CCNA

Portable Command Guide

Second Edition

All the CCNA 640-802 commands in one compact, portable resource

ciscopress.com

Scott Empson

Steps to Configuring a Router

1. Create an IP plan as per your diagram.
   a. Subnetting
   b. VLSM
2. Cable your equipment as per your diagram.
3. Establish a basic router configuration.
   a. Host names
   b. Passwords:
      i. Secret
      ii. Console
      iii. Terminal—vty
      iv. Auxiliary
   c. Turn off DNS so spelling mistakes will not slow you down
   d. Banners: login or MOTD
4. Configure your interfaces.
   a. Addresses
   b. Masks
   c. Clock rates (for serial DCE interfaces)
   d. Descriptions
5. Create IP host name tables for remote access.
6. Configure routing.
   a. Static
   b. Default
   c. Dynamic—Pick the routing protocol that best suits your needs:
      i. RIP-2
      ii. OSPF
      iii. EIGRP
7. Configure access control lists (ACLs).
   a. Standard
   b. Extended
   c. Named
8. Change the WAN encapsulation type.
   a. PPP:
      i. Authentication: CHAP
      ii. Authentication: PAP
   b. HDLC, if returning to default
9. Apply advanced IP configuration as necessary.
   a. NAT/PAT
   b. DHCP
10. Save your configuration.
    a. Locally
    b. Remote

CCNA Portable Command Guide
Second Edition

Scott Empson

Cisco Press
800 East 96th Street
Indianapolis, Indiana 46240 USA

CCNA Portable Command Guide, Second Edition

Scott Empson

Published by:
Cisco Press
800 East 96th Street
Indianapolis, IN 46240 USA

Printed in the United States of America

Eighth Printing June 2011

Library of Congress Cataloging-in-Publication Data

Empson, Scott.

Portable command reference / Scott Empson. -- 2nd ed.

p. cm.

ISBN 978-1-58720-193-6 (pbk.)

1. Computer networks--Examinations--Study guides. 2. Internetworking (Telecommunication)--Examinations--Study guides. 3. Electronic data processing personnel--Certification. I. Title.

TK5105.5.E4352 2007

004.6--dc22

2007023863

ISBN-13: 978-1-5872-0193-6

ISBN-10: 1-58720-193-3

Warning and Disclaimer

This book is designed to provide information about the Certified Cisco Networking Associate (CCNA) exam and the commands needed at this level of network administration. Every effort has been made to make this book as complete and as accurate as possible, but no warranty or fitness is implied.

The information is provided on an “as is” basis. The author, Cisco Press, and Cisco Systems, Inc. shall have neither liability nor responsibility to any person or entity with respect to any loss or damages arising from the information contained in this book or from the use of the discs or programs that may accompany it.

The opinions expressed in this book belong to the author and are not necessarily those of Cisco Systems, Inc.

Trademark Acknowledgments

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. Cisco Press or Cisco Systems, Inc., cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

Corporate and Government Sales

The publisher offers excellent discounts on this book when ordered in quantity for bulk purchases or special sales, which may include electronic versions and/or custom covers and content particular to your business, training goals, marketing focus, and branding interests. For more information, please contact: **U.S. Corporate and Government Sales**
1-800-382-3419 corpsales@pearsontechgroup.com

For sales outside the United States please contact: **International Sales**
international@pearsoned.com

Feedback Information

At Cisco Press, our goal is to create in-depth technical books of the highest quality and value. Each book is crafted with care and precision, undergoing rigorous development that involves the unique expertise of members from the professional technical community.

Readers' feedback is a natural continuation of this process. If you have any comments regarding how we could improve the quality of this book, or otherwise alter it to better suit your needs, you can contact us through e-mail at feedback@ciscopress.com. Please make sure to include the book title and ISBN in your message.

We greatly appreciate your assistance.

Publisher	Paul Boger
Associate Publisher	Dave Dusthimer
Cisco Representative	Anthony Wolfenden
Cisco Press Program Manager	Jeff Brady
Executive Editor	Mary Beth Ray
Managing Editor	Patrick Kanouse
Senior Development Editor	Christopher Cleveland
Project Editor	Meg Shaw
Copy Editor	Keith Cline
Technical Editors	Robert Elling, Philip Vancil
Editorial Assistant	Vanessa Evans
Cover Designer	Louisa Adair
Composition	ICC Macmillan Inc.
Proofreader	Karen A. Gill

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
168 Robinson Road
#28-01 Capital Tower
Singapore 068912
www.cisco.com
Tel: +65 6317 7777
Fax: +65 6317 7799

Europe Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: +31 0 800 020 0791
Fax: +31 0 20 357 1100

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at **www.cisco.com/go/offices.**

About the Author

Scott Empson is the associate chair of the Bachelor of Applied Information Systems Technology degree program at the Northern Alberta Institute of Technology in Edmonton, Alberta, Canada, where he teaches Cisco routing, switching, and network design courses in a variety of different programs (certificate, diploma, and applied degree) at the post-secondary level. Scott is also the program coordinator of the Cisco Networking Academy Program at NAIT, a Regional Academy covering Central and Northern Alberta. He has earned three undergraduate degrees: a Bachelor of Arts, with a major in English; a Bachelor of Education, again with a major in English/Language Arts; and a Bachelor of Applied Information Systems Technology, with a major in Network Management. He currently holds several industry certifications, including CCNP, CCDA, CCAI, and Network+. Before instructing at NAIT, he was a junior/senior high school English/Language Arts/Computer Science teacher at different schools throughout Northern Alberta. Scott lives in Edmonton, Alberta, with his wife, Trina, and two children, Zachariah and Shaelyn, where he enjoys reading, performing music on the weekend with his classic/80s rock band "Miss Understood," and studying the martial art of Taekwon-Do.

About the Technical Reviewers

Robert Elling is a content consultant in the Learning@cisco group in Florida. He works in the Data Center/Foundation group supporting the CCNA, CCNP, and CCIP curriculum. Before coming to Cisco, he worked for Bell Atlantic as a senior network analyst in the Networking Operation Center in Harrisburg, Pennsylvania. He holds numerous certifications, including CNE, ECNE, MCSE, CCNA, CCNP, and CCIP.

Philip Vancil is a technical education consultant with Cisco and has been in the communication industry for more than 20 years. Phil has extensive experience in both LAN and WAN environments. He has performed at the technical level as a national support engineer, at the managerial level running a TAC, and at the instructor level as an instructor for a major LAN/WAN product manufacturer. Phil has earned CCIP and CCNP certifications and is a CCSI for Customer Contact BU products. He has been developing courseware and certifications (including CCIP, CCSP, and CCNP) for Cisco for six years.

