr>
<tr>
<td>Managing Rich Rules</td>
<td>709</td>
</tr>
<tr>
<td>Logging with Rich Rules</td>
<td>711</td>
</tr>
</tbody>
</table>
Chapter 33 Managing Advanced Apache Services 719

“Do I Know This Already?” Quiz 719

Foundation Topics 723

Revising Apache Basics 723

Essential Apache Parameters 723

Revising Apache SE Linux-Related Settings 725

Configuring Write Access to the DocumentRoot 726

Configuring TLS Security 727

Understanding TLS Security 728

Configuring Apache for Using TLS Certificates 729

Deploying CGI Applications 731

Using Common Gateway Interface 731

Serving Dynamic PHP Content 732

Using Dynamic Python Content 733

Connecting to Databases 733

Configuring Private Directories 735

Summary 736

Exam Preparation Tasks 737

Review All Key Topics 737

Complete Tables and Lists from Memory 737

Define Key Terms 737
Chapter 36 Configuring NFS 781

“Do I Know This Already?” Quiz 781
Foundation Topics 785
Setting Up the Basic NFSv4 Server 785
Configuring the NFSv4 Server 785
Accessing NFS Shares 787
Testing Client Access with showmount 787
Making NFS Mounts Persistent 788
Configuring the Firewall for NFSv4 788
Configuring SELinux for NFSv4 788
Configuring NFS Kerberos Authentication 791
Understanding NFSv4 SELinux Transparency 795
Summary 796
Exam Prep Tasks 796
Review All Key Topics 796
Define Key Terms 797
Review Questions 797
End-of-Chapter Labs 798
Lab 36.1 798

Chapter 37 Configuring Samba File Services 801

“Do I Know This Already?” Quiz 801
Foundation Topics 804
Setting Up SMB File Sharing 804
Installing Samba 804
Preparing Shared Directories on Linux 804
Chapter 39  Configuring SSH  845

“Do I Know This Already?” Quiz  845
Foundation Topics  848
Hardening the SSH Server  848
  Limiting Root Access  848
  Configuring Alternative Ports  849
  Modifying SELinux to Allow for Port Changes  849
  Limiting User Access  850
Using Other Useful sshd Options  851
  Session Options  852
  Connection Keepalive Options  852
Configuring Key-Based Authentication with Passphrases  853
Configuring SSH Tunnels  854
Summary  856
Exam Preparation Tasks  856
  Review All Key Topics  856
  Complete Tables and Lists from Memory  856
  Define Key Terms  856
Review Questions  857
End-of-Chapter Labs  857
  Lab 39.1  857

Chapter 40  Managing Time Synchronization  859

“Do I Know This Already?” Quiz  859
Foundation Topics  862
Understanding the Need for Synchronized Time  862
DVD and Companion Website Elements

Appendix A: Answers to the “Do I Know This Already” Quizzes and “Review Questions”
Appendix B: Memory Tables
Appendix C: Memory Tables Answer Key
Appendix D: Setting Up Identity Management
Appendix E: Study Planner
Glossary
Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the IOS Command Reference. The Command Reference describes these conventions as follows:

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a `show` command).
Introduction

Welcome to the Red Hat RHCSA/RHCE 7 Cert Guide. The Red Hat exams are some of the toughest in the business, and this guide will be an essential tool in helping you prepare to take both the Red Hat Certified System Administrator (RHCSA) and the Red Hat Systems Engineer (RHCE) exams.

As a Red Hat instructor with more than 20 years of experience, I have taken both the RHCSA and RHCE exams numerous times so that I can keep current on the progression of the exam, what is new, and what is different. I share my knowledge with you in this comprehensive Cert Guide so that you get the guidance you need to pass both exams.

The RHCSA and RHCE exams were recently updated for Red Hat Enterprise Linux 7. This book contains all you need to know to pass these exams. As you will see, this Cert Guide covers every objective in both exams: 42 chapters, more than 100 exercises, 4 practice exams (2 RHCSA and 2 RHCE), interactive quizzes and exercises, 4 advanced command-line interface (CLI) simulations, 3 virtual machines, and hours of video training. This Red Hat RHCSA/RHCE 7 Cert Guide is the best resource you can get to prepare for and pass the exams.

Goals and Methods

To learn the topics described in this book, it is recommended that you create your own testing environment. You cannot become an RHCSA or RHCE without practicing a lot. Within the exercises included in every chapter of the book, you will find all the examples you need to understand what is on the exam and thoroughly learn the material needed to pass it. The exercises in the chapters provide step-by-step procedure descriptions that you can work through to find working solutions so that you can get real experience before taking the tests.

Each chapter also includes an end-of-chapter lab. These labs ask questions that are very similar to the questions that you might encounter on the exam. There are no solutions for these labs provided, and that is on purpose, because you need to train yourself to verify your work before you take the exams. On the exam, you also have to be able to verify for yourself whether the solution is working as expected.

Before you begin, you can test your knowledge by taking the theoretical pre-assessment exams in Chapter 42. These exams help you determine what you know and what you do not know so that you can better prepare your study plan. When you feel ready to take the exams, take a look at the practice exams that come with this book, two RHCSA and two RHCE. These will help you test your skills and get comfortable with the exam content and how questions might be presented in the testing facility.
This book contains everything you need to pass the exams, but if you want more guidance and practice, I have a number of video training titles available to help you study, including the following:

- Red Hat Certified System Administrator (RHCSA) Complete Video Course
- Red Hat Certified Engineer (RHCE) Complete Video Course
- Red Hat Certified System Administrator (RHCSA) Exam Prep Video Workshop
- Red Hat Certified Engineer (RHCE) Exam Prep Video Workshop

Apart from these products, you might also appreciate my website rhatcert.com. Through this website, I provide updates on anything that is useful to exam candidates. I recommend that you register on the website so that I can send you messages about important updates that I’ve made available. Also, you’ll find occasional video updates on my YouTube channel rhatcertification.com. I hope that all these resources provide you with everything you need to pass the Red Hat exams in an affordable way! Good luck!

Who Should Read This Book?

This book is written as an RHCSA/RHCE exam preparation guide. That means that you should read it if you want to increase your chances of passing either the RHCSA or RHCE exam. A secondary use of this book is as a reference guide for Red Hat system administrators. As an administrator, you’ll like the explanations and procedures that describe how to get things done on Red Hat Enterprise Linux.

So, why should you consider passing the RHCSA/RHCE exams? That question is simple to answer. Linux has become a very important operating system, and qualified professionals are sought after all over the world. If you want to work as a Linux professional, and prove your skills, the RHCSA or RHCE certificate really helps. Having these certificates dramatically increases your chances of becoming hired as a Linux professional.

How This Book Is Organized

This book is organized as a reference guide to help you prepare for the exams. If you’re new to the topics, you can just read it cover to cover. It is a smart idea, though, to distinguish between the RHCSA part and the RHCE part of this book. Finish RHCSA before starting with RHCE, because it will be too much to learn all of it at once.
You can also read the individual chapters that you need to fine-tune your skills in this book. Every chapter starts with a “Do I Know This Already?” quiz. This quiz asks questions about 10 topics that are covered in each chapter and provides a simple tool to check whether you’re already familiar with the topics covered in a chapter. Remember, though, the RHCSA and RHCE practice exams; these are an essential part of readying yourself for the real testing experience. You may be able to provide the right answer to the multiple-choice chapter questions, but that doesn’t mean that you can create the configurations when you take the tests. The companion files, included on the DVD and through the book’s companion web page, also includes more than 40 interactive exercises to help you learn and retain the knowledge needed to pass the exam and 4 simulations that take you through complex CLI exercises so that you can feel sure you’re ready not only for the exams but also to actually use Red Hat Linux.

The core chapters are organized in two parts. The first part, which includes Chapters 1 through 24, covers RHCSA topics; the second part, which consists of Chapters 25 through 40, covers RHCE objectives. All the objectives in both exams are covered in these chapters.

The following topics are covered in the chapters:

Part 1: RHCSA

Part 1-1: Performing Basic System Management Tasks

- Chapter 1: Installing Red Hat Enterprise Linux Server
  
  In this chapter, you learn how to install Red Hat Enterprise Linux Server (RHEL). It also shows how to set up an environment that can be used for working on the labs and exercises in this book.

- Chapter 2: Using Essential Tools
  
  This chapter covers some of the Linux basics, including working with the shell and Linux commands. This chapter is particularly important if you're new to working with Linux.

- Chapter 3: Essential File Management Tools
  
  In this chapter, you learn how to work with tools to manage the Linux file system. This is an important skill because everything on Linux is very file system oriented.

- Chapter 4: Working with Text Files
  
  In this chapter, you learn how to work with text files. The chapter teaches how to create text files, but also how to look for specific contents in the different text files.
Chapter 5: Connecting to a Red Hat Enterprise Linux 7
This chapter teaches about the different methods that can be used to connect to RHEL 7. It explains local login as well as remote login, and the different terminal types used for this purpose as well.

Chapter 6: User and Group Management
On Linux, users are used as an entity that can be used by people or processes that need access to specific resources. This chapter explains how to create users and make user management easier by working with groups.

Chapter 7: Configuring Permissions
In this chapter, you learn how to manage Linux permissions through the basic read, write, and execute permissions, but also through the special permissions and access control lists.

Chapter 8: Configuring Networking
A server is useless if it isn’t connected to a network. In this chapter, you learn the essential skills required for managing network connections.

Part 1-2: Operating Running Systems

Chapter 9: Managing Processes
As an administrator, you need to know how to work with the different tasks that can be running on Linux. This chapter shows how to do this, by sending signals to processes and by changing process priority.

Chapter 10: Working with Virtual Machines
Red Hat Enterprise Linux includes KVM, a complete solution that allows you to run virtual machines on top of RHEL. This chapter explains how to manage virtual machines.

Chapter 11: Managing Software
Red Hat offers an advanced system for managing software packages. This chapter teaches you how it works.

Chapter 12: Scheduling Tasks
In this chapter, you learn how to schedule a task for execution on a moment that fits you best.
Chapter 13: Configuring Logging

As an administrator, you need to know what’s happening on your server. The rsyslogd and journald services are used for this purpose. This chapter explains how to work with them.

Chapter 14: Managing partitions

Storage management is an important skill of a Linux administrator. This chapter explains how hard disks can be organized in partitions, and how these partitions can be mounted in the file system.

Chapter 15: Managing LVM Logical Volumes

Dividing disks in partitions isn’t very flexible. If you need optimal flexibility, you need LVM logical volumes, which are used by default while installing Red Hat Enterprise Linux. This chapter shows how to create and manage those logical volumes.

Part 1-3: Performing Advanced System Administration Tasks

Chapter 16: Basic Kernel Management

The kernel is the part of the operating system that takes care of handling hardware. This chapter explains how that works, and what an administrator can do to analyze the current configuration and manage hardware devices in case the automated procedure doesn’t work well.

Chapter 17: Configuring a Basic Apache Server

Apache is the most commonly used service on Linux. This chapter shows how to set up Apache web services, including the configuration of Apache virtual hosts.

Chapter 18: Managing and Understanding the Boot Procedure

Many things are happening when a Linux server boots. This chapter describes the boot procedure in detail and zooms in on vital aspects of the boot procedure, including the GRUB 2 boot loader and the systemd service manager.

Chapter 19: Troubleshooting the Boot Procedure

Sometimes a misconfiguration might cause your server no longer to boot properly. This chapter teaches you some of the techniques that can be applied when normal server startup is no longer possible.
Part 1-4: Managing Network Services

- Chapter 20: Using Kickstart
  
  If you want to install one server, you can go through a manual installation procedure. If you need to install many servers, you're better off using an installation server. This chapter teaches you how to set up such a server.

- Chapter 21: Managing SELinux
  
  Many Linux administrators only know how to switch it off, because SELinux is hard to manage and is often the reason why services cannot be accessed. In this chapter, you learn how SELinux works and what to do to configure it so that your services are still working and will be much better protected against possible abuse.

- Chapter 22: Configuring a Firewall
  
  Apart from SELinux, RHEL 7 comes with a firewall, which is implemented by the firewalld service. In this chapter, you learn how this service is organized and what you can do to block or enable access to specific services.

- Chapter 23: Configuring Remote Mounts and FTP
  
  While working in a server environment, managing remote mounts is an important skill. A remote mount allows a client computer to access a file system offered through a remote server. These remote mounts can be made through a persistent mount in /etc/fstab, or by using the automount service. This chapter teaches how to set up either of them, and also shows how to configure an FTP server.

- Chapter 24: Configuring Time Services
  
  For many services, such as databases and Kerberos, it is essential to have the right time. That’s why as an administrator you need to be able to manage time on Linux. This chapter teaches you how.

Part 2: RHCE

Part 2-1: System Configuration and Management

- Chapter 25: Configuring External Authentication and Authorization
  
  If you have multiple servers to manage, it makes sense to use an external authentication and authorization server, such as a Lightweight Directory Access Protocol (LDAP) server that uses Kerberos for authorization. This chapter teaches you how to set up a server for usage of an existing LDAP server that uses Kerberized authorization. It also explains Kerberos protocol fundamentals.
Chapter 26: Configuring an iSCSI SAN

RHEL 7 includes everything that is needed to set up a storage-area network (SAN). This chapter explains how to set up the SAN itself, using the iSCSI target software, and how to connect to a SAN, using the iSCSI initiator software on the client server.

Chapter 27: System Performance Reporting

Your server might sometimes have problems replying to a user request adequately. If that happens, you need to be able to find out what is wrong with it. This chapter explains performance reporting and all the different tools available to do this in an efficient way.

Chapter 28: System Optimization Basics

If you’ve found that something is wrong with your server’s performance, you need to optimize it. In this chapter, you learn how to optimize your server for specific workloads.

Chapter 29: Configuring Advanced Log Features

The rsyslog service used for logging on RHEL 7 contains some advanced features, such as working with modules and setting up a remote log server. This chapter explains how to use these features.

Chapter 30: Configuring Routing and Advanced Networking

To integrate a server in a datacenter, advanced network configurations are often needed. This chapter explains how to do so and includes configuring aggregated network interfaces using bonding or teaming, as well as routing and IPv6 configurations.

Chapter 31: An Introduction to Bash Shell Scripting

Some tasks are complex and need to be performed repeatedly. Such tasks are ideal candidates for optimization through shell scripts. In this chapter, you learn how to use conditional structures in shell scripts to automate tasks efficiently.

Part 2-2: System Security

Chapter 32: Advanced Firewall Configuration

In Chapter 22, you learned how to set up a firewalld based firewall, using the default components of this firewall. This chapter zooms in on some more advanced configurations, including port forwarding and rich rules.
Chapter 33: Managing Advanced Apache Services

The Apache web server offers many solutions to access web content. That includes using virtual servers, but also includes authentication and the use of Transport Layer Security (TLS) certificates. This chapter teaches you how to manage these advanced features.

Chapter 34: Configuring DNS

In this chapter, you learn how to set up a caching-only DNS name server, which is useful to handle DNS requests more efficiently.

Chapter 35: Configuring a MariaDB Database

As a Linux administrator, you’ll have to deal with database management as well. That is, you do not have to become a skilled DBA, but at least you need to know how to manage database backups, set up a simple database and perform database queries. This chapter teaches how to do all this.

Chapter 36: Configuring NFS

The Network File System (NFS) protocol is used to share files between Linux servers or between Linux servers and clients. This chapter teaches you how to set up Domain Name System (DNS), including advanced setups such as Kerberized NFS servers.

Chapter 37: Configuring Samba File Services

The Samba file server offers a solution to share directories on Linux to make them accessible for Windows clients. This chapter shows you how to set up a Samba server, and also discusses some of the advanced methods that Samba shares can be integrated in the client file system.

Chapter 38: Setting Up an SMTP Server

A Linux server occasionally needs to send email messages to other servers. This chapter shows how to set up a simple configuration for sending email using other mail servers as a relay host.

Chapter 39: Configuring SSH

The Secure Shell (SSH) service is used for remote access, but it can do so much more. In this chapter, you learn how to optimize the SSH service through its many parameters in the configuration files. You also learn how to set up SSH port forwarding.
Chapter 40: Managing Time Synchronization

As discussed earlier, time is a critical factor for many services to work successfully. This chapter explains how to manage time synchronization by using the Network Time Protocol (NTP).

Part 3: Final Preparation

- Chapter 41: Final Preparation

  In this chapter, you get some final exam preparation tasks. It contains some test exams and many tips that help you maximize your chances of passing the exam.

- Chapter 42: Theoretical Pre-Assessment Exams

  In this chapter, you'll get an RHCSA Theoretical Pre-Assessment Exam and an RHCE Theoretical Pre-Assessment Exam, so you can pre-assess your skills and determine the best route forward for studying for the exams.

- Practice Exams: This section supplies two RHCSA Practice Exams and two RHCE Practice Exams, so you can test your knowledge and skills before taking the exams. These exams are also available on the book’s companion website and DVD as PDF files.

Chapter Features

To help you customize your study time using these books, the core chapters have several features that help you make the best use of your time:

- **“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:** At the end of the “Foundation Topics” section of each chapter, the “Exam Preparation Tasks” section lists a series of study activities that should be done at the end of the chapter. Each chapter includes the activities that make the most sense for studying the topics in that chapter. The activities include the following:
Review Key Topics: The Key Topic icon is shown 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 corresponding 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.

Complete Tables and Lists from Memory: To help you exercise your memory and memorize some lists of facts, many of the more important lists and tables from the chapter are included in a document on the DVD and companion website. This document lists only partial information, allowing you to complete the table or list.

Define Key Terms: This section lists the most important terms from the chapter, asking you to write a short definition and compare your answer to the glossary at the end of this book.

Review Questions: Questions at the end of each chapter that measure insight in the topics that were discussed in the chapter.

End-of-Chapter Labs: Real labs that give you the right impression on what an exam assignment looks like. The end of chapter labs are your first step in finding out what the exam tasks really look like.

Other Features

In addition to the features in each of the core chapters, this book, as a whole, has additional study resources on the DVD and companion website, including the following:

Four practice exams: The companion website and DVD contains the four practice exams, two RHCSA and two RHCE, provided in the book as PDFs so that you can readily test your skills before taking the exams in the testing facility.

Interactive exercises and quizzes: The companion website and DVD contains more than 40 interactive hands-on exercises and 40 interactive quizzes so that you can test your knowledge on the spot.

Four advanced CLI simulations: The companion website and DVD contains four advanced CLI simulations—two RHCSA and two RHCE—that allow you to walk through multistep CLI scenarios in a simulated environment.

Glossary quizzes: The companion website and DVD contains interactive quizzes that allow you to test yourself on every glossary term in the book.
- **More than 2.5 hours of video training:** The companion website and DVD contains 30 minutes of unique test-prep videos plus more than 2 hours of instruction from the best-selling RHCSA and RHCE Complete Video Course series.

- **Virtual Machines:** The companion website and DVD contains three virtual machines so that you can easily get access to an environment where you can work on the labs and exercises in this book.

### Book Organization, Chapters, and Appendixes

I have also included two tables that detail where every objective in the RHCSA and RHCE exams is covered in this book so that you can more easily create a successful plan for passing the tests.

