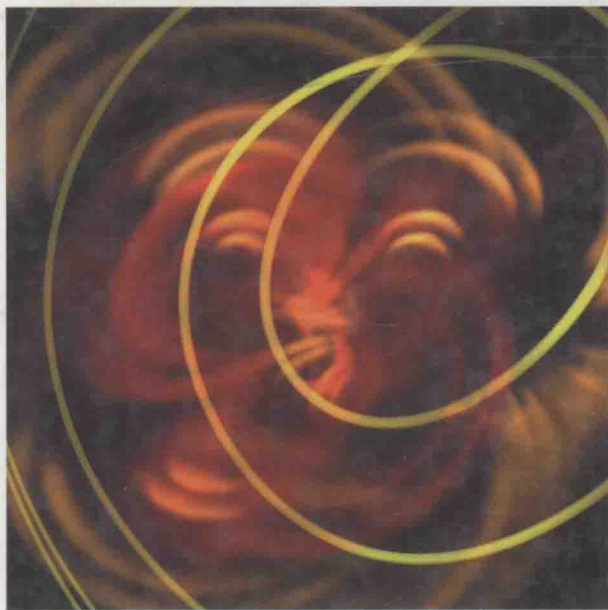


A test prep guide and on-the-job reference

Cisco[®] Certification

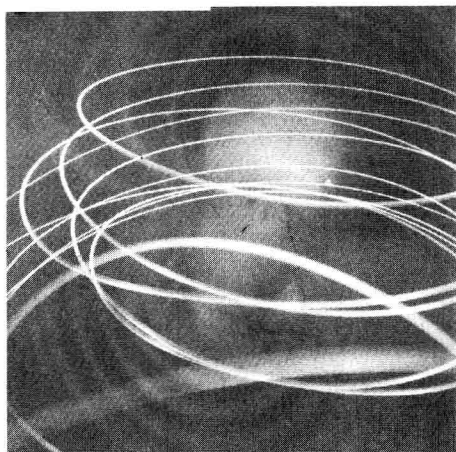
BRIDGES, ROUTERS AND SWITCHES FOR CCIEs

Second Edition



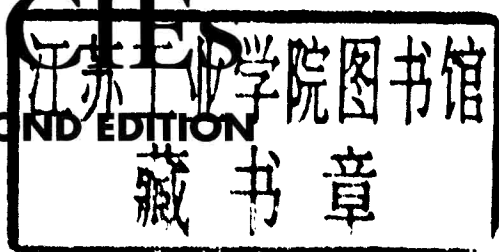
- Bestselling CCIE guide updated for the latest exam!
- World-class troubleshooting practice for the CCIE hands-on labs
- Exclusive "Can You Spot the Issues" challenges
- New coverage: VoIP, QoS, and much more
- Expanded coverage of BGP and OSPF

ANDREW BRUCE CASLOW CCIE #3139
VALERIY PAVLICHENKO CCIE #3765



Cisco Certification: Bridges, Routers and Switches for CCIEs

SECOND EDITION



Andrew Bruce Caslow, CCIE # 3139
Valeriy Pavlichenko, CCIE # 3765

Automation Research Systems, Ltd.



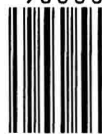
Prentice Hall PTR
Upper Saddle River, NJ 07458
www.phptr.com

ISBN 0-13-090389-2



9 780130 903891

90000



Library of Congress Cataloging-in-Publication Data

Caslow, Andrew Bruce.

Cisco certification: bridges, routers and switches for CCIEs / Andrew Bruce Caslow and Valeriy Pavlichenko.—2nd ed.

p. cm.

ISBN 0-13-090389-2

1. Routers (Computer networks)—Examinations—Study guides. 2. Electronic data processing personnel—Certification. 3. Internetworking (Telecommunication)—Examinations—Study guides. 4. Telecommunications—Switching systems—Examinations—Study guides. 5. Bridges (Computer networks) I. Pavlichenko, Valeriy. II. Title.

TK5105.543.C37 2001

004.6'076—dc21

00-050163

Editorial/production supervision: *Patti Guerrieri*

Acquisitions editor: *Mary Franz*

Editorial assistant: *Noreen Regina*

Cover design director: *Jerry Votta*

Cover designer: *Kiwi Design / Nina Scuderi*

Manufacturing manager: *Alexis Heydt*

Marketing manager: *Bryan Gambrel*

Technical editor: *Valeriy Pavlichenko*



© 2001, 1999 by Prentice Hall PTR

Prentice-Hall, Inc.

Upper Saddle River, NJ 07458

Prentice Hall books are widely used by corporations and government agencies for training, marketing, and resale.

The publisher offers discounts on this book when ordered in bulk quantities.