Dedications

This book is dedicated to Trina, Zach, and Shae, without whom I couldn't have made it through those long nights of writing and editing.

Acknowledgments

Anyone who has ever had anything to do with the publishing industry knows that it takes many, many people to create a book. It may be my name on the cover, but there is no way that I can take credit for all that occurred to get this book from idea to publication. Therefore, I must thank:

The team at Cisco Press—Once again, you amaze me with your professionalism and the ability to make me look good. Mary Beth, Chris, Patrick, Meg, Seth—thank you for your continued support and belief in my little engineering journal.

To my technical reviewers, Robert and Phil—thanks for keeping me on track and making sure that what I wrote was correct and relevant.

To the staff of the Cisco office here in Edmonton, especially Cesar Barrero—thanks for putting up with me and my continued requests to borrow equipment for development and validation of the concepts in this book. But, can I keep the equipment for just a little bit longer? Please?

Contents at a Glance

Introduction xxi

Part I TCP/IP Version 4 1

Chapter 1 How to Subnet 3

Chapter 2 VLSM 21

Chapter 3 Route Summarization 29

Part II Introduction to Cisco Devices 35

Chapter 4 Cables and Connections 37

Chapter 5 The Command-Line Interface 45

Part III Configuring a Router 51

Chapter 6 Configuring a Single Cisco Router 53

Part IV Routing 67

Chapter 7 Static Routing 69

Chapter 8 RIP 75

Chapter 9 EIGRP 81

Chapter 10 Single Area OSPF 91

Part V Switching 103

Chapter 11 Configuring a Switch 105

Chapter 12 VLANs 117

Chapter 13 VLAN Trunking Protocol and Inter-VLAN Routing 125

Chapter 14 STP and EtherChannel 139

Part VI Extending the LAN 159

Chapter 15 Implementing a Wireless LAN 161

Part VII Network Administration and Troubleshooting 183

Chapter 16 Backing Up and Restoring Cisco IOS Software and Configurations 185

Chapter 17 Password-Recovery Procedures and the Configuration Register 193

Chapter 18 Cisco Discovery Protocol (CDP) 201

Chapter 19 Telnet and SSH 203

Chapter 20 The ping and traceroute Commands 207

Chapter 21 SNMP and Syslog 211

Chapter 22 Basic Troubleshooting 213

Part VIII Managing IP Services 219

Chapter 23 Network Address Translation 221

Chapter 24 DHCP 231

Chapter 25 IPv6 237

Part IX WANs 249

Chapter 26 HDLC and PPP 251

Chapter 27 Frame Relay 257

Part X Network Security 267

Chapter 28 IP Access Control List Security 269

Chapter 29 Security Device Manager 283

Part XI Appendixes 315

Appendix A Binary/Hex/Decimal Conversion Chart 317

Appendix B Create Your Own Journal Here 329

Contents

Introduction xxi

Part I TCP/IP Version 4 1

Chapter 1 How to Subnet 3

Class A–E Addresses 3
Converting Between Decimal Numbers and Binary 4
Subnetting a Class C Network Using Binary 4
Subnetting a Class B Network Using Binary 8
Binary ANDing 12
So Why AND? 14
Shortcuts in Binary ANDing 15
The Enhanced Bob Maneuver for Subnetting 16

Chapter 2 VLSM 21

IP Subnet Zero 21
VLSM Example 22
Step 1 Determine How Many H Bits Will Be Needed to Satisfy the Largest Network 22
Step 2 Pick a Subnet for the Largest Network to Use 23
Step 3 Pick the Next Largest Network to Work With 24
Step 4 Pick the Third Largest Network to Work With 26
Step 5 Determine Network Numbers for Serial Links 27

Chapter 3 Route Summarization 29

Example for Understanding Route Summarization 29
Step 1: Summarize Winnipeg's Routes 30
Step 2: Summarize Calgary's Routes 31
Step 3: Summarize Edmonton's Routes 31
Step 4: Summarize Vancouver's Routes 32
Route Summarization and Route Flapping 34
Requirements for Route Summarization 34

Part II Introduction to Cisco Devices 35

Chapter 4 Cables and Connections 37

Connecting a Rollover Cable to Your Router or Switch 37
Terminal Settings 37
LAN Connections 38
Serial Cable Types 39
Which Cable to Use? 41
568A Versus 568B Cables 42

Chapter 5 The Command-Line Interface 45

Shortcuts for Entering Commands 45
Using the Tab Key to Complete Commands 45
Using the Question Mark for Help 46
enable Command 46
exit Command 47
disable Command 47
logout Command 47
Setup Mode 47
Keyboard Help 48
History Commands 49
show Commands 49

Part III Configuring a Router 51

Chapter 6 Configuring a Single Cisco Router 53

Router Modes 53
Entering Global Configuration Mode 54
Configuring a Router Name 54
Configuring Passwords 54
Password Encryption 55
Interface Names 56
Moving Between Interfaces 58
Configuring a Serial Interface 59
Configuring a Fast Ethernet Interface 59
Creating a Message-of-the-Day Banner 60
Creating a Login Banner 60
Setting the Clock Time Zone 60
Assigning a Local Host Name to an IP Address 61
The no ip domain-lookup Command 61
The logging synchronous Command 61
The exec-timeout Command 62
Saving Configurations 62
Erasing Configurations 62
show Commands 63
EXEC Commands in Configuration Mode: The do Command 64
Configuration Example: Basic Router Configuration 64

Part IV Routing 67

Chapter 7 Static Routing 69

Configuring a Static Route on a Router 69
The permanent Keyword (Optional) 70

Static Routes and Administrative Distance (Optional) 70
Configuring a Default Route on a Router 71
Verifying Static Routes 72
Configuration Example: Static Routes 72

Chapter 8 RIP 75

The ip classless Command 75
RIP Routing: Mandatory Commands 75
RIP Routing: Optional Commands 76
Troubleshooting RIP Issues 77
Configuration Example: RIPv2 Routing 78

Chapter 9 EIGRP 81

Configuring Enhanced Interior Gateway Routing Protocol (EIGRP) 81
EIGRP Auto-Summarization 82
Load Balancing: variance 83
Bandwidth Use 84
Authentication 84
Verifying EIGRP 86
Troubleshooting EIGRP 86
Configuration Example: EIGRP 87

Chapter 10 Single Area OSPF 91

Configuring OSPF: Mandatory Commands 91
Using Wildcard Masks with OSPF Areas 92
Configuring OSPF: Optional Commands 93
Loopback Interfaces 93
Router ID 94
DR/BDR Elections 94
Modifying Cost Metrics 95
Authentication: Simple 95
Authentication: Using MD5 Encryption 96
Timers 96
Propagating a Default Route 96
Verifying OSPF Configuration 97
Troubleshooting OSPF 98
Configuration Example: Single Area OSPF 98