#### Table 1  RHCSA Objectives

<table>
<thead>
<tr>
<th>Objective</th>
<th>Chapter Title</th>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand and use essential tools</td>
<td>Using Essential Tools</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Access a shell prompt and issue commands with correct syntax</td>
<td>Using Essential Tools</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Use input-output redirection (&gt;., &gt;&gt;, 1, 2&gt;, etc.)</td>
<td>Using Essential Tools</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Use grep and regular expressions to analyze text</td>
<td>Working with Text Files</td>
<td>4</td>
<td>85</td>
</tr>
<tr>
<td>Access remote systems using ssh</td>
<td>Connecting to an RHEL Server</td>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Log in and switch users in multiuser targets</td>
<td>Connecting to an RHEL Server</td>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Archive, compress, unpack, and uncompress files using tar, star, gzip,</td>
<td>Essential File Management Tools</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>and bzip2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Create and edit text files</td>
<td>Working with Text Files</td>
<td>4</td>
<td>85</td>
</tr>
<tr>
<td>Create, delete, copy, and move files and directories</td>
<td>Essential File Management Tools</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>Create hard and soft links</td>
<td>Essential File Management Tools</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>List, set, and change standard ugo/rwx permissions</td>
<td>Permissions Management</td>
<td>7</td>
<td>151</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapter Title</td>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Locate, read, and use system documentation including man, info, and files in /usr/share/doc</td>
<td>Using Essential Tools</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Note: Red Hat may use applications during the exam that are not included in Red Hat Enterprise Linux for the purpose of evaluating candidate’s abilities to meet this objective.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operate running systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boot, reboot, and shut down a system normally</td>
<td>Connecting to an RHEL Server</td>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Boot systems into different targets manually</td>
<td>Essential Book Procedure Troubleshooting</td>
<td>19</td>
<td>429</td>
</tr>
<tr>
<td>Interrupt the boot process in order to gain access to a system</td>
<td>Essential Book Procedure Troubleshooting</td>
<td>19</td>
<td>429</td>
</tr>
<tr>
<td>Identify CPU/memory intensive processes, adjust process priority with renice, and kill processes</td>
<td>Process Management</td>
<td>9</td>
<td>205</td>
</tr>
<tr>
<td>Locate and interpret system log files and journals</td>
<td>Configuring Logging</td>
<td>13</td>
<td>295</td>
</tr>
<tr>
<td>Access a virtual machine’s console</td>
<td>Working with Virtual Machines</td>
<td>10</td>
<td>225</td>
</tr>
<tr>
<td>Start and stop virtual machines</td>
<td>Working with Virtual Machines</td>
<td>10</td>
<td>225</td>
</tr>
<tr>
<td>Start, stop, and check the status of network services</td>
<td>Configuring Networking</td>
<td>8</td>
<td>177</td>
</tr>
<tr>
<td>Securely transfer files between systems</td>
<td>Connecting to an RHEL Server</td>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Configure local storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>List, create, and delete partitions on MBR and GPT disks</td>
<td>Managing Partitions</td>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>Create and remove physical volumes, assign physical volumes to volume groups, and create and delete logical volumes</td>
<td>Managing LVM Logical Volumes</td>
<td>15</td>
<td>349</td>
</tr>
<tr>
<td>Configure systems to mount file systems at boot by Universally Unique ID (UUID) or label</td>
<td>Managing Partitions</td>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapter Title</td>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Add new partitions and logical volumes, and swap to a system non-destructively</td>
<td>Managing Partitions</td>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>Create and configure file systems</td>
<td>Managing Partitions</td>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>Create, mount, unmount, and use vfat, ext4, and xfs file systems</td>
<td>Managing Partitions</td>
<td>14</td>
<td>319</td>
</tr>
<tr>
<td>Mount and unmount CIFS and NFS network file systems</td>
<td>Configuring Remote Mounts and FTP</td>
<td>23</td>
<td>515</td>
</tr>
<tr>
<td>Extend existing logical volumes</td>
<td>Managing LVM Logical Volumes</td>
<td>15</td>
<td>349</td>
</tr>
<tr>
<td>Create and configure set-GID directories for collaboration</td>
<td>Permissions Management</td>
<td>7</td>
<td>151</td>
</tr>
<tr>
<td>Create and manage access control lists (ACLs)</td>
<td>Permissions Management</td>
<td>7</td>
<td>151</td>
</tr>
<tr>
<td>Diagnose and correct file permission problems</td>
<td>Permissions Management</td>
<td>7</td>
<td>151</td>
</tr>
<tr>
<td>Deploy, configure, and maintain systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure networking and hostname resolution statically or dynamically</td>
<td>Configuring Networking</td>
<td>8</td>
<td>177</td>
</tr>
<tr>
<td>Schedule tasks using at and cron</td>
<td>Scheduling Tasks</td>
<td>12</td>
<td>281</td>
</tr>
<tr>
<td>Start and stop services and configure services to start automatically at boot</td>
<td>Managing and Understanding the Boot Procedure</td>
<td>18</td>
<td>405</td>
</tr>
<tr>
<td>Configure systems to boot into a specific target automatically</td>
<td>Managing and Understanding the Boot Procedure</td>
<td>18</td>
<td>405</td>
</tr>
<tr>
<td>Install Red Hat Enterprise Linux automatically using Kickstart</td>
<td>Using Kickstart</td>
<td>20</td>
<td>451</td>
</tr>
<tr>
<td>Configure a physical machine to host virtual guests</td>
<td>Working with Virtual Machines</td>
<td>10</td>
<td>225</td>
</tr>
<tr>
<td>Install Red Hat Enterprise Linux systems as virtual guests</td>
<td>Working with Virtual Machines</td>
<td>10</td>
<td>225</td>
</tr>
<tr>
<td>Configure systems to launch virtual machines at boot</td>
<td>Working with Virtual Machines</td>
<td>10</td>
<td>225</td>
</tr>
<tr>
<td>Configure network services to start automatically at boot</td>
<td>Configuring Networking</td>
<td>8</td>
<td>177</td>
</tr>
<tr>
<td>Configure a system to use time services</td>
<td>Configuring Time Services</td>
<td>24</td>
<td>539</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapter Title</td>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Install and update software packages from Red Hat Network, a remote</td>
<td>Installing Software Packages</td>
<td>11</td>
<td>249</td>
</tr>
<tr>
<td>repository, or from the local file system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Update the kernel package appropriately to ensure a bootable system</td>
<td>Basic Kernel Management</td>
<td>16</td>
<td>369</td>
</tr>
<tr>
<td>Modify the system bootloader</td>
<td>Managing and Understanding the Boot Procedure</td>
<td>18</td>
<td>405</td>
</tr>
<tr>
<td>Manage users and groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Create, delete, and modify local user accounts</td>
<td>User and Group Management</td>
<td>6</td>
<td>123</td>
</tr>
<tr>
<td>Change passwords and adjust password aging for local user accounts</td>
<td>User and Group Management</td>
<td>6</td>
<td>123</td>
</tr>
<tr>
<td>Create, delete, and modify local groups and group memberships</td>
<td>User and Group Management</td>
<td>6</td>
<td>123</td>
</tr>
<tr>
<td>Configure a system to use an existing authentication service for user</td>
<td>User and Group Management</td>
<td>6</td>
<td>123</td>
</tr>
<tr>
<td>and group information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manage security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure firewall settings using firewall-config, firewall-cmd, or</td>
<td>Configuring a Firewall</td>
<td>22</td>
<td>499</td>
</tr>
<tr>
<td>iptables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure key-based authentication for SSH</td>
<td>Connecting to an RHEL Server</td>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Set enforcing and permissive modes for SELinux</td>
<td>Managing SELinux</td>
<td>21</td>
<td>473</td>
</tr>
<tr>
<td>List and identify SELinux file and process context</td>
<td>Managing SELinux</td>
<td>21</td>
<td>473</td>
</tr>
<tr>
<td>Restore default file contexts</td>
<td>Managing SELinux</td>
<td>21</td>
<td>473</td>
</tr>
<tr>
<td>Use boolean settings to modify system SELinux settings</td>
<td>Managing SELinux</td>
<td>21</td>
<td>473</td>
</tr>
<tr>
<td>Diagnose and address routine SELinux policy violations</td>
<td>Managing SELinux</td>
<td>21</td>
<td>473</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapter Title</td>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>System configuration and management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use network teaming or bonding to configure aggregated network links</td>
<td>Configuring Routing and Advanced Networking</td>
<td>30</td>
<td>655</td>
</tr>
<tr>
<td>between two Red Hat Enterprise Linux systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure IPv6 addresses and perform basic IPv6 troubleshooting</td>
<td>Configuring Routing and Advanced Networking</td>
<td>30</td>
<td>655</td>
</tr>
<tr>
<td>Route IP traffic and create static routes</td>
<td>Configuring Routing and Advanced Networking</td>
<td>30</td>
<td>655</td>
</tr>
<tr>
<td>Use firewalld and associated mechanisms such as rich rules, zones</td>
<td>Managing Linux-Based Firewalls</td>
<td>32</td>
<td>701</td>
</tr>
<tr>
<td>and custom rules, to implement packet filtering and configure Network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address Translation (NAT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use /proc/sys and sysctl to modify and set kernel runtime parameters</td>
<td>System Optimization Basics</td>
<td>28</td>
<td>627</td>
</tr>
<tr>
<td>Configure a system to authenticate using Kerberos</td>
<td>Configuring External Authentication and Authorization</td>
<td>25</td>
<td>557</td>
</tr>
<tr>
<td>Configure a system as either an iSCSI target or initiator that</td>
<td>Configuring an iSCSI SAN</td>
<td>26</td>
<td>577</td>
</tr>
<tr>
<td>persistently mounts an iSCSI target</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produce and deliver reports on system utilization (processor, memory,</td>
<td>System Performance Reporting</td>
<td>27</td>
<td>607</td>
</tr>
<tr>
<td>disk, and network)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use shell scripting to automate system maintenance tasks</td>
<td>An Introduction to Bash Shell Scripting</td>
<td>31</td>
<td>683</td>
</tr>
<tr>
<td>Network services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install the packages needed to provide the service</td>
<td>Installing Software Packages</td>
<td>11, 25, 26, 31, 33, 34, 35, 36, 37, 38, 249, 557, 577, 683, 719, 781, 801, 825</td>
<td></td>
</tr>
<tr>
<td>Configure SELinux to support the service</td>
<td>Managing SELinux</td>
<td>21, 33, 35, 36, 37, 39, 473, 719, 759, 781, 801, 845</td>
<td></td>
</tr>
<tr>
<td>Use SELinux port labeling to allow services to use non-standard ports</td>
<td>Managing SELinux</td>
<td>2, 33, 391, 33, 719, 845</td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td><strong>Chapter Title</strong></td>
<td><strong>Chapter</strong></td>
<td><strong>Page</strong></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Configure the service to start when the system is booted</td>
<td>Managing and Understanding the Boot Procedure</td>
<td>18, 25, 26,</td>
<td>405, 557, 577,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33, 34, 35,</td>
<td>719, 741, 759,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36, 37, 38</td>
<td>781, 801, 825</td>
</tr>
<tr>
<td>Configure the service for basic operation</td>
<td>Sander please insert chapter names and numbers</td>
<td>25, 26, 29,</td>
<td>557, 577, 641,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30, 31, 32,</td>
<td>655, 683, 701,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33, 34, 35,</td>
<td>719, 741, 759,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36, 37, 38,</td>
<td>781, 801, 825,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39, 40</td>
<td>845, 859</td>
</tr>
<tr>
<td>Configure host-based and user-based security for the service</td>
<td>Sander please insert chapter names and numbers</td>
<td>25, 26, 29,</td>
<td>557, 577, 641,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30, 31, 32,</td>
<td>655, 683, 701,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33, 34, 35,</td>
<td>719, 741, 759,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36, 37, 38,</td>
<td>781, 801, 825,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>39, 40</td>
<td>845, 859</td>
</tr>
</tbody>
</table>

**HTTP/HTTPS**

<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
<th><strong>Chapter Title</strong></th>
<th><strong>Chapter</strong></th>
<th><strong>Page</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure a virtual host</td>
<td>Managing Advanced Apache Services</td>
<td>33</td>
<td>719</td>
</tr>
<tr>
<td>Configure private directories</td>
<td>Managing Advanced Apache Services</td>
<td>33</td>
<td>719</td>
</tr>
<tr>
<td>Deploy a basic CGI application</td>
<td>Managing Advanced Apache Services</td>
<td>33</td>
<td>719</td>
</tr>
<tr>
<td>Configure group-managed content</td>
<td>Managing Advanced Apache Services</td>
<td>33</td>
<td>719</td>
</tr>
<tr>
<td>Configure TLS security</td>
<td>Managing Advanced Apache Services</td>
<td>33</td>
<td>719</td>
</tr>
</tbody>
</table>

**DNS**

<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
<th><strong>Chapter Title</strong></th>
<th><strong>Chapter</strong></th>
<th><strong>Page</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Configure a caching-only name server</td>
<td>Configuring DNS</td>
<td>34</td>
<td>741</td>
</tr>
<tr>
<td>Troubleshoot DNS client issues</td>
<td>Configuring DNS</td>
<td>34</td>
<td>741</td>
</tr>
</tbody>
</table>

**NFS**

<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
<th><strong>Chapter Title</strong></th>
<th><strong>Chapter</strong></th>
<th><strong>Page</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide network shares to specific clients</td>
<td>Configuring NFS</td>
<td>36</td>
<td>781</td>
</tr>
<tr>
<td>Provide network shares suitable for group collaboration</td>
<td>Configuring NFS</td>
<td>36</td>
<td>781</td>
</tr>
<tr>
<td>Use Kerberos to control access to NFS network shares</td>
<td>Configuring NFS</td>
<td>36</td>
<td>781</td>
</tr>
</tbody>
</table>

**SMB**

<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
<th><strong>Chapter Title</strong></th>
<th><strong>Chapter</strong></th>
<th><strong>Page</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide network shares to specific clients</td>
<td>Configuring Samba File Services</td>
<td>37</td>
<td>801</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapter Title</td>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Provide network shares suitable for group collaboration</td>
<td>Configuring Samba File Services</td>
<td>37</td>
<td>801</td>
</tr>
<tr>
<td>SMTP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure a system to forward all email to a central mail server</td>
<td>Setting up an SMTP Server</td>
<td>38</td>
<td>825</td>
</tr>
<tr>
<td>SSH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure key-based authentication</td>
<td>Configuring SSH</td>
<td>39</td>
<td>845</td>
</tr>
<tr>
<td>Configure additional options described in documentation</td>
<td>Configuring SSH</td>
<td>39</td>
<td>845</td>
</tr>
<tr>
<td>NTP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronize time using other NTP peers</td>
<td>Managing Time Synchronization</td>
<td>40</td>
<td>859</td>
</tr>
<tr>
<td>Database services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install and configure MariaDB</td>
<td>Configuring a MariaDB Database</td>
<td>35</td>
<td>759</td>
</tr>
<tr>
<td>Backup and restore a database</td>
<td>Configuring a MariaDB Database</td>
<td>35</td>
<td>759</td>
</tr>
<tr>
<td>Create a simple database schema</td>
<td>Configuring a MariaDB Database</td>
<td>35</td>
<td>759</td>
</tr>
<tr>
<td>Perform simple SQL queries against a database</td>
<td>Configuring a MariaDB Database</td>
<td>35</td>
<td>759</td>
</tr>
</tbody>
</table>

**About the Virtual Machines**

On the companion website and DVD that comes with this book, you can find a set of virtual machines that you can use to work through the labs in this book. Alternatively, you can set up an IPA server as instructed in Appendix D of this book and install your own environment according to the instructions in Chapter 1.

To use the virtual machines, you need VMware Workstation/Player or Fusion. Using the VMs if one of these virtualization platforms is installed on your computer is easy—just doubleclick the files that you’ll find in the archive after uncompressing it. Notice that you’ll need the following to use these virtual machines:

- A total of 30 GB of disk space
- A total of 3 GB of available RAM
Where are the Companion Content Files?

Register this print version of Red Hat RHCSA/RHCE 7 Cert Guide to access the Bonus content online.

This print version of this title comes with a disc of companion content. You have online access to these files by following the steps below:

1. Go to www.pearsonITcertification.com/register and log in or create a new account.
2. Enter the ISBN: 9780789754059
3. Answer the challenge question as proof of purchase.
4. Click on the “Access Bonus Content” link in the Registered Products section of your account page, to be taken to the page where your downloadable content is available.

Please 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 the steps at left, please visit www.pearsonITcertification.com/contact and select the “Site Problems/Comments” option. Our customer service representatives will assist you.

This book also includes an exclusive offer for 70% off the Premium Edition eBook and Practice Tests edition of this title. Please see the coupon code included with the DVD for information on how to purchase the Premium Edition.
The following topics are covered in this chapter:

- Working with Systemd
- Working with GRUB 2

The following RHCSA exam objectives are covered in this chapter:

- Start and stop services and configure services to start automatically at boot
- Configure systems to boot into a specific target automatically
- Modify the system bootloader
CHAPTER 18

Managing and Understanding the Boot Procedure

In this chapter, you learn how the boot procedure on Red Hat Enterprise Linux is organized. We first go through a section about systemd, the overall service that takes care of starting everything on your server. In this section, you also learn how systemd targets are used to group systemd units and come to a final operational environment.

The second part of this chapter discusses GRUB2 and how to apply changes to the GRUB 2 boot loader. Troubleshooting is not a topic in this chapter; it is covered in Chapter 19, “Troubleshooting the Boot Procedure.”

“Do I Know This Already?” Quiz

The “Do I Know This Already?” quiz allows you to assess whether you should read this entire chapter thoroughly or jump to the “Exam Preparation Tasks” section. If you are in doubt about your answers to these questions or your own assessment of your knowledge of the topics, read the entire chapter. Table 18.1 lists the major headings in this chapter and their 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 and ‘Review Questions.’”

<table>
<thead>
<tr>
<th>Foundation Topics Section</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working with Systemd</td>
<td>1–7, 10</td>
</tr>
<tr>
<td>Working with GRUB 2</td>
<td>8, 9</td>
</tr>
</tbody>
</table>

1. Which command shows all service unit files on your system that are currently loaded?
   a. systemctl --type=service
   b. systemctl --type=service --all
   c. systemctl --list-services
   d. systemctl --show-units | grep services
2. Which statement about systemd wants is not true?
   a. You can create wants by using the `systemctl enable` command.
   b. The target to which a specific want applies is agnostic of the associated wants.
   c. Wants are always administered in the `/usr/lib/systemd/system` directory.
   d. Each service knows to which target its wants should be added.

3. What is the best solution to avoid conflicts between incompatible units?
   a. Nothing, the unit files have defined for themselves which units they are not compatible with.
   b. Disable the service using `systemctl disable`.
   c. Unmask the service using `systemctl unmask`.
   d. Mask the service using `systemctl mask`.

4. Which of the following is not a valid status for systemd services?
   a. Running(active)
   b. Running(exited)
   c. Running(waiting)
   d. Running(dead)

5. To allow targets to be isolated, you need a specific statement in the target unit file. Which of the following describes that statement?
   a. AllowIsolate
   b. Isolate
   c. SetIsolate
   d. Isolated

6. Which of the following is not a valid systemd unit type?
   a. service
   b. udev
   c. mount
   d. socket
7. You want to find out which other systemd units have dependencies to this specific unit. Which command would you use?
   a. systemd list-dependencies --reverse
   b. systemctl list-dependencies --reverse
   c. systemctl status my.unit --show-deps
   d. systemctl status my.unit --show-deps -r

8. What is the name of the file where you should apply changes to the GRUB 2 configuration?
   a. /boot/grub/menu.lst
   b. /boot/grub2/grub.cfg
   c. /etc/sysconfig/grub
   d. /etc/default/grub

9. After applying changes to the GRUB 2 configuration, you need to write those changes. Which of the following commands will do that for you?
   a. grub2 -o /boot/grub/grub.cfg
   b. grub2-mkconfig > /boot/grub2/grub.cfg
   c. grub2 > /boot/grub2/grub.cfg
   d. grub2-install > /boot/grub2/grub.cfg

10. Which of the following is not a valid command while working with units in systemctl?
    a. systemctl unit start
    b. systemctl status -l unit
    c. systemctl mask unit
    d. systemctl disable unit
Foundation Topics

Working with Systemd

Systemd is the new service in Red Hat Enterprise Linux 7 that is responsible for starting all kinds of things. Systemd goes way beyond starting services; other items are started from systemd as well. In this chapter, you learn how systemd is organized and what items are started from systemd.

Understanding Systemd

To describe it in a generic way, the systemd System and Service Manager is used to start stuff. The stuff is referred to as units. Units can be many things. One of the most important unit types is the service. Typically, services are processes that provide specific functionality and allow connections from external clients coming in. Apart from services, other unit types exist, such as sockets, mounts, and others. To display a list of available units, type `systemctl -t help` (see Listing 18.1).

Listing 18.1  Unit Types in Systemd

```
[root@server1 ~]# systemctl -t help
Available unit types:
service
socket
target
device
mount
automount
snapshot
timer
swap
path
slice
scope
```

TIP  For RHCSA, you need to know how to work with services. The other unit types do not matter that much.
Understanding Service Units

The major benefit of working with systemd, as compared to previous methods Red Hat used for managing services, is that it provides a uniform interface to start units. This interface is defined in the unit file. The system default unit files are in /usr/lib/systemd/system. System-specific modifications (overriding the defaults) are in /etc/systemd/system. Also, the runtime configuration that is generated automatically is stored in /run/systemd/system. Listing 18.2 gives an example of the vsftpd.service unit file.