For more information, contact Corporate Sales Dept.; Phone 800-382-3419; FAX: 201-236-7141

E-mail (Internet): corpsales@prenhall.com

Or write: Prentice Hall PTR, Corp. Sales Department, One Lake Street, Upper Saddle River, NJ 07458

All products or services mentioned in this book are the trademarks or service marks of their respective companies or organizations.

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-090389-2

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall Canada Inc., *Toronto*

Prentice-Hall Hispanoamericana, S.A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Pearson Education Asia Pte. Ltd.

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*


When we think about the future of the world, we always have in mind its being at the place where it would be if it continued to move as we see it moving now. We do not realize that it moves not in a straight line, but in a curve, and that its direction is changing constantly.

Ludwig Wittgenstein

ARS is the corporate sponsor of this book, and the first edition was written while Bruce Caslow was a trainer at ARS. ARS is an Information Technology firm located in Alexandria, VA, with offices throughout the USA. It has been involved with leading edge technologies since its inception in 1982. ARS made the decision to author the *Cisco Certification* book because ARS believes that Cisco Systems offers a solution: the Cisco IOS (Internetworking Operating System). By mastering the Cisco IOS, an internetworking professional can supply virtually any internetworking solution. ARS delivers comprehensive Cisco training at its Certified Training Center and prides itself on both its training and consulting capabilities, delivering a broad array of high-quality training on Cisco and FORE internetworking equipment. ARS students pass the CCIE exam with over an 80% success rate—twice the national average. ARS is also one of the few training organizations that has a direct reseller relationship with some of the top networking manufacturers across the country. As one of the first Cisco and Fore certified trainers nationally, ARS has some of the best networking professionals in the business. Other available training solutions include distance learning options to meet the changing demands of professional development in today's fast-paced work environment, as well as custom training designed for specific customer use. This training program has allowed ARS the opportunity to design and implement networks globally. The ARS IT Solutions Group develops network solutions for large and small enterprises—from federal agencies to community banks. ARS services a vast majority of Northern Virginia community banks, providing the banks a network and desktop solution. Please visit the ARS Web site at www.arslimited.com.

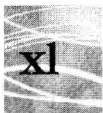


Preface



For the next ten years, the opportunities for internetwork professionals will be immense. However, the challenge of possessing the proper knowledge base and skill set will be faced by every internetworking professional. The challenge is two-fold: (1) how does one develop his internetworking knowledge base and skill sets to the highest possible level and (2) how does one stay current in this rapidly changing field! Cisco Systems offers a solution: the Cisco IOS (Internetworking Operating System). By mastering the Cisco IOS, an internetworking professional can supply virtually any internetworking solution. The IOS has its origins in the routing world but has expanded to LAN switching, ATM switching, multilayer switching, voice-data integration and security.

From an internetwork education perspective, the IOS configuration set, show commands and debugging tools provide a technician with a valuable insight into how internetworking technologies operate. For example, having access to IOS debugging tools and a network protocol analyzer such as a Network Associates Sniffer in a testbed environment allows a technician to develop a strong technical understanding of how internetwork protocols operate at a high level of technical detail. IOS debugging tools should be used with extreme caution in a production internetwork.



Preface


However, in an educational environment, IOS debugging tools should be used to enhance the internetwork education process. One of the goals of this book is to demonstrate how debug output can be used to enhance the internetwork education process.

A broader goal of this book is to demonstrate the power of the Cisco IOS from both a production and education perspective. An internetwork professional that learns the IOS well enough to attain CCIE certification has developed an internetworking knowledge base and skill set that will allow him to accelerate his learning of other internetworking technologies. Therefore, mastering the Cisco IOS and the related internetworking technologies to the point of attaining CCIE certification should be viewed as a foundational beginning rather than an end. Once you have attained your CCIE, you must look ahead to what new internetworking topics you will master. However, as you learn new topics, you will apply the precious internetworking analysis skills you developed while you prepared for CCIE certification.

In sum, I hope this book assists in developing the reader's internetwork analysis skills. By developing methodologies to think like a quality internetworking professional, you will be able to rapidly adapt to the constant changes occurring in this industry. By developing methodologies to think like a quality internetworking professional, you will be better prepared to attain your CCIE. Therefore, a clear road to optimizing your internetworking analysis skills is mastering the Cisco IOS. Once you learn how to speak IOS and think IOS to the highest level of technical detail, improved internetworking analysis skills come along with the territory. Good luck on your journey to CCIE certification!