Part V Switching 103

Chapter 11 Configuring a Switch 105

Help Commands 105
Command Modes 105

Verifying Commands 106
Resetting Switch Configuration 107
Setting Host Names 107
Setting Passwords 107
Setting IP Addresses and Default Gateways 108
Setting Interface Descriptions 108
Setting Duplex Operation 109
Setting Operation Speed 109
Managing the MAC Address Table 109
Configuring Static MAC Addresses 109
Switch Port Security 110
Verifying Switch Port Security 111
Sticky MAC Addresses 112
Configuration Example 113

Chapter 12 VLANs 117

Creating Static VLANs 117
Using VLAN Configuration Mode 117
Using VLAN Database Mode 118
Assigning Ports to VLANs 118
Using the range Command 119
Verifying VLAN Information 119
Saving VLAN Configurations 119
Erasing VLAN Configurations 120
Configuration Example: VLANs 121

Chapter 13 VLAN Trunking Protocol and Inter-VLAN Routing 125

Dynamic Trunking Protocol (DTP) 125
Setting the Encapsulation Type 126
VLAN Trunking Protocol (VTP) 127
Using Global Configuration Mode 127
Using VLAN Database Mode 128
Verifying VTP 130
Inter-VLAN Communication Using an External Router: Router-on-a-Stick 130
Inter-VLAN Communication Tips 131
Configuration Example: Inter-VLAN Communication 132

Chapter 14 STP and EtherChannel 139

Spanning Tree Protocol 139
Enabling Spanning Tree Protocol 139
Configuring the Root Switch 140

Configuring a Secondary Root Switch 141
Configuring Port Priority 141
Configuring the Path Cost 142
Configuring the Switch Priority of a VLAN 142
Configuring STP Timers 143
Verifying STP 143
Optional STP Configurations 144
Changing the Spanning-Tree Mode 145
Extended System ID 146
Enabling Rapid Spanning Tree 146
Troubleshooting Spanning Tree 147
Configuration Example: STP 147
EtherChannel 150
Interface Modes in EtherChannel 151
Guidelines for Configuring EtherChannel 151
Configuring Layer 2 EtherChannel 152
Verifying EtherChannel 152
Configuration Example: EtherChannel 153

Part VI Extending the LAN 159

Chapter 15 Implementing a Wireless LAN 161
Wireless Access Point Configuration: Linksys 300N Access Point 161
Wireless Client Configuration: Linksys Wireless-N Notebook Adapter 174

Part VII Network Administration and Troubleshooting 183

Chapter 16 Backing Up and Restoring Cisco IOS Software and Configurations 185
Boot System Commands 185
The Cisco IOS File System 186
Backing Up Configurations to a TFTP Server 186
Restoring Configurations from a TFTP Server 187
Backing Up the Cisco IOS Software to a TFTP Server 188
Restoring/Upgrading the Cisco IOS Software from a TFTP Server 188
Restoring the Cisco IOS Software from ROM Monitor Mode Using Xmodem 189
Restoring the Cisco IOS Software Using the ROM Monitor Environmental Variables and tftpdnld Command 192

Chapter 17 Password-Recovery Procedures and the Configuration Register 193

The Configuration Register 193
A Visual Representation 193
What the Bits Mean 194
The Boot Field 194
Console Terminal Baud Rate Settings 195
Changing the Console Line Speed: CLI 195
Changing the Console Line Speed: ROM Monitor Mode 195
Password-Recovery Procedures for Cisco Routers 196
Password Recovery for 2960 Series Switches 198

Chapter 18 Cisco Discovery Protocol (CDP) 201

Cisco Discovery Protocol 201

Chapter 19 Telnet and SSH 203

Using Telnet to Remotely Connect to Other Devices 203
Configuring the Secure Shell Protocol (SSH) 205

Chapter 20 The ping and traceroute Commands 207

ICMP Redirect Messages 207
The ping Command 207
Examples of Using the ping and the Extended ping Commands 208
The traceroute Command 209

Chapter 21 SNMP and Syslog 211

Configuring SNMP 211
Configuring Syslog 211

Chapter 22 Basic Troubleshooting 213

Viewing the Routing Table 213
Determining the Gateway of Last Resort 214
Determining the Last Routing Update 214
OSI Layer 3 Testing 214
OSI Layer 7 Testing 215
Interpreting the show interface Command 215
Clearing Interface Counters 215
Using CDP to Troubleshoot 216
The traceroute Command 216
The show controllers Command 216
debug Commands 216
Using Time Stamps 217

Operating System IP Verification Commands 217
The ip http server Command 217
The netstat Command 218

Part VIII Managing IP Services 219

Chapter 23 Network Address Translation 221
Private IP Addresses: RFC 1918 221
Configuring Dynamic NAT: One Private to One Public Address Translation 221
Configuring PAT: Many Private to One Public Address Translation 223
Configuring Static NAT: One Private to One Permanent Public Address Translation 226
Verifying NAT and PAT Configurations 227
Troubleshooting NAT and PAT Configurations 227
Configuration Example: PAT 228

Chapter 24 DHCP 231
Configuring DHCP 231
Verifying and Troubleshooting DHCP Configuration 232
Configuring a DHCP Helper Address 232
DHCP Client on a Cisco IOS Software Ethernet Interface 233
Configuration Example: DHCP 233

Chapter 25 IPv6 237
Assigning IPv6 Addresses to Interfaces 237
IPv6 and RIPng 238
Configuration Example: IPv6 RIP 239
IPv6 Tunnels: Manual Overlay Tunnel 241
Static Routes in IPv6 244
Floating Static Routes in IPv6 245
Verifying and Troubleshooting IPv6 245
IPv6 Ping 247

Part IX WANs 249

Chapter 26 HDLC and PPP 251
Configuring HDLC Encapsulation on a Serial Line 251
Configuring PPP on a Serial Line (Mandatory Commands) 251
Configuring PPP on a Serial Line (Optional Commands): Compression 252
Configuring PPP on a Serial Line (Optional Commands): Link Quality 252

Configuring PPP on a Serial Line (Optional Commands): Multilink 252
Configuring PPP on a Serial Line (Optional Commands): Authentication 252
Verifying or Troubleshooting a Serial Link/PPP Encapsulation 253
Configuration Example: PPP 254