Listing 18.2  Example of the Vsftpd Unit File

```
[Unit]
Description=Vsftpd ftp daemon
After=network.target

[Service]
Type=forking
ExecStart=/usr/sbin/vsftpd /etc/vsftpd/vsftpd.conf

[Install]
WantedBy=multi-user.target
```

From this unit file example, you can see that it is relatively easy to understand. Any systemd service unit file consists of three sections. (You’ll find different sections in other types of unit files.)

- **[Unit]**, which describes the unit and defines dependencies. This section also contains the important After statement, and optionally the Before statement. These statements define dependencies between different units. The Before statement relates to another unit that is started after this unit. The after unit refers to a unit that needs to be started before this unit can be started.

- **[Service]**, in which there is a description on how to start and stop the service and request status installation. Normally, you can expect an ExecStart line, which indicates how to start the unit, or an ExecStop line, which indicates how to stop the unit.

- **[Install]**, in which the wants are taken care of. You’ll read more about this in the next section, “Understanding Target Units.”
Listing 18.3 shows another example of a unit file. This time it is the tmp.mount unit.

Listing 18.3  Example of a Mount Unit File

```
[Unit]
Description=Temporary Directory
Documentation=man:hier(7)
Documentation=http://www.freedesktop.org/wiki/Software/systemd/
APIFileSystems
DefaultDependencies=no
Conflicts=umount.target
Before=local-fs.target umount.target

[Mount]
What=tmpfs
Where=/tmp
Type=tmpfs
Options=mode=1777,strictatime

# Make 'systemctl enable tmp.mount' work:
[Install]
WantedBy=local-fs.target
```

The tmp.mount unit file in Listing 18.3 shows some interesting additional information. In the Unit section, you can see the Conflicts statement. This is used to list units that cannot be used together with this unit. Use this for mutually exclusive units. Next, there is the Mount section, which is specific for this unit type and defines where exactly the mount has to be performed. You’ll recognize the arguments that are typically used in any mount command. Last, there is the WantedBy section, which defines where the unit has to be started.

Another type of unit that is interesting to look at is the socket. A socket creates a method for applications to communicate with one another. Some services create their own sockets while starting, whereas other services need a socket unit file to create sockets for them. It is also the other way around: Every socket needs a corresponding service file. The socket file example in Listing 18.4 shows how this happens for virtlockd, a systemd socket that tracks activity for virtual machines.
Listing 18.4  Socket Unit File Example

[root@server202 system]# cat virtlockd.socket
[Unit]
Description=Virtual machine lock manager socket

[Socket]
ListenStream=/var/run/libvirt/virtlockd-sock

[Install]
WantedBy=multi-user.target

When working with systemd unit files, you risk getting overwhelmed with options. Every unit file can be configured with different options. To figure out which options are available for a specific unit, use the `systemctl show` command. For instance, the `systemctl show sshd` command shows all systemd options that can be configured in the sshd.service unit, including their current default values. Listing 18.5 shows the output of this command.

Listing 18.5  Showing Available Options with `systemctl show`

```
Id=sshd.service
Names=sshd.service
Requires=basic.target
Wants=sshd-keygen.service system.slice
WantedBy=multi-user.target
ConsistsOf=sshd-keygen.service
Conflicts=shutdown.target
ConflictedBy=sshd.socket
Before=shutdown.target multi-user.target
After=network.target sshd-keygen.service systemd-journald.socket basic.target system.slice
Description=OpenSSH server daemon
LoadState=loaded
ActiveState=active
SubState=running
FragmentPath=/usr/lib/systemd/system/sshd.service
UnitFileState=enabled
InactiveExitTimestamp=Sat 2015-05-02 11:06:02 EDT
InactiveExitTimestampMonotonic=2596332166
```
Understanding Target Units

The unit files are used to build the functionality that is needed on your server. To make it possible to load them in the right order and at the right moment, a specific type of unit is used: the target unit. A simple definition of a target unit is “a group of units.” Some targets are used as the equivalents to the old run levels, which on earlier versions of RHEL were used to define the state a server should be started in. A run level was a collection of services that were needed for a server to be started in multi-user mode or in graphical mode. Targets go beyond that. A good starting point to understanding targets is to see them as a group of units.

Targets by themselves can have dependencies to other targets, which are defined in the target unit. Let’s take a look at Listing 18.6, where you can see the definition of the multi-user.target, which defines the normal operational state of an RHEL server.

Listing 18.6  The Multi-user.target File

```
[root@server202 system]# cat multi-user.target
...
[Unit]
Description=Multi-User System
```
You can see that by itself the target unit does not contain much. It just defines what it requires and which services and targets it cannot coexist with. It also defines load ordering, by using the `After` statement in the Unit section. And you can see that in the Install section it is defined as the default.target, so this is what your server starts by default. The target file does not contain any information about the units that should be included; that is in the individual unit files and the wants (explained in the upcoming section “Understanding Wants”).

Even if a systemd target looks a bit like the old run levels, it is more than that. A target is a group of units, and there are multiple different targets. Some targets, such as the multi-user.target and the graphical.target, define a specific state that the system needs to enter. Other targets just bundle a group of units together, such as the nfs.target and the printer.target. These targets are included from other targets, like the multi-user or graphical targets.

### Understanding Wants

To understand the concept of a want, let’s start looking at the verb *want* in the English language, as in “I want a cookie.” Wants in systemd define which units systemd wants when starting a specific target. Wants are created when systemd units are enabled, and this happens by creating a symbolic link in the `/etc/systemd/system` directory. In this directory, you’ll find a subdirectory for every target, containing wants as symbolic links to specific services that are to be started.

### Managing Units Through Systemd

As an administrator, you need to manage systemd units. It starts by starting and stopping units. You use the `systemctl` command to do that. In Exercise 18.1, you walk start, stop, and manage a unit. After you have configured a unit so that it can be started without problems, you need to make sure that it restarts automatically upon reboot. You do this by enabling or disabling the unit.
TIP  Memorizing all the different arguments that can be used with the `systemctl` command might seem hard, but you don’t have to do that. Instead, just type `systemctl` and press the Tab key twice to use command autocompletion. This will show you all available commands.

Exercise 18.1 Managing Units with systemctl

1. Type `yum -y install vsftpd` to install the Very Secure FTP service.
2. Type `systemctl start vsftpd`. This activates the FTP server on your machine.
3. Type `systemctl status vsftpd`. You’ll get an output as in Listing 18.7 and see that the vsftpd service is currently operational. You can also see in the Loaded line that it is currently disabled, which means that it will not be activated on a system restart.
4. Type `systemctl enable vsftpd`. This creates a symbolic link in the wants directory for the multi-user target to ensure that the service gets back after a restart.
5. Type `systemctl status vsftpd` again. You’ll now see that the unit file has changed from being disabled to enabled.

Listing 18.7  Requesting Current Unit Status with systemctl status

```
[root@server202 system]# systemctl status vsftpd
vsftpd.service - Vsftpd ftp daemon
 Loaded: loaded (/usr/lib/systemd/system/vsftpd.service; disabled)
 Active: active (running) since Sun 2014-09-28 08:42:59 EDT; 2s ago
 Process: 34468 ExecStart=/usr/sbin/vsftpd /etc/vsftpd/vsftpd.conf
 (code=exited, status=0/SUCCESS)
 Main PID: 34469 (vsftpd)
 CGroup: /system.slice/vsftpd.service
             └─34469 /usr/sbin/vsftpd /etc/vsftpd/vsftpd.conf

 Sep 28 08:42:59 server202.example.com systemd[1]: Starting Vsftpd ftp daemon...
 Hint: Some lines were ellipsized, use -l to show in full.
```
When requesting the current status of a systemd unit as in Listing 18.6, you can see different kinds of information about it. Table 18.2 shows the different kinds of information that you can get about unit files when using the `systemctl status` command:

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded</td>
<td>The unit file has been processed and the unit is active.</td>
</tr>
<tr>
<td>Active(running)</td>
<td>Running with one or more active processes.</td>
</tr>
<tr>
<td>Active(exited)</td>
<td>Successfully completed a one-time configuration.</td>
</tr>
<tr>
<td>Active(waiting)</td>
<td>Running and waiting for an event.</td>
</tr>
<tr>
<td>Inactive</td>
<td>Not running.</td>
</tr>
<tr>
<td>Enabled</td>
<td>Will be started at boot time.</td>
</tr>
<tr>
<td>Disabled</td>
<td>Will not be started at boot time.</td>
</tr>
<tr>
<td>Static</td>
<td>This unit can not be enabled but may be started by another unit automatically.</td>
</tr>
</tbody>
</table>

As an administrator, you’ll also often need to get a current overview of the current status of systemd unit files. Different commands can help you to get this insight, some of which are shown in Table 18.3.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>systemctl --type=service</code></td>
<td>Shows only service units</td>
</tr>
<tr>
<td><code>systemctl list-units --type=service</code></td>
<td>Shows all active service units (same result as the previous command)</td>
</tr>
<tr>
<td><code>systemctl list-units --type=service --all</code></td>
<td>Shows inactive service units as well as active service units</td>
</tr>
<tr>
<td><code>systemctl --failed --type=service</code></td>
<td>Shows all services that have failed</td>
</tr>
<tr>
<td><code>systemctl status -l your.service</code></td>
<td>Shows detailed status information about services</td>
</tr>
</tbody>
</table>

Managing Dependencies

Systemctl units in many cases have dependencies. Some units will be started as a dependency of other units, and an event where one specific unit is requested may
trigger the start of another unit. An example is the cups.service service. This service can be started by itself, but it can also be started by activity on the cups.path and cups.socket units, which may trigger the service to be started again. As an administrator, you can request a list of unit dependencies. Type `systemctl list-dependencies` followed by a unit name to find out which dependencies it has, and add the `--reverse` option to find out which units are dependent of this unit. Listing 18.8 shows an example of this command.

Listing 18.8  Showing Unit Dependencies

```
[root@server1 ~]# systemctl list-dependencies vsftpd
vsftpd.service
└─system.slice
  └─basic.target
    ├─alsa-restore.service
    ├─alsa-state.service
    ├─firewalld.service
    ├─microcode.service
    ├─rhel-autorelabel-mark.service
    ├─rhel-autorelabel.service
    ├─rhel-configure.service
    ├─rhel-dmesg.service
    ├─rhel-loadmodules.service
    ├─paths.target
    ├─slices.target
    │ └─.slice
    │ └─system.slice
    ├─sockets.target
    │ ├─avahi-daemon.socket
    │ ├─cups.socket
    │ ├─dbus.socket
    │ ├─dm-event.socket
    │ ├─iscsid.socket
    │ └─iscsiuio.socket
    │ └─lvm2-lvmetad.socket
    │ └─rpcbind.socket
    │ └─systemd-initcct1.socket
    │ └─systemd-journald.socket
    │ └─systemd-shutdown.socket
    │ └─systemd-udevd-control.socket
    │ └─systemd-udevd-kernel.socket
```
Apart from dependencies, some units have conflicts with other units. Examples of these include the following:

- Mount and umount units that cannot be loaded together
- The network and NetworkManager service
- The iptables and the firewalld service
- The cronyd and ntpd service

If units have conflicts with other units, this is described in the unit file. As an administrator, you can also make sure that conflicting units will never be loaded at the same time on the same system. To do this, you can use the `systemctl mask` command, which basically makes a unit no longer a candidate for being started. Apply the following procedure to find out how it works:

1. Open a root shell and type `systemctl status firewalld`. Next type `systemctl status iptables`. If one of the services is active, do not load it again in the next step.

2. Type `systemctl start firewalld` and `systemctl start iptables` to load both services. You will see that iptables refuses to start; this is because the firewalld service is already activated.

3. Type `cat /usr/lib/systemd/system/firewalld.service`. Notice the conflicts setting. Type `cat /usr/lib/systemd/system/iptables.service`. Notice that this unit does not have a conflicts line.

4. Unload both services by using `systemctl stop firewalld` followed by `systemctl stop iptables`. Notice that it is not really necessary to stop the iptables service because it has failed to load, but we really need to make sure that it is not loaded at all before continuing.

5. Type `systemctl mask iptables` and look at what is happening: A symbolic link to /dev/null is created for /etc/systemd/system/iptables.service (as you can see in the output of the following command example). Because the unit files in
/etc/systemd have precedence over the files in /usr/lib/systemd, this makes it impossible to start the iptables service by accident:

```
[root@server202 system]# systemctl mask iptables
ln -s '/dev/null' '/etc/systemd/system/iptables.service'
```

6. Type **systemctl start iptables**. You’ll see an error message indicating that this service is masked and for that reason cannot be started.

7. Type **systemctl enable iptables**. Notice that no error message is shown and it looks as if it is working all right. Restart your server using **systemctl reboot** (or just **reboot**).

8. After restart, type **systemctl status -l iptables**. You’ll see that it is inactive and that the loaded status is indicated as masked:

```
[root@server202 ~]# systemctl status -l iptables
iptables.service
    Loaded: masked (/dev/null)
    Active: inactive (dead)
```

Managing Systemd Targets

As an administrator, you need to make sure that the required services are started when your server boots. To do this, use the **systemctl enable** and **systemctl disable** commands. You do not have to think about the specific target a service has to be started in. The services know for themselves in which targets they need to be started and a want is created automatically in that target. The following procedure walks you through the steps of enabling a service:

1. Type **systemctl status vsftpd**. If the service has not yet been enabled, the Loaded line will show that it currently is disabled:

```
[root@server202 ~]# systemctl status vsftpd
vsftpd.service - Vsftpd ftp daemon
    Loaded: loaded (/usr/lib/systemd/system/vsftpd.service; disabled)
    Active: inactive (dead)
```

2. Type **ls /etc/systemd/system/multi-user.target.wants**. You’ll see symbolic links that are taking care of starting the different services on your machine. You can also see that the vsftpd.service link does not exist.

3. Type **systemctl enable vsftpd**. The command shows you that it is creating a symbolic link for the file /usr/lib/systemd/system/vsftpd.service to the directory /etc/systemd/system/multi-user.target.wants. So basically, when you enable a systemd unit file, on the background a symbolic link is created.
Isolating Targets

As already discussed, on systemd machines there are a couple of targets. You also know that a target is a collection of units. Some of those targets have a special role because they can be isolated. By isolating a target, you start that target with all of its dependencies. Not all targets can be isolated, but only targets that have the isolate option enabled. We’ll explore the systemctl isolate command in a while. Before doing that, let’s take a look at the default targets on your computer.

To get a list of all targets currently loaded, type systemctl --type=target. You’ll see a list of all the targets currently active. If your server is running a graphical environment, this will include all the dependencies required to install the graphical.target also. However, this list does not show all the targets, but only the active targets. Type systemctl --type=target --all for an overview of all targets that exist on your computer. You’ll now see inactive targets also.

Of the targets on your system, a few have an important role because they can be started (isolated) to determine the state your server starts in. These are also the targets that can be set as the default target. These targets also roughly correspond to run levels as they were used on earlier versions of RHEL. These are the following targets:

- poweroff.target - runlevel 0
- rescue.target - runlevel 1
- multi-user.target - runlevel 3
- graphical.target - runlevel 5
- reboot.target - runlevel 6

If you look at the contents of each of these targets, you’ll also see that they contain the AllowIsolate=yes line. That means that you can switch the current state of your computer to either one of these targets using the systemctl isolate command. Exercise 18.2 shows you how to do this.
Setting the Default Target

Setting the default target is an easy procedure that can be accomplished from the command line. Type `systemctl get-default` to see the current default target and use `systemctl set-default` to set the desired default target.

To set the graphical target as the default target, you need to make sure that the required packages are installed. If this is not the case, you can use the `yum group list` command to show a list of all RPM package groups. The “server with gui” and “GNOME Desktop” package groups both apply. Use `yum group install “server with gui”` to install all GUI packages on a server where they have not been installed yet.

Working with GRUB 2

The GRUB 2 boot loader is one of the first things that needs to be working well to boot a Linux server. As an administrator, you will sometimes need to apply modifications to the GRUB 2 boot loader configuration. This section explains how to do so. The RHEL 7 boot procedure is discussed in more detail in Chapter 19, where troubleshooting topics are covered as well.

Understanding GRUB 2

The GRUB 2 boot loader makes sure that you can boot Linux. GRUB 2 is installed in the boot sector of your server’s hard drive and is configured to load a Linux kernel and the initramfs:

- The kernel is the heart of the operating system, allowing users to interact with the hardware that is installed in the server.
- The initramfs contains drivers that are needed to start your server. It contains a mini file system that is mounted during boot. In it are kernel modules that are needed during the rest of the boot process (for example, the LVM modules and SCSI modules for accessing disks that are not supported by default).
Normally, GRUB 2 works just fine and does not need much maintenance. In some cases, though, you might have to change its configuration. To apply changes to the GRUB 2 configuration, the starting point is the /etc/default/grub file. In this file, you’ll find options that tell GRUB what to do and how to do it. Listing 18.9 shows the contents of this file after an installation with default settings of CentOS 7.

Listing 18.9  Contents of the /etc/default/grub File

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat /etc/default/grub</td>
<td>Prints the contents of the file</td>
</tr>
<tr>
<td>GRUB_TIMEOUT=5</td>
<td>Sets the timeout to 5 seconds</td>
</tr>
<tr>
<td>GRUB_DISTRIBUTOR=&quot;$(sed 's, release .*$,,g' /etc/system-release)&quot;</td>
<td>Sets the distributor based on the system-release file</td>
</tr>
<tr>
<td>GRUB_DEFAULT=saved</td>
<td>Sets the default to saved</td>
</tr>
<tr>
<td>GRUB_DISABLE_SUBMENU=true</td>
<td>Disables the submenus</td>
</tr>
<tr>
<td>GRUB_TERMINAL_OUTPUT=&quot;console&quot;</td>
<td>Sets the terminal output to console</td>
</tr>
<tr>
<td>GRUB_CMDLINE_LINUX=&quot;rd.lvm.lv=centos/swap vconsole.font=latarcyrheb-sun16 rd.lvm.lv=centos/root crashkernel=auto vconsole.keymap=us rhgb quiet&quot;</td>
<td>Sets the boot arguments for the kernel</td>
</tr>
<tr>
<td>GRUB_DISABLE_RECOVERY=&quot;true&quot;</td>
<td>Disables the recovery mode</td>
</tr>
</tbody>
</table>

As you can see, the /etc/default/grub file does not contain much information. The most important part that it configures is the GRUB-CMDLINE_LINUX option. This line contains boot arguments for the kernel on your server.

**TIP** For the RHCSA exam, make sure that you understand the contents of the /etc/default/grub file. That is the most important part of the GRUB 2 configuration anyway.

Apart from the configuration in /etc/default/grub, there are a few configuration files in /etc/grub.d. In these files, you’ll find rather complicated shell code that tells GRUB what to load and how to load it. You typically do not have to modify it. You also will not need to modify anything if you want to make it possible to select from different kernels while booting. GRUB 2 picks up new kernels automatically and adds them to the boot menu automatically, so nothing has to be added manually.

Based on the configuration files mentioned previously, the main configuration file /boot/grub2/grub.cfg is created. Even if this looks like a configuration file that can be manually modified, you should never do that, because it will get overwritten at some point. This will happen, for instance, after updating the kernel. The RPM from which the kernel is updated will run a post-installation script that regenerates
the kernel. In the next section, you learn how to make changes to the GRUB 2 configuration.

If you enter the GRUB 2 boot prompt to add kernel startup parameters, the contents of the /boot/grub2/grub.cfg file display. From here, you add one-time-only startup options. Listing 18.10 shows the relevant part of the grub.cfg file that takes care of loading the Linux kernel. In this listing, you see the part of the configuration file that takes care of loading the default kernel. Notice the line that starts with linux16; this line specifies all kernel boot parameters.