Chapter 27 Frame Relay 257
Configuring Frame Relay 257
Setting the Frame Relay Encapsulation Type 257
Setting the Frame Relay Encapsulation LMI Type 258
Setting the Frame Relay DLCI Number 258
Configuring a Frame Relay map Statement 258
Configuring a Description of the Interface (Optional) 259
Configuring Frame Relay Using Subinterfaces 259
Verifying Frame Relay 260
Troubleshooting Frame Relay 260
Configuration Examples: Frame Relay 260

Part X Network Security 267

Chapter 28 IP Access Control List Security 269
Access List Numbers 269
Using Wildcard Masks 270
ACL Keywords 270
Creating Standard ACLs 271
Applying Standard ACLs to an Interface 272
Verifying ACLs 273
Removing ACLs 273
Creating Extended ACLs 273
Applying Extended ACLs to an Interface 275
The established Keyword (Optional) 275
Creating Named ACLs 276
Using Sequence Numbers in Named ACLs 276
Removing Specific Lines in Named ACLs Using Sequence Numbers 277
Sequence Number Tips 278
Including Comments About Entries in ACLs 278
Restricting Virtual Terminal Access 279
Configuration Examples: ACLs 279

Chapter 29 Security Device Manager 283

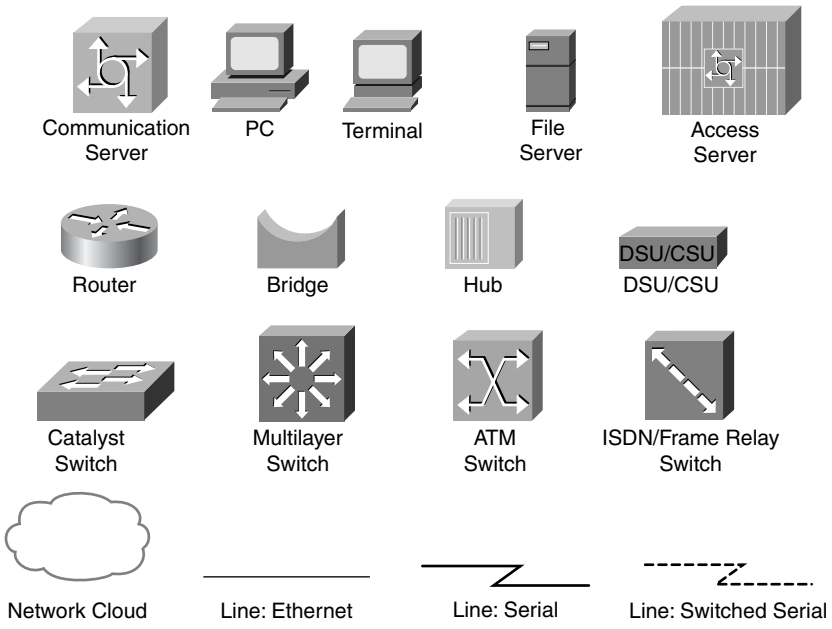
Security Device Manager: Connecting with CLI 283
Security Device Manager: Connecting with GUI 285
SDM Express Wizard with No CLI Preconfiguration 287
Resetting the Router to Factory Defaults Using SDM 297
SDM User Interfaces 298
    Configuring Interfaces Using SDM 298
    Configuring Routing Using SDM 302
SDM Monitor Mode 304
Using SDM to Configure a Router to Act as a DHCP Server 305
Using SDM to Configure an Interface as a DHCP Client 307
Using SDM to Configure NAT/PAT 312
What to Do If You Lose SDM Connectivity Because of an erase startup-config Command 314

Part XI Appendixes 315

Appendix A Binary/Hex/Decimal Conversion Chart 317

Appendix B Create Your Own Journal Here 329

Icons Used in This Book



Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the *Cisco 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).
- *Italics* indicate arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets [ ] indicate optional elements.
- Braces { } indicate a required choice.
- Braces within brackets [{ }] indicate a required choice within an optional element.

Introduction

Welcome to CCNA! Recently Cisco Press came to me and told me, albeit very quietly, that there was going to be some changes made to the CCNA certification exam, and asked whether I would be interested in updating my *CCNA Portable Command Guide* for release around the time of the announcement of the new exam. I was already working on the various command guides for the new CCNP certification exams, but I felt that a revision wouldn't take a lot of time, as hopefully there would still be a lot of concepts that hadn't changed.

I have long been a fan of what I call the "Engineering Journal"—a small notebook that can be carried around and that contains little nuggets of information—commands that you forget, the IP addressing scheme of some remote part of the network, little reminders about how to do something you only have to do once or twice a year (but is vital to the integrity and maintenance of your network). This journal has been a constant companion by my side for the past eight years; I only teach some of these concepts every second or third year, so I constantly need to refresh commands and concepts and learn new commands and ideas as they are released by Cisco. My journals were the best way for me to review because they were written in my own words—words that I could understand. At least, I had better understand them, because if I didn't, I had only myself to blame.

The journals that I would create for my Academy classes would always be different from the journals I would create when I was teaching from a different curriculum or if I was out in the industry working on some production network. I could understand that the Academy needed to split topics into smaller, more manageable chunks, but for me out in the real world, I needed these concepts to follow a different approach—I needed all the routing protocols together in one place in my journals, and not spread across some two-year outline of knowledge.

This book is my "Industry" edition of the Engineering Journal. It contains a different logical flow to the topics, one more suited to someone working in the field. Like topics are grouped together: routing protocols, switches, troubleshooting. More-complex examples are given. New topics have been added, such as IPv6, wireless, and the Security Device Manager (SDM). The popular "Create Your Own Journal" appendix is still here—blank pages for you to add in your own commands that you need in your specific job. We all recognize the fact that no network administrator's job can be so easily pigeonholed as to being just working with CCNA topics—you all have your own specific jobs and duties assigned to you. That is why you will find those blank pages at the end of the book—make this book your own; personalize it with what you need to make it more effective. That way your journal will not look like mine.

The Cisco Networking Academy Program and This Guide

The first book that I ever published for Cisco Press was a command guide that was specially designed to follow the Cisco Networking Academy Program curriculum. The *CCNA Command Quick Reference* was released in 2005 and was organized in such a way that if you were working on CCNA 3, Chapter 8 in the online curriculum, the commands for that chapter were in Part 3, Chapter 8 of that book. However, the Cisco Networking Academy Program has now released two different *flavors* of the Academy curriculum: CCNA

Discovery and CCNA Exploration. The two courses take decidedly different paths in their delivery of content, but they both end up at the same destination—a place where a student completing either set of courses is ready to take the CCNA certification exam. Because there is such a variety in how the courses teach content, Cisco Press believed that creating two books for the Cisco Academy would not be viable, because most of the content would be the same, just in a different order. Therefore, this book can be used with either CCNA Discovery or CCNA Exploration. A quick perusal of the table of contents, or the inside back cover (where I have my "What Do You Want to Do?" list of the more commonly asked questions), should take you to the section with the command(s) that you are looking for. There is even a section in Chapter 15, "Implementing a Wireless LAN," that deals with topics that are only presented in the Academy curriculum—provisioning a Linksys wireless access point and wireless client card. This topic is not covered on the certification exam, but it is part of the Academy courseware, so I have included it in this book, too.

Networking Devices Used in the Preparation of This Book

To verify the commands in this book, I had to try them out on a few different devices. The following is a list of the equipment I used when writing this book:

- C2620 router running Cisco IOS Software Release 12.3(7)T, with a fixed Fast Ethernet interface, a WIC-2A/S serial interface card, and an NM-1E Ethernet interface
- C2821 ISR with PVDM2, CMME, a WIC-2T, FXS and FXO VICs, running 12.4(10a) IPBase IOS
- WS-C2960-24TT-L Catalyst Switch, running 12.2(25)SE IOS
- WS-C2950-12 Catalyst switch, running version C2950-C3.0(5.3)WC(1) Enterprise Edition software

These devices were not running the latest and greatest versions of Cisco IOS Software. Some of it is quite old.

Those of you familiar with Cisco devices will recognize that a majority of these commands work across the entire range of the Cisco product line. These commands are not limited to the platforms and Cisco IOS Software versions listed. In fact, these devices are in most cases adequate for someone to continue his or her studies into the CCNP level, too.

Private Addressing Used in this Book

This book makes use of RFC 1918 addressing throughout. Because I do not have permission to use public addresses in my examples, I have done everything with private addressing. Private addressing is perfect for use in a lab environment or in a testing situation, because it works exactly like public addressing, with the exception that it cannot be routed across a public network. That is why you will see private addresses in my WAN links between two routers using serial connections, or in my Frame Relay cloud.

Who Should Read This Book

This book is for those people preparing for the CCNA exam, whether through self-study, on-the-job training and practice, or even through study within the Cisco Networking

Academy Program. There are also some handy hints and tips along the way to hopefully make life a bit easier for you in this endeavor. It is small enough that you will find it easy to carry around with you. Big, heavy textbooks might look impressive on your bookshelf in your office, but can you really carry them all around with you when you are working in some server room or equipment closet somewhere?

Optional Sections

A few sections in this book have been marked as "Optional." These sections cover topics that are not on the CCNA certification exam, but they are valuable topics that I believe should be known by someone at a CCNA level. Some of the optional topics might also be concepts that are covered in the Cisco Networking Academy Program courses, either the CCNA Discovery or the CCNA Exploration segments.

Organization of This Book

This book follows what I think is a logical approach to configuring a small to mid-size network. It is an approach that I give to my students when they invariably ask for some sort of outline to plan and then configure a network. Specifically, this approach is as follows:

- Part I: TCP/IP Version 4
    - **Chapter 1, "How to Subnet"**—An overview of how to subnet, examples of subnetting (both a Class B and a Class C address), the use of the binary AND operation, the Enhanced Bob Maneuver to Subnetting
    - **Chapter 2, "VLSM"**—An overview of VLSM, an example of using VLSM to make your IP plan more efficient
    - **Chapter 3, "Route Summarization"**—Using route summarization to make your routing updates more efficient, an example of how to summarize a network, necessary requirements for summarizing your network
- Part II: Introduction to Cisco Devices
    - **Chapter 4, "Cables and Connections"**—An overview of how to connect to Cisco devices, which cables to use for which interfaces, and the differences between the TIA/EIA 568A and 568B wiring standards for UTP
    - **Chapter 5, "The Command-Line Interface"**—How to navigate through Cisco IOS Software: editing commands, keyboard shortcuts, and help commands
- Part III: Configuring a Router
    - **Chapter 6, "Configuring a Single Cisco Router"**—Commands needed to configure a single router: names, passwords, configuring interfaces, MOTD and login banners, IP host tables, saving and erasing your configurations

- Part IV: Routing
  - **Chapter 7, "Static Routing"**—Configuring static routes in your internetwork
  - **Chapter 8, "RIP"**—Configuring and verifying RIPv2, how to see and clear your routing table
  - **Chapter 9, "EIGRP"**—Configuring and verifying EIGRP
  - **Chapter 10, "Single Area OSPF"**—Configuring and verifying Single Area OSPF
- Part V: Switching
  - **Chapter 11, "Configuring a Switch"**—Commands to configure Catalyst 2960 switches: names, passwords, IP addresses, default gateways, port speed and duplex; configuring static MAC addresses; managing the MAC address table; port security
  - **Chapter 12, "VLANs"**—Configuring static VLANs, troubleshooting VLANs, saving and deleting VLAN information.
  - **Chapter 13, "VLAN Trunking Protocol and Inter-VLAN Communication"**—Configuring a VLAN trunk link, configuring VTP, verifying VTP, inter-VLAN communication, router-on-a-stick, and subinterfaces
  - **Chapter 14, "STP and EtherChannel"**—Verifying STP, setting switch priorities, and creating and verifying EtherChannel groups between switches
- Part VI: Extending the LAN
  - **Chapter 15, "Implementing a Wireless LAN"**—Configuring a Linksys wireless access point, configuring a Linksys wireless client card
- Part VII: Network Administration and Troubleshooting
  - **Chapter 16, "Backing Up and Restoring Cisco IOS Software and Configurations"**—Boot commands for Cisco IOS Software, backing up and restoring Cisco IOS Software using TFTP, Xmodem, and ROMmon environmental variables
  - **Chapter 17, "Password-Recovery Procedures and the Configuration Register"**—The configuration register, password-recovery procedure for routers and switches
  - **Chapter 18, "Cisco Discovery Protocol (CDP)"**—Customizing and verifying CDP
  - **Chapter 19, "Telnet and SSH"**—Commands used for Telnet and SSH to remotely connect to other devices
  - **Chapter 20, "The ping and traceroute Commands"**—Commands for both **ping** and extended **ping**; the **traceroute** command
  - **Chapter 21, "SNMP and Syslog"**—Configuring SNMP, working with syslog

  - **Chapter 22, "Basic Troubleshooting"**—Various **show** commands used to view the routing table; interpreting the **show** interface command; verifying your IP settings using different operating systems