Listing 18.10 Partial Contents of the /boot/grub2/grub.cfg Configuration File

```plaintext
menuentry 'CentOS Linux (3.10.0-229.1.2.el7.x86_64) 7 (Core)' --class centos --class gnu-linux --class gnu --class os --unrestricted
$menueentry_id_option 'gnulinux-3.10.0-123.el7.x86_64-advanced-50faa2a1-01d3-430b-8114-4a98daf5bddd' {
  load_video
  set gfxpayload=keep
  insmod gzio
  insmod part_msdos
  insmod xfs
  set root='hd0,msdos1'
  if [ x$feature_platform_search_hint = xy ]; then
    search --no-floppy --fs-uuid --set=root --hint-bios=hd0,msdos1 --hint-efi=hd0,msdos1 --hint-baremetal=ahci0,msdos1 --hint='hd0,msdos1' 057ba3d8-bfe7-4676-bb99-79e9980a1966
  else
    search --no-floppy --fs-uuid --set=root 057ba3d8-bfe7-4676-bb99-79e9980a1966
  fi
  linux16 /vmlinuz-3.10.0-229.1.2.el7.x86_64 root=/dev/mapper/
  centos-root ro rd.lvm.lv=centos/swap vconsole.font=latarcyrheb-sun16
  rd.lvm.lv=centos/root crashkernel=auto vconsole.keymap=us rhgb quiet
  LANG=en_US.UTF-8
  initrd16 /initramfs-3.10.0-229.1.2.el7.x86_64.img
}
```

One of the most important differences between GRUB 2 and its previous version is the availability of GRUB 2 modules. In GRUB 2, a large number of modules are available. By default, you can find them in /boot/grub2/i386-pc. The modules determine what you can and what you cannot do from the GRUB 2 boot loader. If some hardware or file system is not supported in what you want to do, check here to make
sure that a supporting GRUB 2 module is available. In Listing 18.10, you can see examples of the code used to load specific GRUB 2 modules.

Modifying Default GRUB 2 Boot Options

To apply modifications to the GRUB 2 boot loader, the file /etc/default/grub is your entry point; do not change the contents of the /boot/grub2/grub.cfg configuration file directly. The most important line in this file is GRUB_CMDLINE_LINUX, which defines how the Linux kernel should be started. In this line, you can apply permanent fixes to the GRUB 2 configuration. Some likely candidates for removal are the options rhgb and quiet. These options tell the kernel to hide all output while booting. That is nice to hide confusing messages for end users, but if you are a server administrator, you probably just want to remove these options.

**TIP** On the exam, you want to know immediately if something does not work out well. To accomplish this, it is a good idea to remove the rhgb and quiet boot options. Without these you will not have to guess why your server takes a long time after a restart; you’ll just be able to see.

Another interesting parameter is GRUB_TIMEOUT. This defines the amount of time your server waits for you to access the GRUB 2 boot menu before it continues booting automatically. If your server runs on physical hardware that takes a long time to get through the BIOS checks, it may be interesting to increase this time a bit.

While working with GRUB 2, you need to know a bit about kernel boot arguments. There are many of them, and most of them you’ll never use, but it is good to know where you can find them. Type man 7 bootparam for a man page that contains an excellent description of all boot parameters that you may use while starting the kernel.

In Exercise 18.3, you learn how to apply modifications to GRUB 2.

**TIP** You should know how to apply changes to the GRUB configuration, but you should also know that the default GRUB 2 configuration works fine as it is for almost all computers. So, you will probably never have to apply any changes at all!
Summary

In this chapter you learned how systemd and GRUB 2 are used to bring your server into the exact state you desire at the end of the boot procedure. You also learned how systemd is organized, and also how units can be configured for automatic start with the use of targets. You also read how to apply changes to the default GRUB 2 boot loader. In the next chapter, you learn how to troubleshoot the boot procedure and fix some common problems.

Exam Prep Tasks

Review All Key Topics

Review the most important topics in the chapter, noted with the Key Topic icon in the outer margin of the page. Table 18.4 lists a reference of these key topics and the page numbers on which each is found.

Table 18.4  Key Topics for Chapter 18

<table>
<thead>
<tr>
<th>Key Topic Element</th>
<th>Description</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listing 18.1</td>
<td>Unit types in systemd</td>
<td>408</td>
</tr>
<tr>
<td>List</td>
<td>Three sections of a systemd unit file</td>
<td>409</td>
</tr>
<tr>
<td>Paragraph</td>
<td>Understanding Target Units</td>
<td>412</td>
</tr>
<tr>
<td>Exercise 18.1</td>
<td>Managing units with systemctl</td>
<td>414</td>
</tr>
</tbody>
</table>

Exercise 18.3 Applying Modifications to GRUB2

In this exercise you’ll apply some changes to the GRUB2 boot configuration and write them to the /boot/grub2/grub.cfg configuration file.

1. Open the file /etc/default/grub with an editor and remove the rhgb and quiet options from the GRUB_CMDLINE_LINUX line.

2. From the same file, set the GRUB_TIMEOUT parameter to 10 seconds. Save changes to the file and close the editor.

3. From the command line, type `grub2-mkconfig > /boot/grub2/grub.cfg` to write the changes to GRUB 2. (Note that instead of using the redirector > to write changes to the grub.cfg file, you could use the -o option. Both methods have the same result.)

4. Reboot and verify that while booting you see boot messages scrolling by.
Chapter 18: Managing and Understanding the Boot Procedure

### Key Topic Element

<table>
<thead>
<tr>
<th>Key Topic Element</th>
<th>Description</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 18.3</td>
<td>Systemctl unit overview commands</td>
<td>415</td>
</tr>
<tr>
<td>Section</td>
<td>Managing systemd targets</td>
<td>418</td>
</tr>
<tr>
<td>Exercise 18.2</td>
<td>Isolating targets</td>
<td>420</td>
</tr>
<tr>
<td>Bullet list</td>
<td>Explanation of the role of kernel and initramfs</td>
<td>420</td>
</tr>
<tr>
<td>Listing 18.9</td>
<td>Contents of the /etc/default/grub file</td>
<td>421</td>
</tr>
<tr>
<td>Exercise 18.3</td>
<td>Applying modifications to GRUB 2</td>
<td>424</td>
</tr>
</tbody>
</table>

### Complete Tables and Lists from Memory

Print a copy of Appendix B, “Memory Tables” (found on the disc), or at least the section for this chapter, and complete the tables and lists from memory. Appendix C, “Memory Tables Answer Key,” also on the disc, includes completed tables and lists to check your work.

### Define Key Terms

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

- unit
- wants
- target
- systemd
- dependencies
- initramfs
- kernel
- boot loader
- GRUB

### Review Questions

1. What is a unit?
2. Which command enables you to make sure that a target is no longer eligible for automatic start on system boot?
3. Which configuration file should you modify to apply common changes to GRUB 2?
4. Which command should you use to show all service units that are currently loaded?
5. How do you create a want for a service?
6. How do you switch the current operational target to the rescue target?
7. Why can it happen that you get the message that a target cannot be isolated?
8. You want to shut down a systemd service, but before doing that you want to know which other units have dependencies to this service. Which command would you use?

9. What is the name of the GRUB 2 configuration file where you apply changes to GRUB 2?

10. After applying changes to the GRUB 2 configuration, which command should you run?

End-of-Chapter Labs

You have now learned how to work with systemd units and the GRUB 2 boot loader. Before continuing, it is a good idea to work on some labs that help you ensure that you can apply the skills that you acquired in this chapter.

Lab 18.1

Make sure that the firewalld service is started on boot. Also make sure that the iptables service can never be started at the same time.

Lab 18.2

Change your GRUB 2 boot configuration so that you will see boot messages upon startup.
Symbols

./ (dot-slash), current directory, 37
- (hyphen), in log files, 306
- (minus sign), in command options, 213
" " (quotation marks), escaping regular expressions, 95
. (dot)
  changing group ownership, 156
  hidden files, 70
  regular expressions, 95
  root domain, 744
.profile files, changing umask setting, 170
.repo files, creating, 253-256
/ (forward slash), root directory, 60
/.autorelabel file, 444
/bin directory, 60
/boot directory, 60
  kernel files, 384
  mounting, 62
/boot/grub2/grub.cfg file, 422-423
/dev directory, 60
/dev/hda device, 325
/dev/pts directory, 110
/dev/sda device, 325
/dev/tty in files, 109
/dev/vda device, 325
/dev/xvda device, 325
/etc directory, 60
/etc/anacrontab file, 288-289
/etc/auto-guests file, 819
/etc/auto.master file, 819
/etc/bashrc file, 46, 136
/etc/chrony.conf file, 543, 864-866
/etc/cron.allow file, 289
/etc/cron.d directory, 287-288
/etc/cron.daily directory, 288
/etc/cron.deny file, 289
/etc/cron.hourly directory, 288
/etc/cron.monthly directory, 288
/etc/crontab file, 286
/etc/cron.weekly directory, 288
/etc/default/grub file, 421-423
/etc/default/useradd file, 134-135
/etc/dracut.conf file, 439-442
/etc/dracut.conf.d files, 439
/etc/exports file, 786
/etc/firewalld/services directory, 505, 706
/etc/fstab file, 528, 788
ACL support, 166
fields, 342
iSCSI devices, mounting, 601
mount options, 343
mounting file systems, 341-343
NFS shares, mounting, 528
SMB shares, mounting, 529-530
troubleshooting, 442-443
user extended attributes, 171
/etc/group file, 137-138
/etc/grub.d files, 421
/etc/hosts file, 198
/etc/httpd directory, Apache configuration files, 393, 397-398
/etc/httpd/conf directory, 397
/etc/httpd/conf.d directory, 398
/etc/httpd/conf.d/php.conf file, 732
/etc/httpd/conf.d/ssl.conf file, 730
/etc/httpd/conf/httpd.conf file, 392-395, 723-724
/etc/httpd/conf.modules.d directory, 398
/etc/krb5.conf file, 567
/etc/krb5.keytab file, 563-564, 792-793, 814
/etc/ldap.conf file, 567
/etc/login.defs file, 135
/etc/logrotate.conf file, 309-310
/etc/modprobe.d directory, 383
/etc/modules-load.d directory, 378
/etc/motd file, 46-47
/etc/pam.d/* files, 567
/etc/passwd file, 560
/etc/profile file, 46, 136, 170
/etc/resolv.conf file, 745, 755
/etc/ssh/ssh_config file, 815
/etc/ssh/sshd_config file, 848
/etc/sssd/sssd.conf file, 144, 567, 571-572
/etc/sysconfig/authconfig file, 567
/etc/sysconfig/network-scripts directory, 661, 666
/etc/sysconfig/network-scripts/
   route-interface file, 678
/etc/sysconfig/rsyslog file, 303
/etc/sysconfig/selinux file, 478
/etc/sysctl.conf file, 635-636
/etc/sysconf.d directory, 635-636
/etc/systemd/journald.conf file, 315, 646
/etc/systemd/system directory, 409
/etc/target/saveconfig.json file, 590
/etc/udev/rules.d directory, 376
/etc/xinetd.d/tftp file, 456
/home directory, 60, 62
/lib directory, 60
/lib64 directory, 60
/media directory, 60
/mnt directory, 60
/opt directory, 60
/proc directory, 60
/proc file system
   kernel information, 375
   performance optimization, 631
   /proc/sys directory parameters, 633-634
      configuration files, 631
      PID (process ID) directories, 632-633
      sysctl command, 635-637
   /proc/cpuinfo file, 231
   /proc/meminfo file, 613
   /proc/net/bonding interface, 662
   /proc/sys directory parameters, 633-634
   /proc/sys/net/ipv4/ip_forward, 678
   /root directory, 60
   /run directory, 60
   /run/log/journal file, 314
   /run/systemd/system directory, 409
   /sbin directory, 60
   /srv directory, 60
   /sys file system, hardware initialization, 376-378
   /text (vim command), 43
   /tmp directory, 60
   /usr directory, 60, 62
absolute pathnames, 68-69
accepting, license agreement, 29
access control. See also permissions
  Apache private directories, 735-736
  in SSH, 850-851
  user extended attributes, 170-172
access control list (ACL). See ACLs
  (access control lists)
accessing
  GRUB boot prompt, 434-435
  NFS shares, 519, 521
    /etc/fstab file, 787
    Kerberos requirements, 520-521
    NFS version support, 521
    persistent mounts, 788
    pseudo root mounts, 519
    security options, 519-520
    systemd process, 790-791
    testing access, 787-788
  repositories, 13-14
  restoring system access from rescue disk, 437
  SMB shares, 522-525
    as guest, 525
    user authentication, 525
    via graphical interface, 526-527
  VMs
    with libvirt, 229-231
    methods of, 240-242
    recovering access to, 444-446
accounts
  group accounts. See group accounts
  user accounts. See user accounts
acl mount option, 166, 343
ACLs (access control lists), 165, 584
  backing up, 166
  creating, 588
  default ACLs, 168
  to DocumentRoot, 726
  file system preparation, 166
  viewing and changing, 166-168
Active Directory, 572
active memory, 613
active-backup bonding mode, 659

A

a (vim command), 43
a attribute, 171
A resource record type, 748
AAAA resource record type, 748
abi tunable directory, 633
absolute mode, applying permissions, 159-161
activebackup runner, 663
Add Network Device option, 467
adding, files, to archives, 77
add-ons, list of, 15
addresses
  IP addresses. See IP addresses
  MAC addresses, 183
  port addresses, 183
administration
  of databases, 768-773
    creating databases, 772-773
    CRUD operations, 769-770
    user management, 771-772
help resources, 47
  documentation files, 53
  --help option, 48
  info system, 51-52
  man pages, 48-51
shell
  command execution, 36-37
  history file, 40
  I/O redirection, 37-40
  tab completion, 42
shell environment
  configuration files, 46
  managing, 47
  user communication in, 46-47
  variables, 45-46
vim, editing files, 42-45
administrator permissions, granting, 128
advanced permissions
  applying, 164
  explained, 161-163
aggregated network interfaces, 658
  network bonding, 658-662
  network teaming
    configuration, 663-671
    runners, 663
    troubleshooting, 671-672
alert priority, 306
aliases, 36, 75, 380
AllowOverride parameter, 724
AllowUsers option, 850, 853
Alt+Fn (virtual terminals), 109
anaconda-ks.cfg file, 462, 467-469
anacron service, 288-289
analyzing, kernel, 374-375
anonymous FTP drop boxes,
  configuration, 533-535
Apache web servers
  configuration, 392
    configuration files, 392-395, 397-398
    creating content, 395
    essential parameters, 723-724
    installing required software, 392
    private directories, 735-736
    SELinux settings, 725
    testing, 395-396
    write permission to DocumentRoot, 726
dynamic content
  CGI (Common Gateway Interface),
    731-732
  database connections, 733
  PHP scripts, 732
  Python scripts, 733
httpd-manual RPM package, 733-735
TLS (Transport Layer Security)
  configuration, 727-731
virtual hosts
  creating, 398-400
  editing configuration, 726-727
application servers, 562
apropos command, 49-50
arch command, 231
archives, 76-77
  compression, 78-79
  creating, 77
  extracting contents, 78
  listing contents, 77-78
  tar command usage, 79-80
arguments, in shell scripts, 688-689
at command, 290
atd service, 290-291
atime mount option, 343
atq command, 290
atrm command, 290
attributes, for file security, 170-172
audit log file, SELinux troubleshooting, 491-492
auth facility, 305
authconfig command, 142, 565
authconfig-gtk interface, 142, 144, 565
authconfig-tui interface, 142-143, 565, 568
authentication. See user authentication
Authentication option, 467
authoritative DNS answers, 746-747
authorization. See Kerberos
authpriv facility, 305
AUTHPRIV syslog facility, 851
auto mount option, 343
autofs command, 819-820
autofs service, automount configuration, 530
automated installation with, with Kickstart, 462-463
automatic completion. See tab completion
automount mounts, 819-820
configuration, 530
for NFS shares, 531-532
for SMB shares, 533
wildcards, 532-533
availability, of drivers, 381-383
awk command, 97-98

B

backend storage, 584
background jobs
running, 208-209
terminating, 211
backing up, ACLs, 166
backups, MariaDB databases, 773-776
balance-alb bonding mode, 659
balance-rr bonding mode, 659
balance-tlb bonding mode, 659
balance-xor bonding mode, 659
base context, 141
base environment settings, RHEL 7 installation, 22
base parameter, 143
base repository type, 256
baseurl= option, 255-256
bash shell. See shell; shell scripts
bash -x command, 697-698
Basic Configuration option, 465
batch command, 291
bg command, 209
binary notation
decimal conversion, 182
IP addresses, 182-183
blkid command, 340, 601
Block default zone (firewalld), 503
bonding. See network bonding
Boolean settings, SELinux, 489-491
Boot Loader Options, 466
boot menu, CentOS 7, 17
boot procedure
configuration, overview by boot phase, 433
GRUB 2 boot loader
explained, 420-423
modifying options, 423
phases in, 432-433
PXE boot. See PXE boot configuration
rebooting server, 110-112
systemd process
default targets, setting, 420
dependency management, 415-418
explained, 408
isolating targets, 419
service units, 409-412
target management, 418-419
target units, 412-413
unit management, 413-415
unit types, 408
wants, 413
troubleshooting
accessing GRUB boot prompt, 434-435
overview by boot phase, 433
recovering from file system issues, 442-443
recovering virtual machine access, 444-446
re-creating initramfs, 439–442
reinstalling GRUB 2 boot loader, 439–442
resetting root password, 443–444
restoring system access from rescue disk, 437
starting from rescue disk, 436
starting troubleshooting targets, 435–436
boot.iso image, 456
brct show command, 234
bridging configuration, 233–234
broadcast addresses, 181
broadcast bonding mode, 659
broadcast runner, 663
browsable directive, 807
browsers, launching, 395
Btrfs file system, 334
buffers, explained, 613
buffers parameter (memory usage), 612
bunzip2 command, 79
bzip2 command, 78–79
C

c attribute, 171
CA (certificate authority), 728
cache
  dropping caches, 614
  explained, 613
cache poisoning, 749
cache-only DNS servers, 749
  configuration, 749–751
  dumping unbound cache, 753
  security issues, 749
cached Mem parameter (memory usage), 612
canceling, shell jobs, 209
case loops, 696–697
cat command, 88–89
cat /proc/cpuinfo command, 231
cd command, 68, 768
CentOS 7 (Community Enterprise Operating System)
  installing, 17–29
  obtaining, 12–13
certificate authority (CA), 728
certificates in TLS, 141, 728
CGI (Common Gateway Interface), 731–732
chage command, 135–136
chage -l command, 135
changing
  ACLs, 166–168
  effective primary group, 157–158
  ownership
    group owners, 156–157
    user owners, 156
  passwords, permissions needed, 161–162
  process priorities, 214–216
  /proc/sys directory parameters
    persistently, 635–637
    temporarily, 634
characters, counting, in text files, 93
chattr command, 172
chcon command, 444, 483
chmod command, 156–157
chgrp command, 156–157
choosing, repositories, 253–256
chown command, 156–157
chown -R command, 156
chrony command, 546
chronyc command, 866–871
chronyc sources command, 867–868
chronyc sourcestats command, 868
chronyc tracking command, 868
chronyd process, 546, 858–866
chroot command, 437
chroot environment, Apache web servers, 397
chvt command, 109
CIDR (classless interdomain routing) notation, 181
CIFS (Common Internet File System) See SMB shares
cifcreds command, 817-819