- Part VIII: Managing IP Services
  - **Chapter 23, "Network Address Translation"**—Configuring and verifying NAT and PAT
  - **Chapter 24, "DHCP"**—Configuring and verifying DHCP
  - **Chapter 25, "IPv6"**—Transitioning to IPv6; format of IPv6 addresses; configuring IPv6 (interfaces, tunneling, routing with RIPng)
- Part IX: WANs
  - **Chapter 26, "HDLC and PPP"**—Configuring PPP, authentication of PPP using PAP or CHAP, compression in PPP; multilink in PPP, troubleshooting PPP, returning to HDLC encapsulation
  - **Chapter 27, "Frame Relay"**—Configuring basic Frame Relay, Frame Relay and subinterfaces, DLCIs, verifying and troubleshooting Frame Relay
- Part X: Network Security
  - **Chapter 28, "IP Access Control List Security"**—Configuring standard ACLs, wildcard masking, creating extended ACLs, creating named ACLs, using sequence numbers in named ACLs, verifying and troubleshooting ACLs
  - **Chapter 29, "Security Device Manager"**—Connecting to a router using SDM, SDM user interfaces, SDM wizards, using SDM to configure a router as a DHCP server (or an interface as a DHCP client), using SDM to configure NAT
- Part XI: Appendixes
  - **Appendix A, "Binary/Hex/Decimal Conversion Chart"**—A chart showing numbers 0 through 255 in the three numbering systems of binary, hexadecimal, and decimal
  - **Appendix B, "Create Your Own Journal Here"**—Some blank pages for you to add in your own specific commands that might not be in this book

Did I Miss Anything?

I am always interested to hear how my students, and now readers of my books, do on both certification exams and future studies. If you would like to contact me and let me know how this book helped you in your certification goals, please do so. Did I miss anything? Let me know. My e-mail address is ccnaguide@empson.ca.

This page intentionally left blank

CHAPTER 25

IPv6

This chapter provides information and commands concerning the following topics:

- Assigning IPv6 addresses to interfaces
- IPv6 and RIPng
- Configuration example: IPv6 RIP
- IPv6 tunnels: manual overlay tunnel
- Static routes in IPv6
- Floating static routes in IPv6
- Verifying and troubleshooting IPv6
- IPv6 ping

NOTE: For an excellent overview of IPv6, I strongly recommend you read Jeff Doyle's book, *Routing TCP/IP Volume I*, Second Edition.

Assigning IPv6 Addresses to Interfaces

`Router(config)#`**`ipv6 unicast-routing`**	Enables the forwarding of IPV6 unicast datagrams globally on the router.
`Router(config)#`**`interface fastethernet 0/0`**	Moves to interface configuration mode.
`Router(config-if)#`**`ipv6 enable`**	Automatically configures an IPv6 link-local address on the interface and enables IPv6 processing on the interface.
	NOTE: The link-local address that the **ipv6 enable** command configures can be used only to communicate with nodes on the same link.
`Router(config-if)#`**`ipv6 address 3000::1/64`**	Configures a global IPv6 address on the interface and enables IPv6 processing on the interface.
`Router(config-if)#`**`ipv6 address 2001:db8:0:1::/64 eui-64`**	Configures a global IPv6 address with an interface identifier in the low-order 64 bits of the IPv6 address.

`Router(config-if)#ipv6 address fe80::260:3eff:fe47:1530/64 link-local`	Configures a specific link-local IPv6 address on the interface instead of the one that is automatically configured when IPv6 is enabled on the interface.
`Router(config-if)#ipv6 unnumbered` *type/number*	Specifies an unnumbered interface and enables IPv6 processing on the interface. The global IPv6 address of the interface specified by *type/number* will be used as the source address.

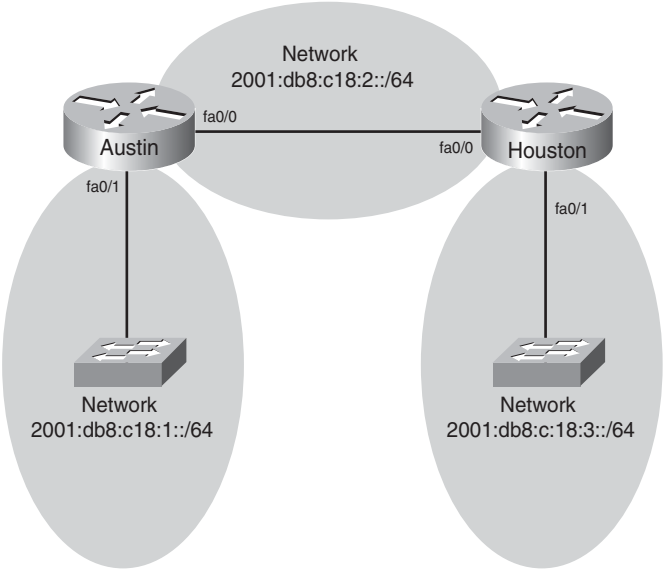
IPv6 and RIPng

`Router(config)#interface serial 0/0`	Moves to interface configuration mode.
`Router(config-if)#ipv6 rip tower enable`	Creates the RIPng process named tower and enables RIPng on the interface.
	NOTE: Unlike RIPv1 and RIPv2, where you needed to create the RIP routing process with the **router rip** command and then use the **network** command to specify the interfaces on which to run RIP, the RIPng process is created automatically when RIPng is enabled on an interface with the **ipv6 rip** *name* **enable** command.
	NOTE: Cisco IOS Software automatically creates an entry in the configuration for the RIPng routing process when it is enabled on an interface.
	NOTE: The **ipv6 router rip** *process-name* command is still needed when configuring optional features of RIPng.
`Router(config)#ipv6 router rip tower`	Creates the RIPng process named tower if it has not already been created, and moves to router configuration mode
`Router(config-router)#maximum-paths 2`	Defines the maximum number of equal-cost routes that RIPng can support.
	NOTE: The number of paths that can be used is a number from 1 to 64. The default is 4.

Configuration Example: IPv6 RIP

Figure 25-1 illustrates the network topology for the configuration that follows, which shows how to configure IPv6 and RIPng using the commands covered in this chapter.

Figure 25-1 Network Topology for IPv6/RIPng Configuration Example



Austin Router

`Router>enable`	Moves to privileged mode
`Router#configure terminal`	Moves to global configuration mode
`Router(config)#hostname Austin`	Assigns a host name to the router
`Austin(config)#ipv6 unicast-routing`	Enables the forwarding of IPv6 unicast datagrams globally on the router
`Austin(config)#interface fastethernet 0/0`	Enters interface configuration mode
`Austin(config-if)#ipv6 enable`	Automatically configures an IPv6 link-local address on the interface and enables IPv6 processing on the interface
`Austin(config-if)#ipv6 address 2001:db8:c18:2::/64 eui-64`	Configures a global IPv6 address with an interface identifier in the low-order 64 bits of the IPv6 address

`Austin(config-if)#ipv6 rip tower enable`	Creates the RIPng process named tower and enables RIPng on the interface
`Austin(config-if)#no shutdown`	Activates the interface
`Austin(config-if)#interface fastethernet 0/1`	Enters interface configuration mode
`Austin(config-if)#ipv6 enable`	Automatically configures an IPv6 link-local address on the interface and enables IPv6 processing on the interface
`Austin(config-if)#ipv6 address 2001:db8:c18:1::/64 eui-64`	Configures a global IPv6 address with an interface identifier in the low-order 64 bits of the IPv6 address
`Austin(config-if)#ipv6 rip tower enable`	Creates the RIPng process named tower and enables RIPng on the interface
`Austin(config-if)#no shutdown`	Activates the interface
`Austin(config-if)#exit`	Moves to global configuration mode
`Austin(config)#exit`	Moves to privileged mode
`Austin#copy running-config startup-config`	Saves the configuration to NVRAM

Houston Router

`Router>enable`	Moves to privileged mode
`Router#configure terminal`	Moves to global configuration mode
`Router(config)#hostname Houston`	Assigns a host name to the router
`Houston(config)#ipv6 unicast-routing`	Enables the forwarding of IPv6 unicast datagrams globally on the router
`Houston(config)#interface fastethernet 0/0`	Enters interface configuration mode
`Houston(config-if)#ipv6 enable`	Automatically configures an IPv6 link-local address on the interface and enables IPv6 processing on the interface
`Houston(config-if)#ipv6 address 2001:db8:c18:2::/64 eui-64`	Configures a global IPv6 address with an interface identifier in the low-order 64 bits of the IPv6 address
`Houston(config-if)#ipv6 rip tower enable`	Creates the RIPng process named tower and enables RIPng on the interface

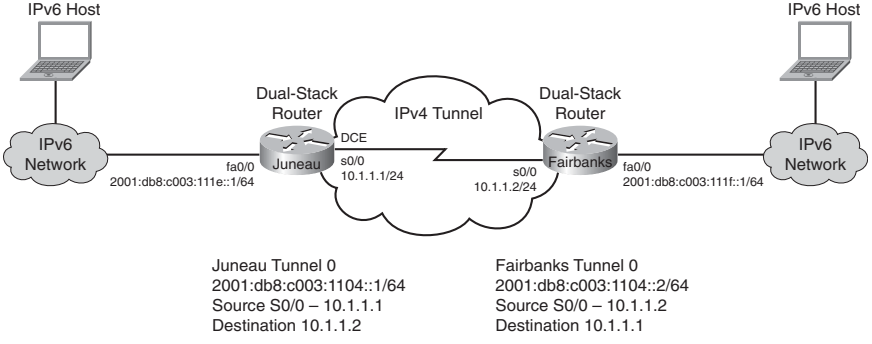
`Houston(config-if)#no shutdown`	Activates the interface
`Houston(config-if)#interface fastethernet 0/1`	Enters interface configuration mode
`Houston(config-if)#ipv6 enable`	Automatically configures an IPv6 link-local address on the interface and enables IPv6 processing on the interface
`Houston(config-if)#ipv6 address 2001:db8:c18:3::/64 eui-64`	Configures a global IPv6 address with an interface identifier in the low-order 64 bits of the IPv6 address
`Houston(config-if)#ipv6 rip tower enable`	Creates the RIPng process named tower and enables RIPng on the interface
`Houston(config-if)#no shutdown`	Activates the interface
`Houston(config-if)#exit`	Moves to global configuration mode
`Houston(config)#exit`	Moves to privileged mode
`Houston#copy running-config startup-config`	Saves the configuration to NVRAM

IPv6 Tunnels: Manual Overlay Tunnel

NOTE: Although not part of the official CCNA exam objectives, the concept of IPv6 tunnels is one that network administrators dealing with IPv6 need to be comfortable with.

Figure 25-2 illustrates the network topology for the configuration that follows, which shows how IPv6 tunnels are created.

Figure 25-2 Network Topology for IPv6 Tunnel Creation



Juneau Router

`Router>enable`	Moves to privileged mode
`Router#configure terminal`	Moves to global configuration mode
`Router(config)#hostname Juneau`	Sets the host name of the router
`Juneau(config)#ipv6 unicast-routing`	Enables the forwarding of IPv6 unicast datagrams globally on the router
`Juneau(config)#interface tunnel0`	Moves to tunnel interface configuration mode
`Juneau(config-if)#ipv6 address 2001:db8:c003:1104::1/64`	Assigns an IPv6 address to this interface
`Juneau(config-if)#tunnel source serial 0/0`	Specifies the source interface type and number for the tunnel interface
`Juneau(config-if)#tunnel destination 10.1.1.2`	Specifies the destination IPv4 address for the tunnel interface
`Juneau(config-if)#tunnel mode ipv6ip`	Defines a manual IPv6 tunnel; specifically, that IPv6 is the passenger protocol and IPv4 is both the encapsulation and protocol for the IPv6 tunnel
`Juneau(config-if)#interface fastethernet 0/0`	Moves to interface configuration mode
`Juneau(config-if)#ipv6 address 2001:db8:c003:111e::1/64`	Assigns an IPv6 address to this interface
`Juneau(config-if)#no shutdown`	Activates the interface
`Juneau(config-if)#interface serial 0/0`	Moves to interface configuration mode
`Juneau(config-if)#ip address 10.1.1.1 255.255.255.252`	Assigns an IPv4 address and netmask
`Juneau(config-if)#clock rate 56000`	Sets the clock rate on interface
`Juneau(config-if)#no shutdown`	Starts the interface
`Juneau(config-if)#exit`	Moves to global configuration mode
`Juneau(config)#exit`	Moves to privileged mode
`Juneau#copy running-config startup-config`	Saves the configuration to NVRAM

Fairbanks Router

`Router>enable`	Moves to privileged mode
`Router#configure terminal`	Moves to global configuration mode
`Router(config)#hostname Fairbanks`	Sets the host name of the router
`Fairbanks(config)#interface tunnel0`	Moves to tunnel interface configuration mode
`Fairbanks(config-if)#ipv6 address 2001:db8:c003:1104::2/64`	Assigns an IPv6 address to this interface
`Fairbanks(config-if)#tunnel source serial 0/0`	Specifies the source interface type and number for the tunnel interface
`Fairbanks(config-if)#tunnel destination 10.1.1.1`	Specifies the destination IPv4 address for the tunnel interface
`Fairbanks(config-if)#tunnel mode ipv6ip`	Defines a manual IPv6 tunnel; specifically, that IPv6 is the passenger protocol and IPv4 is both the encapsulation and protocol for the IPv6 tunnel
`Fairbanks(config-if)#interface fastethernet 0/0`	Moves to interface configuration mode
`Fairbanks(config-if)#ipv6 address 2001:db8:c003:111f::1/64`	Assigns an IPv6 address to this interface
`Fairbanks(config-if)#no shutdown`	Activates the interface
`Fairbanks(config-if)#interface serial 0/0`	Moves to interface configuration mode
`Fairbanks(config-if)#ip address 10.1.1.2 255.255.255.252`	Assigns an IPv4 address and netmask
`Fairbanks(config-if)#no shutdown`	Starts the interface
`Fairbanks(config-if)#exit`	Moves to global configuration mode
`Fairbanks(config)#exit`	Moves to privileged mode
`Fairbanks#copy running-config startup-config`	Saves the configuration to NVRAM