cifsiostat command, 616

cifs-utils package, 816

classless interdomain routing (CIDR) notation, 181

classroom exam registration, 876

cleanup process (Postfix), 831

ClientAliveCountMax option, 852-853

ClientAliveInterval option, 852-853

closed source drivers, open source drivers versus, 373

clustered environments, 576

cmdline file, 631

CNAME resource record type, 748

command mode (vim), 43

command substitution, 689-691

commands

/etc/redhat-release, 375
/usr/libexec/mysqld --help --verbose, 766

apropos, 49-50

arch, 231

at, 290

atq, 290

atrm, 290

authconfig, 142, 565

autofs, 819-820

bash -x, 697-698

batch, 291

bg, 209

blkid, 340, 601

brctl show, 234

bunzip2, 79

bzip2, 78-79

cat /proc/cpuinfo, 231

cd, 68, 768

chage, 135-136

chage -l, 135

chattr, 172

chcon, 444, 483

chgrp, 156-157

chmod, 159-161, 164

chown, 156-157

chown -R, 156

chrony, 546

chrony, 866-871

chrony sources, 867-868

chrony sourcestats, 868

chrony tracking, 868

chroot, 437

chvt, 109

cifcreds, 817-819

cifsiostat, 616

cp, 70-71

create, 586

createrepo, 259

crontab -e, 287

crontab -l, 289

in current directory, 37

database administration, 768-773

CREATE DATABASE, 768

CREATE TABLE, 769

CREATE USER, 771

DELETE, 770

DESCRIBE, 769

describe user, 768

FLUSH PRIVILEGES, 772

GRANT, 771-772

INSERT, 770

mysqldump, 774

SELECT, 770

SHOW DATABASES, 767

SHOW TABLES, 768

UPDATE, 770

USE, 768

WHERE clause, 770

date, 543-544

df -hT, 64, 66

dig, 746, 753-754

dig +dnssec DNSKEY, 751-752

dmesg, 374-375

dracut, 439-442

dracut --force, 244

dump, 343

e2label, 341

echo, 46, 634

echo b > /proc/sysrq-trigger, 112
env, 45
executing, in shell, 36-37
fdisk, 325-328, 355
fg, 209
file, 78
find, 156
findmnt, 64-65
firewall-cmd, 506-507, 788, 812
  masquerading configuration, 712
  options, 507
  port forwarding configuration, 713-714
  rich rules, 709-711
firewall-cmd --add-port=3260/tcp
  --permanent, 595
firewall-cmd --get-services, 504, 706
firewall-cmd --list-all, 595
firewall-cmd --reload, 595
firewall-config, 508-511, 714
free -m, 614
fsc, 442
gdisk, 325, 330-334
getenforce, 478
getent hosts, 200
getfacl, 166-168
getsebool -a, 489
gpasswd, 158
groupadd, 138
groupmems, 139
groupmod, 139
grups, 157
grubby, 241
gunzip, 79
gzip, 78-79
head, 379
help resources, 47
  documentation files, 53
  --help option, 48
  info system, 51-52
  man pages, 48-51
history file, 40
hostnamectl, 197, 634
hostnamectl status, 375
hwclock, 543-545
id, 126
ifconfig, 185
insmod, 381
iostat, 616-618
ip, 185-187
ip addr show, 676
ip route show, 676, 678
iscsiadm, 584, 596-598
iscsiadm -m session -P 3, 603
iscsiadm --mode node -P, 598
jobs, 209
journalctl, 298, 310-314
journalctl --dmesg, 374
journalctl -k, 374
journalctl -o verbose, 313
kill, 211, 216-217
killall, 217
klist, 792
klist -k, 814
kpartx -a, 445
less, 39, 379
list-timezone, 545
ln, 74
load_policy -i, 443
logger, 302-303
logrotate, 308-310, 648
ls, 39, 69-70, 75, 602
ls -l, 155, 167
lsattr, 172
lsblk, 358
lsmod, 378-379
lspci -k, 381-383
lsscsi, 599
lvcreate, 360-362
lvdisplay, 362
lvetend, 364
lvresize, 364-365
lvs, 362, 445
mail, 696
man -f, 50
man -k, 49-51
man -k _selinux, 486
man nmcli-examples, 659
mkdir, 68
mkfs, 335
mod probe -r, 378, 381
modinfo, 378, 380-381
modprobe, 378, 381
more, 89
mount, 62-63, 340, 525, 787, 816
mpstat, 616
mv, 71
mysql_secure_installation, 763-764
net share -l, 524
netstat, 187
netstat -tulp | grep 123, 863
newgrp, 157-158
nfsiostat, 616
nice, 214-216
nmcli, 189-193
IPv6 address configuration, 675-676
network bonding configuration, 658-660
network teaming configuration, 663-666
nm-connection-editor, 194
nmtui, 193-195, 197, 658, 678
nohup, 211
partprobe, 328, 330
passwd, 134-135
pdbedit, 809
pgrep, 214
pidstat, 616, 620
pinfo, 51-52
ping6, 676
pkill, 217
postconf, 832-836
postqueue -f, 839
postqueue -p, 839
postsuper -d, 840
ps, 212-214
ps aux, 212, 372-373
ps aux | grep dd, 214
ps -ef, 213
ps fax, 213
pvcreate, 362
pvcreate --help, 354-355
pvdisplay, 358, 362
pvs, 356, 362
pvscan, 445
pwd, 67
read, 689-691
realm, 572
renice, 214-216
repoquery, 275
restorecon, 487-488
rm, 71-72
rmdir, 68
rmmod, 381
rpm, 271-272
database queries, 273
package file queries, 273-276
rsync, 116
sar, 621-622
scp, 115-116
screen, 118-119
sealert, 492-494
semanage, 483-485, 535
semanage boolean -l, 489
semanage port, 849-850
setstatus, 478
setenforce, 478
setfpack, 166-168
setfpack -d, 168
setfpack -R, 168
set-local-rtc, 545
set-ntp, 545
setsebool, 490
set-time, 545
set-timezone, 545
shell jobs
foreground versus background jobs, 208-209
managing, 209-211
parent-child management, 211
showmount, 521, 787-788
smbclient -L, 523-524, 815-816
smbpasswd, 808
ss, 187
ssh, 112-114
ssh -p, 115
ssh -v, 114, 115
ssh -X, 115
ssh-add, 854
ssh-agent, 854
ssh-copy-id, 117
ssh-keygen, 117
star, 58, 166
status, 545
su, 127
su -107, 127
sudo, 127-128
swapon -s, 615
sysctl, 635-637
sysctl -a, 635-636
system-config-date, 550
systemctl, 413-415
systemctl enable target, 594
systemctl --failed --type=service, 415
systemctl get-default, 420
systemctl halt, 111
systemctl list-dependencies, 416
systemctl list-units --type=service, 415
systemctl list-units --type=service --all, 415
systemctl mask, 417-418
systemctl mask iptables, 505, 705-706
systemctl poweroff, 111
systemctl reboot, 111
systemctl set-default, 420
systemctl show, 411-412
systemctl start nslcd, 143
systemctl start target, 594
systemctl status, 299, 396, 414-415
systemctl status chronyd, 869-870
systemctl status crond -l, 284
systemctl status iscsi, 602
systemctl status -l, 415
systemctl status -l libvirtd, 229
systemctl status mariadb, 762
systemctl status NetworkManager, 189
systemctl status nslcd, 143
systemctl status sssd, 144
systemctl status target, 602
systemctl -t help, 408
systemctl --type=service, 415
systemctl --type=target, 419
systemctl --type=target --all, 419
tab completion, 42, 69, 354
tail -f, 302-303
tar, 76-80
  compression, 79
  creating archives, 77
  extracting archive contents, 78
  lack of ACL support, 166
  listing archive contents, 77-78
  options, 79
targetctl, 585-594, 602
teamdctl, 666
teamdctl team0 config dump, 672
teamnl, 671-672
test, 690, 692
testparm, 808
for text files
  awk, 97-98
  cat, 89
  cut, 91
  grep, 96-97
  head, 90-91
  less, 88-89
  list of, 88
  sed, 97-98
  sort, 91-92
  tac, 90
  tail, 90-91
  wc, 93
timedatectl, 543-548
top, 244, 610
  CPU usage, 611
  customizing display, 615-616
  load average, 610-611
  memory usage, 612-613
  process memory usage, 615
  process states, 218-220
  swap usage, 613-615
touch, 68
tracepath6, 676
tune2fs, 336-338
type, 36
tzselect, 548-549
udeadm monitor, 376-378
umount, 340
uname, 375
uname -i, 231
unbound-control dump_cache, 753
unbound-control-setup, 751
useradd, 133-135
userdel, 132
userdel -r, 132
usermod, 134, 139
vgchange, 445
vgcreate, 359, 362
vgdisplay, 360, 362
vgextend, 363
vgreduce, 363
vgs, 360-363
vigr, 133, 138
vim, 43
vimtutor, 44
vipw, 133
virsh, 243-244
virsh console, 241
virsh dumpxml vmname | grep “source file=”, 444
virsh edit, 240
virsh list, 241
virt-viewer, 241
vmstat, 616-619
vmstat -s, 619
which, 36
xfs_admin, 338
xfs_admin -L, 341
yum
creating repositories, 259-260
finding packages, 261-262
history list, 270-271
information about packages, 262-263
installing packages, 263-265
list of tasks, 260
listing packages, 263-266
managing packages, 271
package groups, 268-270
removing packages, 265
repositories, explained, 252-253
repository security, 256-258
rpm command versus, 271-272
specifying which repository to use, 253-256
updating packages, 267
yum group info, 269-270
yum groups install, 392
yum groups list, 268-269, 392
yum history, 270-271
yum info, 262-263
yum install, 263-265
yum install elinks, 395
yum install httpd, 392
yum install kernel, 384
yum install -y screen, 118
yum list, 265-266
yum list installed, 266
yum list kernel, 266
yum provides, 262
yum remove, 265
yum repolist, 260
yum search, 261-262
yum search http, 392
yum update, 267
yum upgrade kernel, 384
yum whatprovides, 262, 483
yumdownloader, 260, 275
comment directive, 807
comment field (/etc/passwd file), 130
Common Gateway Interface (CGI), 731-732
Common Internet File System (CIFS). See SMB shares
communication, with users, in shell environment, 46-47
Community Enterprise Operating System (CentOS 7). See CentOS 7
completion. See tab completion
compression, 78-79
conditional loops
case loops, 696-697
if.then.else loops, 690-693
for loops, 689, 693-694
configuration

Apache virtual hosts, 398-400, 726-727
Apache web servers, 392
  configuration files, 392-398
  creating content, 395
  essential parameters, 723-724
  installing required software, 392
  private directories, 735-736
  SELinux settings, 725
  testing, 395-396
  write permission to DocumentRoot, 726
automount, 530
  for NFS shares, 531-532
  for SMB shares, 533
  wildcards, 532-533
boot procedure, overview by boot phase, 433
cache-only DNS servers, 749-751
chronyd process, 864-866
DHCP servers, for PXE boot, 457-458
firewalld service, 505
  firewall-cmd command, 506-507
  firewall-config command, 508-511
forwarders, 749
FTP servers, 533-535
installation servers, 454
  Kickstart file creation, 462-469
  network server configuration, 454
  PXE boot configuration, 455-462
ipa clients, 572
IPv6 addresses, 675-676
iSCSI initiators, 596-598
iSCSI targets, 585-595
Kerberos, on NFS servers, 791-794
LDAP
  with Kerberos authorization, 564-568
  platform configuration, 142
  RHEL 7 configuration for, 142
MariaDB, 762-767
multiuser Samba mounts, 818-819
NAT, 711-712
  masquerading, 712
  port forwarding, 713-714
network addresses, validating, 185-187
network bonding, 658-662
network teaming, 663-671
networking
  configuration files, 195-196
  DNS resolution, 198-200
  hostnames, 196-198
  for KVM boots, 233-234
  with NetworkManager service, 189
  with nmcli, 189-193
  with nmtui, 193-195
during RHEL 7 installation, 26
NFSv4 servers, 789-790
  creating exports, 786-787
  firewall configuration, 788
  mounting shares, 787
  new features, 785-786
  persistent mounts, 788
  SELinux configuration, 788-789
  SELinux transparency, 794-796
null clients, 837-838
Postfix parameters, 832-838
remote logging, 649-650
rich rules, 709-711
routing, 677-679
rsyslogd process, 303-308
  facilities, priorities, destinations, 304-308
  file locations, 303
  modules, 645-646
  rsyslog.conf sections, 304
Samba file servers, 809-810
  /etc/samba/smb.conf file, 805-806
  creating shares, 807-808
  creating users, 808-809
  installing Samba, 804
  for keytab files, 814-815
  preparing shared directories, 804-805
troubleshooting, 810
of sar command, 621-622
SSH (Secure Shell). See SSH (Secure Shell)
  connection keepalive options, 852
  options, 853
  session options, 852
  tunneling, 854-855
TLS (Transport Layer Security), 727-731
trust anchors, 751-752
configuration files
Apache web servers, 392-395, 397-398
  essential parameters, 723-724
  PHP scripts, 732
chronyd process, 864-866
cron service, 286-288
cron service security, 289
DHCP servers, 458
  for dracut, 439-442
  for group accounts, 138
  for GRUB 2 boot loader, 421-423
  for LDAP configuration with Kerberos, 565-567
  for MariaDB network access, 765-766
network bonding, 661-662
network teaming, 666-669
  for networking, 195-196
  performance optimization, 631
  picking up changes, 848
repositories, specifying which to use, 253-256
  for routing, 679
Samba file servers, 805-806
  for shell environment, 46
  for syscl service, 635
for user accounts
  default properties, 134-135
  editing, 132-133
  properties of, 129-132
for VMs
  editing, 240
  validation, 238
conflicts with units, 417-418
connections
to iSCSI targets, 598-602
  mounting iSCSI devices, 601-602
  persistent mounts, 600-601
  keepalive options, in SSH, 852
to LDAP servers, 144-146
in networking, 189
  changing parameters, 192-193
  displaying properties, 190
  dual fixed and dynamic IP addresses, 196
  managing with nmcli, 192
  managing with nmtui, 193-195
  showing status, 190
rsyslogd and journald processes, 646-648
consoles
  local consoles, login, 106-107
  terminals versus, 106
context switches, 620
contexts (SELinux), 477, 481
  finding context types, 486
  monitoring, 481-482
  relabeling, 487-488
  setting context types, 483-486
copying files, 70-71, 115-116
counting lines, words, characters in text files, 93
course environment setup, 16-17
cp -a command, 71
cp command, 70-71
cp -R command, 70
CPU usage, 611
cpuinfo file, 631
crcreato command, 586
CREATE DATABASE command, 768
CREATE TABLE command, 769
CREATE USER command, 771
CREATE_HOME property, 135
creatererepo command, 259
credentials files, 529-530
crit priority, 306
cron facility, 305
cron service, 284
anacron service, 288-289
configuration files, 286-288
exercises, 289-290
listing cron jobs, 289
managing, 284-285
security management, 289
time and date fields, 285-286
crond daemon, 284
crontab -e command, 287
crontab -l command, 289
CRUD operations, in databases, 769-770
crypto tunable directory, 633
Ctrl+a (screen command), 118
Ctrl+Alt+F< n> (virtual terminals), 109
Ctrl+C, stopping jobs, 209
Ctrl+D, stopping jobs, 209
Ctrl+r (vim command), 43
Ctrl+Z, pausing jobs, 209
cups options Samba parameter, 806
current directory, commands in, 37
customizing, top display, 615-616
cut command, 88, 91
d date and time settings, RHEL 7
installation, 19-20
date command, 543-544
date fields, cron service, 285-286
daylight savings time (DST). See DST (daylight savings time)
dd (vim command), 43
debug priority, 306
debug tunable directory, 633
debugging, shell scripts, 697-698
decimal notation, binary conversion, 182
decompression, 79
dedicated network architecture, 583
default ACLs, 168
default file, in PXE boot configuration, 459
default file contexts, restoring, SELinux, 487-488
default ownership, 157-158
default permissions, setting with umask, 169-170
default properties, for user accounts, 134-135
default targets, setting, 420
default zones, firewalld service, 503
DELETE command, 770
deleting files, 71-72, 163
user accounts, 132
dependencies, 252-253, 271-272, 415-418
DESCRIBE command, 769
describe user command, 768
desktop-based virtualization, hypervisor-based virtualization versus, 228
destinations, 304-308
dev tunable directory, 633
device files, 39, 306
device mapper, 361
device names
LVM volumes, 361
mounting file systems, 340-341
devices in networking, 189, 192
df -hT command, 64-66
d attribute, 171
d attribute, 171
daemon facility, 305
daemons, 208
database connections, for dynamic website content, 733
databases
administration, 768-773
creating databases, 772-773
CRUD operations, 769-770
user management, 771-772
defined, 767
MariaDB. See MariaDB
rpm database, 272
querying, 273
time synchronization, importance of, 862
yum database, 272
DHCP servers
configuration, for PXE boot, 457-458
IPv6 address configuration, 675
dhcpd.conf file, 458
dictionary attacks, 848
dig +dnssec DNSKEY command, 751-752
dig command, 746, 753-754
direct mounts, 531-532
direct rules, 708
direct write logging, 298
directories
for file management, 67-68
in file system hierarchy
list of, 60
mounting on dedicated devices, 61-62
home directories, 133-134
ownership
changing, 156-157
default ownership, 157-158
viewing, 155-156
permissions
advanced permissions, 161-164
applying, 159-161
explained, 158-159
setting default, 169-170
PID (process ID) directories, 632-633
private directories, Apache web servers, 735-736
shared directories, preparing for Samba file servers, 804-805
sharing, permissions needed, 162-163
skeleton directory, 134
user extended attributes, 170-172
directory field (/etc/passwd file), 130
Directory parameter, 724
directory shares (Samba). See shares (Samba)
DirectoryIndex parameter, 724
disabled mode (SELinux), 477-481
disabling, root login, 848-849
discovering
iSCSI targets, 596-598
shares (Samba), 815-816
SMB shares, 523-525
discovery process (iSCSI), 584
disk device types, 324-325
disk labels. See labels
disk sizes, 324
Display Configuration option, 467
displaying. See viewing
dmesg command, 374-375
Dmz default zone (firewalld), 503
DNS (Domain Name System)
  cache-only DNS servers, 749
    configuration, 749-751
    security issues, 749
  hierarchy, 744
  lookups with, 745-747
  resource records, 747-748
  terminology, 745
  troubleshooting, 752-755
    client issues, 755
    dig command, 753-754
    dumping unbound cache, 753
    trust anchors, 751-752
DNS resolution, 198-200
DNSSEC (Domain Name System Security Extensions), 749
documentation files, 53
DocumentRoot parameter, 392, 726
Domain Name System. See DNS (Domain Name System)
Domain Name System Security Extensions (DNSSEC), 749
domains, 745
  root domain, 744
  second-level domains, 744
  top-level domains, 744
downloading, RPM packages, 275
dracut command, 439-442
dracut --force command, 244
drivers, 373
   checking availability, 381-383
   loading, 376-378
Drop default zone (firewalld), 503
dropping, caches, 614
DST (daylight savings time), 542
dumb terminals, 109
dump utility, 343
dumping unbound cache, 753
dynamic content on websites
   CGI (Common Gateway Interface),
      731-732
   database connections, 733
   PHP scripts, 732
   Python scripts, 733
dynamic IP addresses, with fixed IP
   addresses, 196
emerg priority, 306
emergency reset option, 112
enabled mode (SELinux), 477-481
enabling
   routing, 677-678
   services, 418-419
End Of File (EOF) character, 209
enforcing mode (SELinux), 477-481
ev command, 45
ENV_PATH property, 135
environment
   course environment setup, 16-17
   shell environment. See shell environment
   user environments, creating, 136
EOF (End Of File) character, 209
EPEL (Extra Packages for Enterprise
   Linux), 253
epoch time, 544
error messages, STDERR, 37-39
error priority, 306
ErrorLog parameter, 724
Esc (vim command), 43
escaping, regular expressions, 95
exam preparation, 875-878
exam registration, 876
excluding, iptables service, 705-706
exec mount option, 343
execute permission
   applying, 159-161
   explained, 158-159
executing
   commands in shell, 36-37
   scripts, 687
   shell jobs, 208-209
exercises
   applying modifications to GRUB 2, 423
   changing connection parameters with
      nmcli, 192-193
   changing Postfix parameters with
      postconf command, 836
   changing rsyslog.conf rules, 307-308
   configuring a Samba server, 809-810
   configuring direct and indirect maps to
      mount NFS shares, 531-532
configuring FTP anonymous drop box, 534-535
configuring Kerberized NFS server, 793-795
configuring Kerberos authorization, 570-571
configuring multiuser SMB mounts, 818-819
configuring network teaming, 669-670
configuring port forwarding, 714
configuring Postfix null client setup, 837-838
configuring Samba server firewalling and SELinux, 812-813
configuring SSH security options, 851
configuring TFTP server for PXE boot, 459-461
connecting to external LDAP server, 144-146
connecting to remote server with public/private keys, 117
creating a database, 772-773
creating custom firewalld service, 707-708
creating file system, 335
creating GPT partitions with gdisk, 331-334
creating logical partitions, 329-330
creating MBR partitions with fdisk, 325-328
creating physical MySQL database backup, 775-776
creating physical volume, 355-357
creating repositories, 259
creating swap partition, 339
creating user accounts, 136-137
creating volume group and logical volumes, 361
currently mounted devices, 65
directory structure, 67-68
discovering and mounting SMB shares, 525
displaying system activity information with sar command, 622
enabling NFS SELinux transparency, 796
exploring troubleshooting targets, 436
file management, 72-73
finalizing iSCSI target configuration, 594-595
firewall management with firewall-cmd command, 506-507
firewall-config command usage, 510-511
grep options, 97
head and tail command usage, 90-91
history file, 40
if.then.else loops, 693
info system, 52
installing and configuring unbound caching name server, 749
installing Apache virtual hosts, 399-400
installing MariaDB, 766-767
installing SELinux-specific man pages, 486
installing VMs, 234-238
internal and external command usage, 37
I/O redirection and pipes, 39-40
isolating targets, 419
journald filtering options, 312-313
less command usage, 89
live log monitoring and logger command, 302-303
loading kernel modules with parameters, 383-384
local time management, 546-547
logging into remote server with SSH, 113
making iSCSI connections, 601-602
man -k command, 51
managing advanced permissions using ACLs, 168
managing basic permissions, 161
managing jobs, 210
managing kernel modules from command line, 381
managing network connections with nmcli, 192
managing processes from command-line, 217
managing time synchronization with chrony command, 870-871
managing units with systemctl, 414
manipulating SELinux modes, 479-480
modifying kernel tunables through `sysctl` command, 636-637
mounting NFS share, 521
mounting partitions through `/etc/fstab`, 343
mounting Samba shares through `automount`, 820
mounting SMB file system, 816
multiple terminals in graphical environment, 108
network configuration validation, 187
network settings validation, 188-189
NFSv4 server configuration, 789-790
package management with `yum`, 271
performing virtual machine network installation with `Kickstart` file, 463
pseudo terminals, 110
relabeling files with `restorecon` command, 488
remote logging setup, 649-650
Rescue a Red Hat System option usage, 437
resizing logical volumes, 365
rich rule usage, 710-711
RPM queries, 275-276
running scheduled tasks through `cron`, 289-290
scheduling jobs with `at`, 291
SELinux `Booleans`, 490-491
setting context label on nondefault Apache document root, 485-486
setting up basic web server, 395
setting up external authentication, 569-570
setting up iSCSI target with `targetcli` utility, 585-588
setting up network installation server, 454
setting up server as KVM `hypervisor` host, 233
shell environment management, 47
surviving advanced Apache topics on RHCE test, 733
switching user accounts, 128-129
symbolic links and hard links, 76
tab completion, 42
tar command usage, 79-80
temporarily changing `/proc` settings, 634
troubleshooting mail servers, 839-840
`vim`, 44-45
working with groups, 139
working with input, 691
working with IPv6 addresses, 676-677
working with positional parameters, 689
working with special permissions, 164
writing simple shell script, 687
`exit statement`, 687
`exports (NFS)`. See `NFS shares`
`Ext2` file system, 334
`Ext3` file system, 334
`Ext4` file system, 334-338
extended partitions, creating, 329-330
Extended Support add-on, 15
`external authentication`
Active Directory, 572
explained, 560-561
ipa client configuration, 572
LDAP. See LDAP (Lightweight Directory Access Protocol)
`external commands`, 36
External default zone (`firewalld`), 503
`Extra Packages for Enterprise Linux (EPEL)`, 253
`extracting`, archive contents, 78
extras repository type, 256
file management, 72-73
    absolute and relative pathnames, 68-69
    archives, 76-77
        creating, 77
        extracting contents, 78
        listing contents, 77-78
tar command usage, 79-80
    compression, 78-79
    copying files, 70-71
    creating links, 74-75
    deleting files, 71-72
    directories, 67-68
    hard links, 73-76
    listing files, 69-70
    moving files, 71
    removing links, 75-76
    symbolic links, 74, 76
tab completion, 69
wildcards, 67
file system hierarchy
    ACL support, 166
directories
        list of, 60
        mounting on dedicated devices, 61-62
        mounting, 61-66
        NFS shares, 519-521
        SMB shares, 522-527
    SELinux. See SELinux
troubleshooting boot problems, 442-443
file systems
    creating, 334-335
    managing
        Ext4 file system properties, 336-338
        XFS file system properties, 338
        mounting
        automatically with /etc/fstab file, 341-343
        with device names, UUIDs, disk labels, 340-341
        information needed, 339-340
        manually, 340
    resizing, 364-365
types of, 334
filenames, RPM packages, 272-273
files
    adding to archives, 77
    copying, 70-71
    deleting, 71-72, 163
    editing, with vim, 42-45
hidden
        copying, 71
        viewing, 70
    listing, 69-70
    moving, 71
    ownership
        changing, 156-157
        default ownership, 157-158
        viewing, 155-156
    permissions
        advanced permissions, 161-164
        applying, 159-161
        drawbacks of, 472
        explained, 158-159
        setting default, 169-170
    renaming, 71
    sharing, NFS (Network File System). See
        NFS (Network File System)
    transferring securely, 115-116
    user extended attributes, 170-172
Filesystem Hierarchy Standard (FHS), 60
filtering text files
    awk command, 97-98
    cut command, 91
    head command, 90-91
    sed command, 97-98
    tail command, 90-91
find command, 156
finding
    context types (SELinux), 486
    man pages, 49-50
findmnt command, 64-65
Firewall Configuration option, 467
firewall-cmd --add-port=3260/tcp
    --permanent command, 595
firewall-cmd command, 506-507, 788, 812
masquerading configuration, 712
options, 507
port forwarding configuration, 713-714
rich rules, 709-711
firewall-cmd --get-services command, 504, 706
firewall-cmd --list-all command, 595
firewall-cmd --reload command, 595
firewalld service, 508-511, 714
firewalld service, 502-503
configuration, 505
firewall-cmd command, 506-507
firewalld-config command, 508-511
rich rules
configuration, 709-711
explained, 708
logging, 711
ordering, 709
syntax, 708-709
services
creating, 706-708
explained, 504-505
zones, 503
firewalls
configuration, for NFSv4, 788
ebtables service, 705
firewalld service, 502-503
configuration, 505-511
rich rules, 708-711
services, 504-505, 706-708
zones, 503
iptables service, 502, 705-706
NAT configuration, 711-712
masquerading, 712
port forwarding, 713-714
netfilter, 502
in NFSv4, 786, 787-788
opening
for iSCSI target, 594-595
for MariaDB network access, 766
Samba file servers, 811-813
fixed IP addresses, 196
fixing, problems. See troubleshooting
FLUSH PRIVILEGES command, 772
for loops, 689, 693-694
forced reset option, 112
foreground jobs, running, 208-209
formatting, partitions, with file systems, 334-335
forwarders, configuration, 749
FQDN (fully qualified domain name), 196
free -m command, 614
free parameter (memory usage), 612
FreeIPA, 140
fs tunable directory, 633
tsck command, 442
fstab file. See /etc/fstab file
FTP servers, configuration, 533-535
fully qualified domain name (FQDN), 196

G

G (vim command), 43
gdisk command, 325, 330-334
getenforce command, 478
getent hosts command, 200
getfACL command, 166-168
getsebool -a command, 489
gg (vim command), 43
gibibyte (GiB), 324
GID field (/etc/passwd file), 130
gigabyte (GB), 324
###GLOBAL DIRECTIVES###
section (rsyslog), 304
GNOME Boxes utility, 241
gpasswd command, 158
GPG keys, 256-258
gpgcheck= option, 255
gpgkey= option, 255
GPT (Guid Partition Table) partitions, 323, 330-334
GRANT command, 771-772
granting permissions

administrator permissions, 128
in databases, 771-772

graphical applications, in SSH (Secure Shell), 114-115

graphical environment, switching terminals, 107-108

graphical interface, mounting SMB shares, 526-527

graphical tools, for time management, 550

grep command, 96-97

group access, Apache private directories, 735-736

group accounts
.configuration files, 138
creating, 138

.grpadd command, 138

.vigr command, 138

property management, 139
types of, 137

group owners
.ACLs, viewing and changing, 165-168
changing, 157-158
viewing, 155-156

groupadd command, 138

grouping, software packages, 268-270

groupmembers command, 139

groupmems command, 139

groupmod command, 139

groups. See volume groups
groups command, 157

GRUB 2 boot loader
accessing boot prompt, 434-435
entering troubleshooting options, 435-436
explained, 420-423
modifying options, 423
reinstalling, 439-442

GRUB_CMDLINE_LINUX parameter, 423

GRUB_TIMEOUT parameter, 423

grubby command, 241

GSSAPIAuthentication option, 852-853

guest ok directive, 807

guest user, mounting SMB shares as, 525

Guid Partition Table (GPT) partitions, 323, 330-334
gunzip command, 79
gzip command, 78-79

hard links, 73
creating, 74-75
removing, 75-76

hardware clock, 542
hwclock command, 544-545
increasing reliability, 543

hardware devices, checking driver availability, 381-383

hardware initialization, 376-378

hardware iSCSI, software iSCSI versus, 582

head command, 88-91, 379

help resources
for commands, 47
documentation files, 53
--help option, 48
info system, 51-52
man pages, 48-51

httpd-manual RPM package, 728, 733-735

hexadecimal IP addresses, 459

hi parameter (CPU usage), 611

hidden files
copying, 71
viewing, 70

High Availability add-on, 15

high-availability clusters, 576

High-Performance Computing (HPC), server variants, 14

history file, 40

history list, for yum actions, 270-271

Home default zone (firewalld), 503

home directories, 133-134

host allow Samba parameter, 806
hostnamectl command, 197, 634
hostnamectl status command, 197, 375
hostnames, 196-198
hosts, 180
  KVM hosts
    networking configuration, 233-234
    system requirements, 231-232
HPC (High-Performance Computing),
  server variants, 14
httpd software package, 392
httpd.conf file, 397
httpd-manual RPM package, 728,
  733-735
hwclock -c command, 544
hwclock command, 543-545
hwclock --htcys command, 544
hwclock --systohc command, 544
hypervisor-based virtualization,
  desktop-based virtualization
  versus, 228

inet_interfaces Postfix parameter,
  833-834
inet_protocols Postfix parameter,
  833, 835
info priority, 306
info system, 51-52
init=/bin/bash boot option, 435
init=/bin/sh boot option, 435
initializing, hardware, 376-378
initiatorname, setting, 596
initiators (iSCSI), 584
  configuration, 596-598
  connecting to target, 598-602
    mounting iSCSI devices, 601-602
    persistent mounts, 600-601
initramfs, 420, 439-442
inodes, 73
input mode (vim), 43
input modules, 644
INSERT command, 770
input modules, 644
installation server setup, 454
  Kickstart files, 462
    automated installation with, 462-463
    manual modifications, 467-469
    modifying with system-config-kickstart
      graphical interface, 464-467
  network server configuration, 454
  PXE boot configuration, 455-456
    creating TFTP PXE server content,
      458-462
    DHCP server configuration, 457-458
    TFTP server installation, 456-457
installation source settings, RHEL 7
  installation, 21
installing
  Apache virtual hosts, 398-400
  Apache web server software, 392
  KVM software, 232-233
  MariaDB, 762-767
  RHEL 7 Server, 17-29. See also
    installation server setup
  Samba, 804
  sealert command, 492
SELinux-specific man pages, 486
semanage command, 483
software packages, 263-265, 271-272
TFTP servers, 456-457
VMs, 234-240
internal clock, 864
internal commands, 36
Internal default zone (firewalld), 503
Internet Protocol (IP) addresses. See IP addresses
I/O redirection
pipes, 39-40
STDIN, STDOUT, STDERR, 37-39
iostat command, 616-618
ip addr show command, 185, 676
IP addresses
binary notation, 182-183
dual fixed and dynamic IP addresses, 196
hexadecimal values, 459
IPv6 addresses, 181
managing, 183
network masks, 181
terminology, 180-181
versions, 180
IP-based virtual hosts, 399
ip link set command, 186
ip link show command, 186
IP masquerading, configuration, 712
ip route show command, 187, 676, 678
ip utility, 185-187
ipa clients, configuration, 572
IPA servers, client configuration, 572
ipa-client-install utility, 572
iptables service, 502, 505, 705-706
IPv4 addresses, 180
broadcast addresses, 181
private network addresses, 180-181
IPv6 addresses, 180-181
common addresses, 673
configuration, 675-676
explained, 673-675
managing, 676-677
troubleshooting, 676
IQN (iSCSI qualified name), 584, 587
iSCSI
architecture, 582-584
connecting to target, 598-602
mounting iSCSI devices, 601-602
persistent mounts, 600-601
Fibre Channel versus, 581-582
hardware versus software solutions, 582
initiator configuration, 596-598
target configuration, 585-595
terminology, 584
troubleshooting, 602-603
iSCSI qualified name (IQN). See IQN (iSCSI qualified name)
iscsi service, 596
iscsiadm command, 584, 596-598
iscsiadm --mode node -P command, 598
iscsid service, 596
isolating, target units, 419
J
j attribute, 171
jobs, scheduling. See scheduling tasks
jobs command, 209
journalctl command, 298, 310-314
journalctl --dmesg command, 374
journalctl -k command, 374
journalctl -o verbose command, 313
journald process, 298, 310
connecting to rsyslog, 646-648
journalctl command, 310-314
permanent journal storage, 314-316
role of, 298-299
K
kcore file, 631
KDC (Key Distribution Center), 562
Kdump, 29
Kerberos, 560-561
explained, 561-562
LDAP configuration with, 564-568
on NFS servers, 786
configuration, 791-794
NFS share mounts, 520-521
principals, 563-564
on Samba shares, 813-815
time synchronization, importance of, 862
kern facility, 305
kernel, 372, 420
analyzing, 374-375
boot arguments, passing, 434
drivers, 373
checking availability, 381-383
loading, 376-378
modules, 375-376
checking driver availability, 381-383
hardware initialization, 376-378
managing, 378-381
parameter management, 383-384
performance optimization. See performance optimization threads, 211-212, 372-373
upgrading, 267, 384
kernel ring buffer, 374
kernel tunable directory, 633
Kernel Virtual Machine. See KVM (Kernel Virtual Machine)
kern.hostname tunable, 637
Key Distribution Center (KDC), 562
key-based authentication, in SSH, 116-118, 853-854
keyboard settings, RHEL 7 installation, 18-21
keytab files, 520, 792, 793
creating, 813-814
viewing contents, 563-564
KiB Mem parameter (memory usage), 612
kibibyte (KiB), 324
Kickstart files, 462
automated installation with, 462-463
manual modifications, 467-469
modifying with system-config-kickstart graphical interface, 464-467
kill command, 211, 216-217
killall command, 217
kilobyte (KB), 324
kiosk exam registration, 876
klist command, 792
klist -k command, 814
kpartx -a command, 445
krb5 security option, 520
krb5i security option, 520, 792
krb5p security option, 520
KVM (Kernel Virtual Machine), 228
host requirements, 231-232
installing software, 232-233
networking configuration, 233-234
VM access
with libvirtd, 229-231
methods of, 240-242
labels
for file systems, 337
mounting file systems, 340-341
SELinux, 477, 481
finding context types, 486
monitoring, 481-482
relabeling, 487-488
setting context types, 483-486
lacp runner, 663
LANG variable, 45
language settings, RHEL 7 installation, 18, 21
launching, browsers, 395
LDAP (Lightweight Directory Access Protocol), 560-561
configuration, with Kerberos authorization, 564-568
connecting to server, 144-146
explained, 140-142
nsclsd service management, 143
platform configuration, 142
LDAP (Lightweight Directory Access Protocol)

RHEL 7 configuration for, 142
sssd service management, 144
less command, 39, 88-89, 379
libvirtd, 229-231
license agreement, accepting, 29
limiting user access. See access control
line anchors, 94-95
lines, counting, in text files, 93
link-local addresses, 674
links
creating, 74-75
hard links, 73-76
removing, 75-76
symbolic links, 74-76
Linux, 11. See also RHEL 7 Server (Red Hat Enterprise Linux 7 Server)
Linux I/O (LIO) target, 585
LIO (Linux I/O) target, 585
Listen parameter, 724
listening ports, 188
SELinux settings, 849-850
SSH configuration, 849
listing
archive contents, 77-78
cron jobs, 289
files, 69-70
kernel modules, 379
package groups, 268-269
shares (Samba), 815-816
software packages, 265-266
list-timezone command, 545
live log file monitoring, 302-303
ln command, 74
ln -s command, 74
load average, 610-611
load printers Samba parameter, 806
load_policy -i command, 443
loadbalance runner, 663
loading
drivers, 376-378
kernel modules, 378, 381-384
local authoritative data, 746
local cached nonauthoritative data, 746
local consoles, login, 106-107
local time, 542
managing, 546-547
time zone settings, 548-549
local_transport Postfix parameter, 833, 835
local0-7 facilities, 305
log file Samba parameter, 806
log files
journald process, 310
connecting to rsyslog, 646-648
journalctl command, 310-314
permanent journal storage, 314-316
role of, 298-299
reading
list of files, 300
live monitoring, 302-303
sample contents, 300-302
remote logging, 648
configuration, 649-650
reasons for using, 648-649
rich rules, 711
rotating, 308-310
rsyslogd modules
configuration, 645-646
reasons for using, 644-645
types of, 644
rsyslogd process
configuration, 303-308
connecting to journald, 646-648
role of, 298-299
SELinux, analyzing, 491-494
types of logging, 298
log reception, enabling, 650
logger command, 302-303
logical backups, 774
logical extents, 365
logical partitions, creating, 329-330
logical unit number (LUN). See LUN (logical unit number)
Logical Volume Manager (LVM). See LVM (Logical Volume Manager)

logical volumes
creating, 354-355
   device names, 361
   physical volume creation, 355-358
   volume group creation, 359-361
   volume size, 360-361
LVM architecture, 352-353
resizing, 353, 363-365
   file system resizing, 364-365
   volume group resizing, 363-364

login
   iSCSI, 584
   key-based login, with SSH, 116-118, 853-854
   local consoles, 106-107
   remote access, with SSH, 112-114
   root login, disabling, 848-849

login shells, 46, 127
LogLevel parameter, 724
logrotate command, 308-310, 648
logrotate service, 284
lookups, with DNS (Domain Name System), 745-747

loops
   case loops, 696-697
   for loops, 689, 693-694
   if.then.else loops, 690-693
   types of, 691-692
   until loops, 696
   while loops, 695-696

lpr facility, 305
ls -a command, 69
ls command, 39, 69-70, 602
ls -d command, 69
ls -l command, 69
ls -lrt command, 69
lsattr command, 172
lsblk command, 358
lsmod command, 378-379
lspci -k command, 381-383
ls-R command, 69
lsscsi command, 599

LUN (logical unit number), 584, 588
lvcreate command, 360-362
lvdisplay command, 362
lvextend command, 364

LVM (Logical Volume Manager), 352
   architecture, 352-353
   features, 353-354
   logical volumes
      creating, 354-362
      resizing, 363-365
LVM volumes, snapshots of, 774-775
lvresize command, 364-365
lvs command, 362, 445