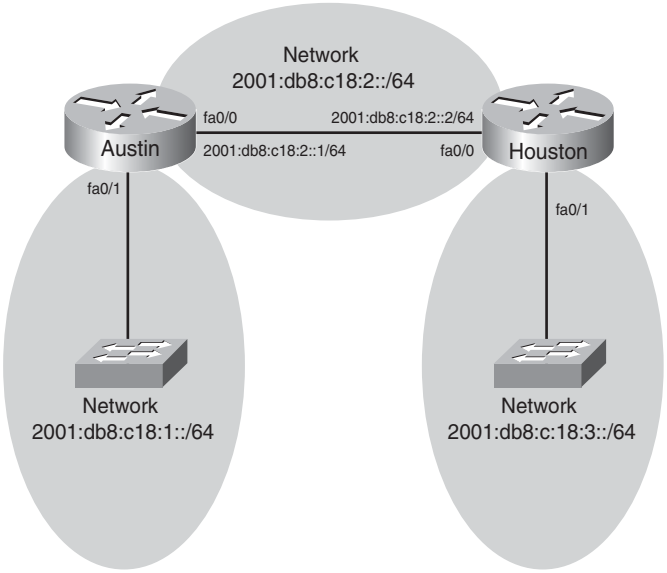
Static Routes in IPv6

NOTE: Although not part of the CCNA exam objectives, the concept of static routes in IPv6 is one that network administrators dealing with IPv6 need to be comfortable with.

NOTE: To create a static route in IPv6, you use the same format as creating a static route in IPv4.

Figure 25-3 illustrates the network topology for the configuration that follows, which shows how to configure static routes with IPv6. Note that only the static routes on the Austin router are displayed.

Figure 25-3 Network Topology for IPv6 Static Route Configuration



`Austin(config)#ipv6 route 2001:db8:c18:3::/64 2001:db8:c18:2::2`	Creates a static route configured to send all packets to a next-hop address of 2001:db8:c18:2::2
`Austin(config)#ipv6 route 2001:db8:c18:3::/64 fastethernet 0/0`	Creates a directly attached static route configured to send packets out interface fastethernet 0/0
`Austin(config)#ipv6 route 2001:db8:c18:3::/64 fastethernet 0/0 2001:db8:c18:2::2`	Creates a fully specified static route on a broadcast interface

Floating Static Routes in IPv6

NOTE: Although not part of the CCNA exam objectives, the concept of floating static routes in IPv6 is one that network administrators dealing with IPv6 need to be comfortable with.

To create a static route with an administrative distance (AD) set to 200, as opposed the default AD of one (1), enter the following command, for example:

```
Austin(config)# ipv6 route 2001:db8:c18:3::/64 fastethernet 0/0 200
```

The default ADs used in IPv4 are the same for IPv6.

Verifying and Troubleshooting IPv6

CAUTION: Using the **debug** command may severely affect router performance and might even cause the router to reboot. Always exercise caution when using the **debug** command. Do not leave **debug** on. Use it long enough to gather needed information, and then disable debugging with the **undebug all** command.

TIP: Send your **debug** output to a syslog server to ensure you have a copy of it in case your router is overloaded and needs to reboot.

`Router#clear ipv6 rip`	Deletes routes from the IPv6 RIP routing table and, if installed, routes in the IPv6 routing table
`Router#clear ipv6 route *`	Deletes all routes from the IPv6 routing table
	NOTE: Clearing all routes from the routing table will cause high CPU utilization rates as the routing table is rebuilt.
`Router#clear ipv6 route 2001:db8:c18:3::/64`	Clears this specific route from the IPv6 routing table.
`Router#clear ipv6 traffic`	Resets IPv6 traffic counters.
`Router#debug ipv6 packet`	Displays debug messages for IPv6 packets.
`Router#debug ipv6 rip`	Displays debug messages for IPv6 RIP routing transactions.

`Router#debug ipv6 routing`	Displays debug messages for IPv6 routing table updates and route cache updates.
`Router#show ipv6 interface`	Displays the status of interfaces configured for IPv6.
`Router#show ipv6 interface brief`	Displays a summarized status of interfaces configured for IPv6.
`Router#show ipv6 neighbors`	Displays IPv6 neighbor discovery cache information.
`Router#show ipv6 protocols`	Displays the parameters and current state of the active IPv6 routing protocol processes.
`Router#show ipv6 rip`	Displays information about the current IPv6 RIP process.
`Router#show ipv6 route`	Displays the current IPv6 routing table.
`Router#show ipv6 route summary`	Displays a summarized form of the current IPv6 routing table.
`Router#show ipv6 routers`	Displays IPv6 router advertisement information received from other routers.
`Router#show ipv6 static`	Displays only static IPv6 routes installed in the routing table.
`Router#show ipv6 static 2001:db8:5555:0/16`	Displays only static route information about the specific address given.
`Router#show ipv6 static interface serial 0/0`	Displays only static route information with the specified interface as the outgoing interface.
`Router#show ipv6 static detail`	Displays a more detailed entry for IPv6 static routes.
`Router#show ipv6 traffic`	Displays statistics about IPv6 traffic.
`Router#show ipv6 tunnel`	Displays IPv6 tunnel information.

IPv6 Ping

To diagnose basic network connectivity using IPv6 to the specified address, enter the following command:

```
Router#ping ipv6 2001:db8::3/64
```

The following characters can be displayed as output when using PING in IPv6.

Character	Description
!	Each exclamation point indicates receipt of a reply.
.	Each period indicates that the network server timed out while waiting for a reply.
?	Unknown error.
@	Unreachable for unknown reason.
A	Administratively unreachable. Usually means that an access control list (ACL) is blocking traffic.
B	Packet too big.
H	Host unreachable.
N	Network unreachable (beyond scope).
P	Port unreachable.
R	Parameter problem.
T	Time exceeded.
U	No route to host.

This page intentionally left blank