M

MAC addresses, 183
magic file, 397
mail command, 696
mail facility, 305
mail handling
   email transmission process, 829-830
   roles, 828

mail servers
   email transmission process, 829-830
   Postfix
      configuring parameters, 832-838
      null client setup, 837-838
      processes, 830-832
   Sendmail, 830
   troubleshooting, 838-840

mail user agent (MUA), 828
man -f command, 50
man -k _selinux command, 486
man -k command, 49-51
man nmcli-examples command, 659
man pages, 48-49
   finding, 49-50
   mandb updates, 50-51
   for NFS versions, 794
   SELinux-specific pages, installing, 486
managing

cron service security, 289
dependencies, 415-418
file systems
  Ext4 file system properties, 336-338
  XFS file system properties, 338
files, 72-73
  absolute and relative pathnames, 68-69
  archives, 76-80
  compression, 78-79
  copying files, 70-71
  creating links, 74-75
  deleting files, 71-72
  directories, 67-68
  hard links, 73-76
  listing files, 69-70
  moving files, 71
  removing links, 75-76
  symbolic links, 74, 76
  tab completion, 69
  wildcards, 67
IP addresses, 183
IPv6 addresses, 676-677
kernel modules, 378-384
network connections
  with nmcli, 192
  with nmtui, 193-195
parent-child processes, 211
permissions
  advanced permissions, 161-164
  read/write/execute, 158-161
processes. See process management
shell environment, 47
shell jobs, 209-211
software packages
  creating repositories, 259-260
  downloading RPM packages, 275
  finding packages, 261-262
  history list, 270-271
  information about packages, 262-263
  installing packages, 263-265
  listing packages, 265-266
  package groups, 268-270
  removing packages, 265
  repository command, 275
  repositories, explained, 252-253
  repository security, 256-258
  rpm command, 271-272
  rpm database queries, 273
  RPM filenames, 272-273
  rpm package file queries, 273-276
  specifying which repository to use, 253-256
  updating packages, 267
  with yum command, 271
  yum command tasks, 260
target units, 418-419
time
  commands, list of, 543
  date command, 544
  hwclock command, 544-545
  timedatectl command, 545-548
units (systemd), 413-415
VMs (virtual machines)
  from command-line, 243-244
  in Virtual Machine Manager, 242-243
mandb updates, 50-51
MariaDB
  backup and restore procedure, 773-776
  configuration, 762-767
  dynamic content, 733
  installing, 762-767
  network access, 765-766
  security, 763-764
  terminology, 767
mark facility, 305
masquerading, configuration, 712
master process (Postfix), 831
MaxAuthTries option, 850-853
MaxSessions option, 852-853
MBR (Master Boot Record) partitions,
  322-323
  creating, 325-328
  extended and logical partitions, 329-330
MDA (message delivery agent), 828
measurement units, 324
mebibyte (MiB), 324
megabyte (MB), 324
meminfo file, 631
memory usage, 612–613. See also process memory usage; swap usage
message delivery agent (MDA), 828
message transfer agent (MTA), 828
mirrorlist= option, 255
mkdir command, 68
mkfs command, 335
mod probe -r command, 378, 381
mod_php Apache module, 732
mod_wsgi Apache module, 733
modes, SELinux, 477–481
modinfo command, 378–381
modprobe command, 378, 381
modules
Apache web server modules, 398
kernel modules, 375–376
checking driver availability, 381–383
hardware initialization, 376–378
managing, 378–381
parameter management, 383–384
rsyslogd
configuration, 645–646
reasons for using, 644–645
types of, 644
modules file, 631
####MODULES#### section (rsyslog), 304
monitoring, SELinux context labels, 481–482
monitoring performance. See performance monitoring
more command, 89
MOTD_FILE property, 135
mount command, 62–63, 340, 525, 787, 816
mount units, 410, 442–443
mounting, 61–66
file systems
automatically with /etc/fstab file, 341–343
with device names, UUIDs, disk labels, 340–341
information needed, 339–340
manually, 340
iSCSI devices, 601–602
NFS shares, 519, 521
/etc/fstab file, 787
with automount, 531–532
Kerberos requirements, 520–521
NFS version support, 521
persistent mounts, 788
pseudo root mounts, 519
security options, 519–520
systemd process, 790–791
testing access, 787–788
via /etc/fstab file, 528
shares (Samba), 816
automount mounts, 819–820
multiuser mounts, 817–819
SMB shares, 522–525
with automount, 533
as guest, 525
user authentication, 525
via /etc/fstab file, 529–530
via graphical interface, 526–527
moving files, 71
mpstat command, 616
MTA (message transfer agent), 828
MUA (mail user agent), 828
multicast addresses, 675
multiple terminals
in graphical environment, 107–108
in nongraphical environment, 108–109
switching, with screen command, 118–119
multipliers, in regular expressions, 95–96
multitasking, context switches, 620
multiuser Samba mounts, 817–819
multi-user.target file, 412
mv command, 71
MX resource record type, 748
mydestination Postfix parameter, 833, 835
mynetworks Postfix parameter, 833, 835
myorigin Postfix parameter, 833–834
MySQL. See databases
mysql_secure_installation command, 763-764
mysqlldump command, 774

N

name servers
defined, 745
resolving DNS queries, 745-747
name= option, 255
name-based virtual hosts, 398
naming conventions
device names. See device names
initiatorname, 596
network cards, 184
NAS (network-attached storage), SANs
(storage-area networks) versus, 578
NAT (Network Address Translation), 181
configuration, 711-712
masquerading, 712
port forwarding, 713-714
net share -l command, 524
net tunable directory, 633
netfilter, firewalls, 502
net.ipv4.icmp_echo_ignore_all tunable, 637
net.ipv4.icmp_echo_ignore_broadcasts tunable, 637
net.ipv4.ip_forward tunable, 637
netstat command, 187
netstat -tulpen | grep 123 command, 863
Network Address Translation (NAT). See NAT (Network Address Translation)
network addresses, 181
managing, 183
validating configuration, 185-187
network bonding
configuration, 658-662
network teaming versus, 658
network cards, naming conventions, 184
Network Configuration option, 467
Network File System (NFS), 785
network masks, 181
binary notation, 182-183
network servers, configuring as installation servers, 454
network teaming
configuration, 663-671
network bonding versus, 658
runners, 663
troubleshooting, 671-672
Network Time Protocol (NTP). See NTP (Network Time Protocol)
network-attached storage (NAS), SANs
(storage-area networks) versus, 578
networking
aggregated network interfaces, 658
network bonding, 658-662
network teaming, 663-672
configuration
configuration files, 195-196
DNS resolution, 198-200
hostnames, 196-198
for KVM hosts, 233-234
with NetworkManager service, 189
with nmcli, 189-193
with nmtui, 193-195
during RHEL 7 installation, 26
DNS. See DNS (Domain Name System)
IP addresses
binary notation, 182-183
IPv6 addresses, 181
managing, 183
network masks, 181
terminology, 180-181
versions, 180
IPv6 addresses
common addresses, 673
configuration, 675-676
explained, 673-675
managing, 676-677
troubleshooting, 676
MAC addresses, 183
MariaDB access configuration, 765-766
network cards, naming conventions, 184
port addresses, 183
protocols, 183
routing, configuration, 677-679
validation
  network address configuration, 185-187
  network settings, 187-189
  routing, 187
NetworkManager service, 189
NetworkManager utility, custom route configuration, 678
newgrp command, 157-158
news facility, 305
NFS (Network File System), 785
NFS servers
  Kerberos on, 786
    configuration, 791-794
NFS shares
  creating, 786-787
  mounting, 519-521
  /etc/fstab file, 787
    with automount, 531-532
  Kerberos requirements, 520-521
  NFS version support, 521
  pseudo root mounts, 519
  security options, 519-520
  systemd process, 790-791
  via /etc/fstab file, 528
persistent mounts, 788
testing access, 787-788
nfsiostat command, 616
nfss-secure service, 792
nfss-secure-server service, 792
nfss-server service, 792
NFSv4 servers
  configuration, 789-790
    creating exports, 786-787
    firewall configuration, 788
    new features, 785-786
    SELinux configuration, 788-789
    SELinux transparency, 795-796
shares
  mounting, 787, 790-791
  persistent mounts, 788
testing access, 787-788

ni parameter (CPU usage), 611
nice command, 214-216
NIS, 560
NIS+, 560
nmap package, 262-263
nmcli command, 189-193
  IPv6 address configuration, 675-676
  network bonding configuration, 658-660
  network teaming configuration, 663-666
nmcli con add command, 192
nmcli con mod command, 192-193
nmcli con reload command, 196
nmcli con show command, 190
nmcli dev show command, 192
nmcli dev status command, 192
nm-connection-editor command, 194
nm-connection-editor command, 194
nmntui command, 193-197, 658, 678
noatime mount option, 343
noauto mount option, 343
nodes, 180
NOERROR status indicator, 754
noexec mount option, 343
nohup command, 211
nondisclosure agreement, 878
none security option, 520, 791
nonvolatile context switches, 620
notice priority, 306
NS resource record type, 748
ns1cl service, 568
  as authentication backend service, 142, 568
  managing, 143
NTFS file system, 334
NTP (Network Time Protocol), 543
  explained, 863-864
  managing, 546
ntpd process, 546, 862-863
null clients, 828
  configuration, 837-838
troubleshooting, 838-840
numbers, in regular expressions, 95
NXDOMAIN status indicator, 754
o (vim command), 43
ommysql module, 646
open source drivers, closed source drivers versus, 373
opening firewalls
for iSCSI target, 594-595
for MariaDB network access, 766
OpenLDAP, 140
OpenStack, 229
operators, WHERE clause, 770
optimization. See performance optimization
optional repository type, 256
Options parameter, 724
ordering, rich rules, 709
output modules, 644-645
ownership
changing
  group owners, 156-157
  user owners, 156
  default ownership, 157-158
  viewing, 155-156
partitioning settings, RHEL 7 installation, 23-26
partitions, 322
disk device types, 324-325
formatting, with file systems, 334-335
GPT (Guid Partition Table) partitions, 323, 330-334
LVM (Logical Volume Manager). See LVM (Logical Volume Manager)
MBR (Master Boot Record) partitions, 322-323
  creating, 325-328
  extended and logical partitions, 329-330
mounting
  automatically with /etc/fstab file,
  341-343
  information needed, 339-340
  swap partitions, creating, 338-339
partitions file, 631
partprobe command, 328-330
PASS_MAX_DAYS property, 135
PASS_MIN_DAYS property, 135
PASS_WARN_AGE property, 135
passing, kernel boot arguments, 434
passphrases, 117, 853-854
passwd command, 134-135
password field (/etc/passwd file), 130
PasswordAuthentication option, 853
passwords
  changing, permissions needed, 161-162
  property management, 135-136
  RHEL 7 installation, 28
  root password, resetting, 443-444
path directive, 807
pathnames
  absolute pathnames, 68-69
  relative pathnames, 68-69
pausing, shell jobs, 209
PCI devices, checking driver availability, 381-383
pdbedit command, 809
performance monitoring. See also process management
sar command, 621-622
top command, 610
  CPU usage, 611
  customizing display, 615-616
  load average, 610-611
  memory usage, 612-613
  process memory usage, 615
  swap usage, 613-615
utilities
  iostat, 617-618
  list of, 616
  pidstat, 620
  vmstat, 618-619
performance optimization, 630. See also process management
/proc file system, 631
  /proc/sys directory parameters, 633-634
  configuration files, 631
  PID (process ID) directories, 632-633
  sysctl command, 635-637
permanent journal storage, 314-316
permissions
  ACLs, 165
    backing up, 166
    default ACLs, 168
    to DocumentRoot, 726
  file system preparation, 166
    viewing and changing, 166-168
advanced permissions
  applying, 164
  explained, 161-163
copying files, 71
default permissions, setting with umask, 169-170
file permissions, drawbacks of, 472
  granting
    administrator permissions, 128
    in databases, 771-772
ownership settings, viewing, 155-156
read/write/execute
  applying, 159-161
  explained, 158-159
  on Samba shares, 807-808
  on shared directories, preparing for Samba file servers, 804-805
  permissive mode (SELinux), 477-481
  PermitRootLogin option, 853
  persistent mounts (iSCSI), 600-602
  persistent mounts (NFS), 788
  pgrep command, 214
  PHP scripts, 732
  physical backups, 774-776
  physical extent size, 359
  physical volumes, creating, 355-358
  pickup process (Postfix), 831
  PID (process ID), 214
  PID (process ID) directories, 632-633
  pidstat command, 616, 620
  pinfo command, 51-52
  ping6 command, 676
  pipes, 39-40, 88
  pkill command, 217
  policies, SELinux, 477
  PolicyKit, 127-128
  port addresses, 183, 187-189
  port forwarding
    configuration, 713-714
    SSH tunneling configuration, 854-855
  Port option, 853
  portals, 584, 589
  ports. See listening ports
  positional parameters, in shell scripts, 688-689
  postconf command, 832-836
  Postfix
    configuring parameters, 832-838
    null client setup, 837-838
    processes, 830-832
    troubleshooting, 838-840
  Post-Installation Script option, 467
  postqueue -f command, 839
  postqueue -p command, 839
  postsuper -d command, 840
  Pre-Installation Script option, 467
  preparation for exam, 875-878
  primary groups, 137
principals (Kerberos), 563-564
priorities, 304-308
  list of, 306
  of processes, changing, 214-216
private directories, Apache web servers, 735-736
private network addresses, 180-181
privileged user accounts
  unprivileged versus, 126
  working as, 126-127
    PolicyKit, 128
    su command, 127
    sudo command, 128
  switching user accounts, 128-129
privileges. See permissions
problem-solving. See troubleshooting
process ID (PID), 214
process ID (PID) directories, 632-633
process management. See also performance monitoring; performance optimization
  changing priorities, 214-216
  exercises, 217
  kernel threads, 211-212
  ps command, 212-214
  shell jobs
    foreground versus background jobs, 208-209
    managing, 209-211
    parent-child management, 211
  terminating processes, 216-217
  terminology, 208
  top command, 218-220
process memory usage, 615
processes, Postfix, 830-832
property management
  for group accounts, 139
  for user accounts, 134
    default properties, 134-135
    passwords, 135-136
protected software packages, 265
protocols, networking, 183
ps aux | grep dd command, 214
ps aux command, 212, 372-373
ps command, 212-214
ps -ef command, 213
ps fax command, 213
pseudo root mounts, 519, 785
pseudo terminals, 109-110
PTR resource record type, 748
Public default zone (firewalld), 503
PuTTY, 112
pvcreate command, 362
pvcreate --help command, 354-355
pvdisplay command, 358, 362
pvss command, 356, 362
pvscan command, 445
pwd command, 67
PXE boot configuration, 455-456
  creating TFTP PXE server content, 458-462
  DHCP server configuration, 457-458
  TFTP server installation, 456-457
Python scripts, 733
Q
QEMU (Quick Emulator), 228
qmgr process (Postfix), 831
querying
  rpm database, 273
  rpm package files, 273-276
quotation marks ("'"'), escaping regular expressions, 95
R
r command (top utility), 215
rd.break boot option, 435
read command, 689-691
read only directive, 807
read permission
  applying, 159-161
  explained, 158-159
reading. See also viewing
  exam questions, 877
  log files
    list of files, 300
    live monitoring, 302-303
    sample contents, 300-302
realm command, 572
realms (Kerberos), 562
real-time clock, 542
rebooting
  during exam, 111, 878
  RHEL 7 Server, 110-112
records, in databases, 767
recovering. See restoring
recurring tasks, scheduling. See cron
  service
recursive option on commands, 71, 156, 168
Red Hat Enterprise Linux 7 Server. See
  RHEL 7 Server (Red Hat Enterprise Linux 7 Server)
Red Hat Enterprise Virtualization (RHEV), 229
Red Hat Network (RHN), registering
  with, 253
Red Hat Package Manager (RPM)
  format, 252
  database queries, 273
  downloading packages, 275
  filenames, 272-273
  package file queries, 273-276
redirection. See I/O redirection
redundant network architecture, 583
reference clock, 863
registering, with RHN (Red Hat Network), 253
registration for exam, 876
regular expressions, 93-96
  escaping, 95
  grep command, 96-97
  line anchors, 94-95
  wildcards and multipliers, 95-96
reinstalling, GRUB 2 boot loader, 439-442
relabeling, file system (SELinux), 487-488
relative mode, applying permissions, 159-161
relative pathnames, 68-69
relayhost Postfix parameter, 833-834
remote access, SSH (Secure Shell), 112-114
remote authentication
  Active Directory, 572
  explained, 560-561
  ipa client configuration, 572
  LDAP, with Kerberos authorization, 564-568
remote logging, 648
  configuration, 649-650
  reasons for using, 648-649
remote non-authoritative data via recursion, 746
remote-fs.target systemd unit, 788
removing
  links, 75-76
  software packages, 265
renaming files, 71
renice command, 214-216
repoquery command, 275
repositories. See also software packages
  accessing, 13-14
  creating, 259-260
  explained, 252-253
  security, 256-258
  specifying which to use, 253-256
Require All parameter, 724
requirements. See system requirements
rescue disks
  re-creating initramfs, 439-442
  reinstalling GRUB 2 boot loader, 439-442
  restoring system access from rescue disk, 437
    starting from, 436
rescue.target mode, 435-436
resetting root password, 443-444
resident memory, 615
Resilient Storage add-on, 15
resizing logical volumes, 353, 363-365
file system resizing, 364-365
volume group resizing, 363-364
resolving DNS queries, 745-747
resource records, 745-748
restorecon command, 487-488
restoring
default file contexts, SELinux, 487-488
MariaDB databases, 773-776
system access
/etc/fstab file, 442-443
from rescue disk, 437
VM access, 444-446
retrieving, user account information, 126
rewrite process (Postfix), 831
RHEL 7 Server (Red Hat Enterprise Linux 7 Server)
benefits, 11
configuring for LDAP, 142
course environment setup, 16-17
installing, 17-29. See also installation source settings
obtaining
CentOS 7, 12-13
Fedora, 13
paid version, 12
Scientific Linux, 13
rebooting, 110-1112
repository access, 13-14
system requirements, 15
variants and add-ons, 14-15
version information, 375
RHEV (Red Hat Enterprise Virtualization), 229
RHN (Red Hat Network), registering with, 253
rich rules
configuration, 709-711
explained, 708
logging, 711
ordering, 709
syntax, 708-709
rm command, 71-72
rm -f command, 72
rm -r command, 71
rmdir command, 68
rmmod command, 381
ro mount option, 343
roles, in mail handling, 828
root directory, 60
root domain (.), 744
root password, resetting, 443-444
root user account, 126
disabling root login, 848-849
working as, 126-127
PolicyKit, 128
su command, 127
sudo command, 128
switching user accounts, 128-129
rotating log files, 308-310
roundrobin runner, 663
routers, 180
routing
configuration, 677-679
validation, 187
RPM (Red Hat Package Manager) format, 252
database queries, 273
downloading packages, 275
filenames, 272-273
package file queries, 273-276
rpm command, 271-272
database queries, 273
package file queries, 273-276
rpm -q --scripts command, 274
rpm -qa command, 274
rpm -qc command, 274
rpm -qd command, 274
rpm -qf command, 274
rpm -qi command, 274
rpm -ql command, 274
rpm -qp command, 274
rpm -qR command, 274
rpm -V command, 274
rpm -Va command, 274
rsync command, 116
rsyslog.conf file, sections, 304
rsyslogd process, 298
configuration, 303-308
facilities, priorities, destinations, 304-308
file locations, 303
rsyslog.conf sections, 304
connecting to journald, 646-648
modules
configuration, 645-646
reasons for using, 644-645
types of, 644
role of, 298-299
rules, SELinux, 477
###RULES### section (rsyslog), 304
run levels, 412
runners, in network teaming, 663
running. See executing
Running process state, 218

S

s attribute, 171
sa processes, starting, 621
Samba file servers
configuration, 809-810
/etc/samba/smb.conf file, 805-806
creating shares, 807-808
creating users, 808-809
installing Samba, 804
for keytab files, 814-815
preparing shared directories, 804-805
troubleshooting, 810
security
firewalls, 811-813
Kerberized shares, 813-815
SELinux settings, 810-811
shares
automount mounts, 819-820
discovering, 815-816
mounting, 816
multiuser mounts, 817-819

SANs (storage-area networks), 576
iSCSI
architecture, 582-584
connecting to target, 598-602
Fibre Channel versus, 581-582
hardware versus software solutions, 582
initiator configuration, 596-598
target configuration, 585-595
terminology, 584
troubleshooting, 602-603
NAS (network-attached storage) versus, 578
SAP business applications, server
variants, 14
SAP HANA, server variants, 14
sar command, 621-622
scheduling tasks
atd service, 290-291
cron service, 284-285
anacron service, 288-289
configuration files, 286-288
exercises, 289-290
listing cron jobs, 289
managing, 284-285
security management, 289
time and date fields, 285-286
Scientific Linux, 13
scp command, 115-116
screen command, 118-119
ScriptAlias parameter, 724
scripts. See shell scripts
sealert command, 492-494
searching text files
awk command, 97-98
grep command, 96-97
regular expressions, 93-96
sed command, 97-98
sec=method option, 792
second-level domains, 744
secondary groups, 137
Secure Shell. See SSH (Secure Shell)
security
authentication. See user authentication
cache-only DNS servers, 749
file permissions, drawbacks of, 472
MariaDB, 763-764
NFS shares, 519-520
permissions. See permissions
private directories, 735-736
repositories, 256-258
Samba file servers
firewalls, 811-813
Kerberized shares, 813-815
SELinux settings, 810-811
SELinux. See SELinux
SSH (Secure Shell), 848
configuration, 851
configuring alternative ports, 849
disabling root login, 848-849
limiting user access, 850-851
SELinux settings, 849-850
TLS (Transport Layer Security)
configuration, 727-731
trust anchors, 751-752
security facility, 305
security management, for cron service, 289
security message, in remote access, 114
security Samba parameter, 806
sed command, 97-98
SELECT command, 770
selecting, repositories, 253-256
SELinux
Apache web server settings, 725
Boolean settings, 489-491
configuration, for NFSv4, 788-789
contexts, 481
finding context types, 486
monitoring, 481-482
relabeling, 487-488
setting context types, 483-486
modes, 477-481
Samba settings, 810-811
SSH port changes, 849-850
terminology, 477
transparency, in NFSv4, 795-796
troubleshooting, 491-494
semanage boolean -l command, 489
semanage command, 483-485, 535
semanage port command, 849-850
sending, signals, to processes, 216-217
Sendmail, 830
sendmail process (Postfix), 831
Server Message Block (SMB). See Samba
file servers; SMB shares
Server with GUI option, RHEL 7
installation, 22
ServerAdmin parameter, 724
ServerAliveCountMax option, 852-853
ServerAliveInterval option, 852-853
ServerRoot parameter, 393, 724
servers, web servers. See Apache web
servers
SERVFAIL status indicator, 754
service files, 505
service units, 409-412
dependency management, 415-418
managing, 413-415
target management, 418-419
services
enabling, 418-419
in firewalld service
creating, 706-708
explained, 504-505
session options, in SSH, 852
sestatus command, 478
set group ID (SGID) permission
applying, 164
explained, 162-163
set user ID (SUID) permission
applying, 164
explained, 161-162
setenforce command, 478
setfacl command, 166-168
setfacl -m d command, 168
setfacl -R command, 168
set-local-rtc command, 545
set-ntp command, 545
setsebool command, 490
set-time command, 545
set-timezone command, 545
setup. See configuration
SGID (set group ID) permission
   applying, 164
   explained, 162-163
shares (NFS). See NFS shares
shares (Samba). See also SMB shares
   creating, 807-808
discovering, 815-816
Kerberos on, 813-815
mounting, 816
   automount mounts, 819-820
   multiuser mounts, 817-819
sharing
directories
   permissions needed, 162-163
   preparing for Samba file servers, 804-805
files. See NFS (Network File System)
shebang (in scripts), 686
shell, 36
   command execution, 36-37
   history file, 40
   I/O redirection
   pipes, 39-40
       STDIN, STDOUT, STDERR, 37-39
   tab completion, 42
shell environment, 45
   configuration files, 46
   managing, 47
   starting with su - command, 127
   umask setting, 169-170
   user communication in, 46-47
   variables, 45-46
shell field (/etc/passwd file), 131
shell jobs, 208
   foreground versus background jobs, 208-209
   managing, 209-211
   parent-child management, 211
shell scripts
   conditional loops
      case loops, 696-697
      if.then.else loops, 692-693
      for loops, 693-694
      types of, 691-692
      until loops, 696
      while loops, 695-696
debugging, 697-698
   explained, 686-687
   positional parameters, 688-689
   variables, 689-691
show databases command, 767
SHOW TABLES command, 768
showing. See viewing
showmount command, 521, 787-788
   si parameter (CPU usage), 611
SIGHUP signal, 216
SIGKILL signal, 216
signals, sending to processes, 216-217
SIGTERM signal, 216
sizing, logical volumes, 360-361
skeleton directory, 134
SLAAC (stateless address autoconfiguration), 675
Sleeping process state, 218
Smart Management add-on, 15
SMB (Server Message Block). See Samba file servers
SMB shares. See also shares (Samba)
discovering, 523-525
mounting, 522-525
   with automount, 533
   as guest, 525
   user authentication, 525
   via /etc/fstab file, 529-530
   via graphical interface, 526-527
smbclient -L command, 523-524, 815-816
smbpasswd command, 808
smtp process (Postfix), 831
snapshots, 353-354, 774-775
SOA resource record type, 748
socket units, 410-411
soft links. See symbolic links
software clock, 542
software iSCSI, hardware iSCSI versus, 582
software packages
downloading RPM packages, 275
repoquery command, 275
repositories
creating, 259-260
explained, 252-253
security, 256-258
specifying which to use, 253-256
rpm command, 271-272
database queries, 273
package file queries, 273-276
RPM filenames, 272-273
yum command
finding packages, 261-262
history list, 270-271
information about packages, 262-263
installing packages, 263-265
list of tasks, 260
listing packages, 265-266
managing packages, 271
package groups, 268-270
removing packages, 265
updating packages, 267
sort command, 88, 91-92
sorting
performance parameters, 615
text files, sort command, 91-92
source domains, SELinux, 477
SRV resource record type, 748
ss command, 187
ss -lt command, 187
SSH (Secure Shell), 112
configuration
connection keepalive options, 852
options, 853
session options, 852
tunneling, 854-855
graphical applications in, 114-115
key-based authentication in, 116-118, 853-854
remote access, 112-114
screen command, 118-119
security, 848
configuration, 851
configuring alternative ports, 849
disabling root login, 848-849
limiting user access, 850-851
SELinux settings, 849-850
transferring files, 115-116
VM access, 241
ssh command, 112-114
ssh -p command, 115
ssh -v command, 114-115
ssh -X command, 115
ssh-add command, 854
ssh-agent command, 854
ssh-copy-id command, 117
ssh-keygen command, 117
sssd service, 567
as authentication backend service, 142, 568
managing, 144
sample configuration file contents, 571-572
st parameter (CPU usage), 611
standard error, 37-39
standard input, 37-39
standard output, 37-39
star command, 78, 166
starting sa processes, 621. See also boot procedure
stateless address autoconfiguration (SLAAC), 675
status command, 545
STDERR, 37-39
STDIN, 37-39
STDOUT, 37-39
Stevens, Brian, 12
sticky bit
  applying, 164
  explained, 163

Stopped process state, 218
stopping
  processes, 216-217
  shell jobs, 209

storage
  LVM (Logical Volume Manager). See LVM (Logical Volume Manager)
  measurement units, 324
  partitions. See partitions
  swap files, creating, 339

storage-area networks. See SANs (storage-area networks)
stratums, 863-864
su - command, 107, 127
su command, 127
subdomains, 745
subnet masks, 181
  binary notation, 182-183
  IPv6 addresses, 673

subshells, 46
sudo command, 127-128
SUID (set user ID) permission
  applying, 164
  explained, 161-162

sunrpc tunable directory, 633
superuser account. See root user account
supplementary repository type, 256
swap files, creating, 339
swap partitions, creating, 338-339
swap usage, 613-615
swapon -s command, 615

switching
  terminals
    in graphical environment, 107-108
    in nongraphical environment, 108-109
    with screen command, 118-119
  user accounts
    exercises, 128-129
    with su command, 127
  between VMs, 469

sy parameter (CPU usage), 611
symbolic links
  creating, 74-75
  removing, 75-76

synchronization of time
  chronyc command, 866-871
  chronyd process, 862-863
  chronyd process configuration, 864-866
  importance of, 862
  monitoring status, 547
  NTP (Network Time Protocol), 863-864

sys security option, 520
sysctl -a command, 635-636
sysctl command, 635-637
syslog facility, 305
syslogd process, 298
SYSLOGD_OPTIONS variable, 303
sysrq-trigger file, 631

system accounts, 129
system logging
  journal process, 310
    connecting to rsyslog, 646-648
    journalctl command, 310-314
    permanent journal storage, 314-316
    role of, 298-299
  reading log files
    list of files, 300
    live monitoring, 302-303
    sample contents, 300-302
  remote logging, 648
    configuration, 649-650
    reasons for using, 648-649
  rich rules, 711
  rotating log files, 308-310
  rsyslogd modules
    configuration, 645-646
    reasons for using, 644-645
    types of, 644
  rsyslogd process
    configuration, 303-308
    connecting to journald, 646-648
    role of, 298-299
  types of, 298
system optimization. See performance optimization

system requirements
  KVM hosts, 231-232
  RHEL 7 Server (Red Hat Enterprise Linux 7 Server), 15

system time, 542
  date command, 544
  hardware clock versus, 544-545
  increasing reliability, 543

system-config-date command, 550
system-config-kickstart graphical interface, modifying Kickstart files, 464-467

systemctl command, 413-415
  enable target command, 594
  --failed --type=service command, 415
  get-default command, 420
  halt command, 111
  list-dependencies command, 416
  list-units --type=service --all command, 415
  list-units --type=service command, 415
  mask command, 417-418
  mask iptables command, 505, 705-706
  poweroff command, 111
  reboot command, 111
  set-default command, 420
  show command, 411-412
  start nscd command, 143
  start target command, 594
  status chronyd command, 869-870
  status command, 299, 396, 414-415
  status crond -l command, 284
  status iscsi command, 602
  status -l command, 415
  status -l libvirtd command, 229
  status mariadb command, 762

systemctl status NetworkManager command, 189
systemctl status nscd command, 143
systemctl status sssd command, 144
systemctl status target command, 602
systemctl -t help command, 408
systemctl --type=service command, 415
systemctl --type=target --all command, 419
systemctl --type=target command, 419

systemd process, 298, 790-791
  explained, 408
  rebooting, 111
  unit types, 408
    default targets, setting, 420
    dependency management, 415-418
    isolating targets, 419
    service units, 409-412
    target management, 418-419
    target units, 412-413
    unit management, 413-415
    wants, 413

systemd-journald service. See journald process

systemd-sysctl service, 635
systemd-udevd process, 376-378
systemd.unit=emergency.target boot option, 435
systemd.unit=rescue.target boot option, 435

T

tab completion, 42, 69, 354

tables, in databases, 767
tac command, 90
tail command, 88, 90-91
tail -f command, 302-303
tainted kernel, 373
tar -c command, 79
tar -C command, 79
tar -cf command, 77
tar command, 76-80
  compression, 79
  creating archives, 77
  extracting archive contents, 78
  lack of ACL support, 166
  listing archive contents, 77-78
  options, 79
  tar -f command, 79
  tar -j command, 79
  tar -r command, 77, 79
  tar -t command, 77, 79
  tar -u command, 77, 79
  tar -x command, 79
  tar -xvf command, 78
  tar -z command, 79
  target domains, SELinux, 477
  target portal group (TPG), 584
  target units, 412-413
    default targets, setting, 420
    isolating, 419
    managing, 418-419
    starting troubleshooting targets, 435-436
  targetcli command, 585-594, 602
  targets (iSCSI), 584
    configuration, 585-595
    connecting to, 598-602
      mounting iSCSI devices, 601-602
      persistent mounts, 600-601
  tasks, scheduling. See scheduling tasks
  TCP (Transfer Control Protocol), 183, 650
  TCPKeepAlive option, 852-853
  teamd driver, 663
  teamdctl command, 666
  teamdctl team0 config dump command, 672
  teaming. See network teaming
  teamnl command, 671-672
  terminals
    consoles versus, 106
    pseudo terminals, 109-110
  switching
    in graphical environment, 107-108
    in nongraphical environment, 108-109
    with screen command, 118-119
  terminating
    background jobs, 211
    processes, 216-217
  test command, 690, 692
  testing
    Apache web servers, 395-396
    NFS server access, 787-788
  testparm command, 808
  text consoles, login, 106-107
  text files
    commands
      awk, 97-98
      cat, 89
      cut, 91
      grep, 96-97
      head, 90-91
      less, 88-89
      list of, 88
      sed, 97-98
      sort, 91-92
      tac, 90
      tail, 90-91
      wc, 93
    counting lines, words, characters, 93
    filtering
      awk command, 97-98
      cut command, 91
      head command, 90-91
      sed command, 97-98
      tail command, 90-91
    searching
      awk command, 97-98
      grep command, 96-97
      regular expressions, 93-96
      sed command, 97-98
    sorting, 91-92
    viewing
      cat command, 89
      less command, 88-89
      tac command, 90
text-only consoles, VM access, 241-242
TFTP (Trivial File Transfer Protocol) servers
creating content, 458-462
installing, 456-457
threads, 208, 211-212, 372-373
tickets (Kerberos), 562
time
epoch time, 544
hardware time, hwclock command, 544-545
synchronization
chronyc command, 866-871
chronyd process, 862-863
chronyd process configuration, 864-866
importance of, 862
monitoring status, 547
NTP (Network Time Protocol), 863-864
system time
date command, 544
increasing reliability, 543
termiology, 542
time fields, cron service, 285-286
time indicator, for kernel messages, 375
time management
commands
date, 544
hwclock, 544-545
list of, 543
timedatectl, 545-548
graphical tools for, 550
time zone settings, 548-549
Time To Live (TTL), 746-748
time zone settings, 548-549
timedatectl command, 543-548
TLS (Transport Layer Security)
certificates, 141
configuration, 727-731
tls_reqcert parameter, 143
top command, 244, 610
CPU usage, 611
customizing display, 615-616
load average, 610-611
memory usage, 612-613
process memory usage, 615
process states, 218-220
swap usage, 613-615
top-level domains, 744-745
touch command, 68
TPG (target portal group), 584
tracepath6 command, 676
Transfer Control Protocol (TCP). See
TCP (Transfer Control Protocol)
transferring, files, 115-116
transparency, SELinux, in NFSv4,
794-796
Transport Layer Security (TLS),
727-731
certificates, 141
configuration, 727-731
Trivial File Transfer Protocol (TFTP) servers
creating content, 458-462
installing, 456-457
troubleshooting
boot procedure
accessing GRUB boot prompt, 434-435
overview by boot phase, 433
recovering from file system issues,
442-443
re-creating initramfs, 439-442
reinstalling GRUB 2 boot loader,
439-442
resetting root password, 443-444
restoring system access from rescue
disk, 437
starting from rescue disk, 436
starting troubleshooting targets, 435-436
DNS (Domain Name System), 752-755
client issues, 755
dig command, 753-754
dumping unbound cache, 753
firewall-config command, 508
IPv6 addresses, 676
iSCSI, 602-603
Kickstart installation, 469
mail servers, 838-840
network teaming, 671-672
Samba configuration, 810
SELinux, 480, 491-494
shell scripts, 697-698
unbound caching servers, 751
trust anchors, configuration, 751-752
trusted default zone (firewalld), 503
TTL (Time To Live), 746-748
tune2fs command, 336-338
tuning. See performance optimization
tunneling (SSH), configuration, 854-855
TXT resource record type, 748
type command, 36
tzselect command, 548-549

u (vim command), 43
u attribute, 171
udevadm monitor command, 376-378
UDP (User Datagram Protocol), 183, 650
UID field (/etc/passwd file), 130
UID_MIN property, 135
umask setting, 169-170
umount command, 340
uname command, 375
uname -i command, 231
unbound
  as cache-only DNS server, 749-751
dumping unbound cache, 753
unbound-control dump_cache
command, 753
unbound-control-setup command, 751
Uninterruptable sleep process state, 218
unique local addresses, 674
units (systemd)
  dependency management, 415-418
  managing, 413-415
  mount units, troubleshooting, 442-443
  service units, 409-412
target units, 412-413
  default targets, setting, 420
  isolating, 419
  managing, 418-419
  starting troubleshooting targets, 435-436
types of, 408
  wants, 413
universal time coordinated (UTC). See
  UTC (universal time coordinated)
unloading, kernel modules, 381
unprivileged user accounts, privileged
  versus, 126
until loops, 696
UPDATE command, 770
updates repository type, 256
updating
  archives, 77
  mandb, 50-51
  software packages, 267
upgrading, kernel, 267, 384
us parameter (CPU usage), 611
USE command, 768
used parameter (memory usage), 612
UseDNS option, 852-853
user accounts
  configuration files
    default properties, 134-135
    editing, 132-133
    properties of, 129-132
  creating, 132, 136-137
    directly in configuration files, 132-133
    user environments, 136
    useradd command, 133
  deleting, 132
  groups. See group accounts
  home directories, 133-134
  login, which to use, 106-107
  privileged versus unprivileged, 126
  property management, 134
    default properties, 134-135
    passwords, 135-136
  retrieving information about, 126
root user account, working as, 126-127
switching
   exercises, 128-129
   with su command, 127
system accounts, 129
user authentication
Active Directory, 572
for databases, 771-772
ipa client configuration, 572
IPA server preparation,
Kerberos. See Kerberos
   explained, 561-562
   principals, 563-564
LDAP
   configuration with Kerberos
   authorization, 565-568
   connecting to server, 144-146
   explained, 140-142
   nsclsd service management, 143
   platform configuration, 142
   RHEL 7 configuration for, 142
   sssd service management, 144
NFS shares, 519-520
nsclsd service, as backend service, 568-
   remote authentication, explained, 560-561
SMB shares, 525
in SSH, 116-118, 853-854
   sssd service, as backend service, 568
user communication, in shell
environment, 46-47
User Datagram Protocol (UDP). See
   UDP (User Datagram Protocol)
user environments, creating, 136
user extended attributes, 170-172
user facility, 305
user owners
   ACLs, changing, 168
   changing, 156
   default ownership, changing, 157-158
   viewing, 155-156
user settings, RHEL 7 installation, 27-28
user_xattr option, 171, 343
useradd command, 133-135
userdel command, 132
userdel -r command, 132
USERGROUPS_ENAB property, 135
usermod command, 134, 139
username field (/etc/passwd file), 130
users (Samba), creating, 808-809
UTC (universal time coordinated), 542
utilities. See commands
   uucp facility, 305
   UUIDs, mounting file systems, 340-341

V

v (vim command), 43
valid users directive, 807
validation
   network address configuration, 185-187
   network settings, 187-189
   routing, 187
   VM configuration file XML code, 238
values, in databases, 767
variables
   in shell environment, 45-46
   in shell scripts, 689-691
variants, list of, 14
verifying. See validation
VFAT file system, 334
vchange command, 445
vgcreate command, 359, 362
vgdisplay command, 360, 362
vgextend command, 363
vgreduce command, 363
vgs command, 360-363
vi, 42
viewing
   ACLs, 166-168
   bridging configuration, 234
   connection properties, 190
   connection status, 190
   device status, 192
   effective primary group, 157
   hidden files, 70
   hostname configuration, 197
   keytab file contents, 563-564
wildcards

ownership, 155-156
text files
  cat command, 89
  less command, 88-89
  tac command, 90
vigr command, 133, 138
vim, 42-45
vimtutor command, 44
vipw command, 133
virsh command, 243-244
virsh console command, 241, 243
virsh destroy command, 243
virsh dumpxml vmname | grep “source
  files” command, 444
virsh edit command, 240, 243
virsh help command, 243
virsh list --all command, 243
virsh list command, 241, 243
virsh reboot command, 243
virsh shutdown command, 243
virsh start command, 243
virtual hosts
  creating, 398-400
  editing configuration, 726-727
Virtual Machine Manager, 240-243
virtual machines (VMs). See VMs (virtual
  machines)
virtual memory
  explained, 615
  usage information, 618-619
virtual terminals, 108-109
virtualization
  KVM, 228
    host requirements, 231-232
    installing software, 232-233
    networking configuration, 233-234
  libvirt, 229-231
  OpenStack, 229
  QEMU, 228
  RHET, 229
  VMs
    accessing, 240-242
    installing, 234-240
    managing, 242-244
    monitoring, 244
    recovering access to, 444-446
virt-viewer command, 241
vm tunable directory, 633
VMs (virtual machines)
  accessing
    with libvirt, 229-231
  methods of, 240-242
  recovering access to, 444-446
  installing, 234-240
  managing
    from command-line, 243-244
    in Virtual Machine Manager, 242-243
  monitoring, 244
  switching between, 469
vmstat command, 616-619
vmstat -s command, 619
vm.stat swappiness tunable, 637
volume groups
  creating, 359-361
  resizing, 363-364
volumes
  logical volumes. See logical volumes
  physical volumes, creating, 355-358
voluntary context switches, 620

W

wa parameter (CPU usage), 611
wants (systemd), 413
warning priority, 306
wc command, 88, 93
Web Server Gateway Interface (WSGI), 733
web servers. See Apache web servers
WHERE clause, 770
which command, 36
while loops, 695-696
wildcards
  in automount, 532-533
  file management, 67
  in regular expressions, 95-96
windows. See terminals
words, counting, in text files, 93
work default zone (firewalld), 503
workgroup Samba parameter, 806
writable directive, 807
write list directive, 807
write permission
applying, 159-161
configuring to DocumentRoot, 726
explained, 158-159
on Samba shares, 807-808
WSGI (Web Server Gateway Interface), 733

X
x forwarding, 115
XFS file system, 25, 334
managing properties, 338
resizing, 365
xfs_admin command, 338
xfs_admin -L command, 341
xinetd service, TFTP server installation, 456-457
x-systemd.automount mount option, 528, 529

Y
yum command
finding packages, 261-262
history list, 270-271
information about packages, 262-263
installing packages, 263-265
list of tasks, 260
listing packages, 265-266
managing packages, 271
package groups, 268-270
removing packages, 265
repositories
creating, 259-260
explained, 252-253
security, 256-258
specifying which to use, 253-256
rpm command versus, 271-272
updating packages, 267
yum groups info command, 269-270
yum groups install command, 392
yum groups list command, 268-269, 392
yum history command, 270-271
yum info command, 262-263
yum install command, 263-265
yum install elinks command, 395
yum install httpd command, 392
yum install kernel command, 384
yum install -y screen command, 118
yum list command, 265-266
yum list installed command, 266
yum list kernel command, 266
yum provides command, 262
yum remove command, 265
yum repolist command, 260
yum search command, 261-262
yum search http command, 392
yum update command, 267
yum upgrade kernel command, 384
yum whatprovides command, 262, 483
yumdownloader command, 260, 275
yy (vim command), 43

Z
Zombie process state, 218
zones, 503, 745
This page intentionally left blank