Acknowledgments



Writing this book was a tremendous challenge. The potential topics of CCIE certification are vast, ever expanding and ever changing. In order to cover the wide range of topics covered in this book, assistance from several associates in the Cisco community was required. In particular, I would like to thank Valeriy Pavlichenko (CCIE) for providing technical editing services. Valeriy is one of the most disciplined and systematic internetworking engineers in the business. Without his feedback, much of the work of this book would not have been done. Secondly, special thanks must be given to Brent Baccala, the editor of the Internet Encyclopedia at **www.freessoft.org**. Brent provided key contributions to Chapters Nine, Eleven and Fourteen. Brent Baccala is blessed with a tremendous combination of brilliant technical insight and strong writing skills. Brent's ability to explain highly technical topics clearly has been tremendous inspiration to me. Finally, special thanks must be given to fellow Cisco Certified Instructor and CCIE Rajah Chowbay. Rajah assisted in drafting Chapter Seven of this book as well as provided tremendous influence in the structure in each and every chapter of this book.

Thanks must also be given to Mr. Albert Spaulding and his company ARS, Ltd. (Alexandria, Virginia) for providing the time and resources to write this book. Thank you Mr. Spaulding and ARS!

Specific contributions to the book came from the following associates:

Paul Borghese (CCIE and Certified Cisco Instructor) for developing Chapter Twenty-four.

James Park (CCIE and Certified Cisco Instructor) for editing Chapters Sixteen, Seventeen and Twenty-five.

Fred Ingham (CCIE and Certified Cisco Instructor) for editing Chapters Twenty-one as well as Chapters Twenty-three through Thirty. Fred has been an excellent technical resource and friend to Bruce and Valeriy for the last three years.

Guillermo "The Marine!!" Rastelli for providing graphics and logistics support.

All Bridges, Routers and Switches for CCIEs students. They are the best and brightest in the internetworking industry! Remember my students, "Can you spot the issue?"

Writing this book also required extensive support of friends and family of both Andrew Caslow and Valeriy Pavlichenko.

Special thanks goes out to the friends and family of Andrew Caslow: his mother, brothers, sisters, and dear friends Spottie, the Constable of France and the Schwarz Graf. Finally, Andrew wants to thank his wife, Lania, and his two daughters, Andreina and Gabriela, for their love and support while writing this book.

Valeriy would like to acknowledge the support of his wife, Tatiana, and the great inspiration from his two children, Eada and Mark.

For further information on topics covered in this book see www.cccert.com. Also, access the extensive set of vLabs from www.mentortech.com.



Solutions from experts you know and trust.

Articles Free Library eBooks Expert Q & A Training Career Center Downloads MyInformIT
Login Register About InformIT

Topics

Operating Systems
Web Development
Programming
Networking
Certification
and more...

Expert Access



www.informit.com

- ✓ Free, in-depth articles and supplements
- ✓ Master the skills you need, when you need them
- ✓ Choose from industry leading books, ebooks, and training products
- ✓ Get answers when you need them - from live experts or InformIT's comprehensive library
- ✓ Achieve industry certification and advance your career

Visit **InformIT** today
and get great content
from **PH**
PTR

Free
Content

Prentice Hall and InformIT are trademarks of Pearson plc /
Copyright © 2000 Pearson



Back



Forward



Reload



Home



Search



Guide



Images



Print



Security



Stop

PH
PTR<http://www.phptr.com/>

P R E N T I C E H A L L

Professional Technical Reference*Tomorrow's Solutions for Today's Professionals.*

Keep Up-to-Date with PH PTR Online!

We strive to stay on the cutting edge of what's happening in professional computer science and engineering. Here's a bit of what you'll find when you stop by **www.phptr.com**:

- ⓐ **Special interest areas** offering our latest books, book series, software, features of the month, related links and other useful information to help you get the job done.
- 💰 **Deals, deals, deals!** Come to our promotions section for the latest bargains offered to you exclusively from our retailers.
- 💵 **Need to find a bookstore?** Chances are, there's a bookseller near you that carries a broad selection of PTR titles. Locate a Magnet bookstore near you at www.phptr.com.
- ❗ **What's new at PH PTR?** We don't just publish books for the professional community, we're a part of it. Check out our convention schedule, join an author chat, get the latest reviews and press releases on topics of interest to you.
- ✉ **Subscribe today! Join PH PTR's monthly email newsletter!**

Want to be kept up-to-date on your area of interest? Choose a targeted category on our website, and we'll keep you informed of the latest PH PTR products, author events, reviews and conferences in your interest area.

Visit our mailroom to subscribe today! http://www.phptr.com/mail_lists



Contents

Preface xxxix

Acknowledgments xli

Chapter 1	Introduction to CCIE Certification	1
	The Influence of the OSI Model	2
	The Influence of Graduate School Examination Testing Formats	3
	What This Book Does Not Cover	5
	CCIE Test Nondisclosure Policy	6
	The Cisco Web Site	6
	The Origins of This Book	6
	CCIE Defined	9
	Routing and Switching	9
	ISP/Dial	9
	WAN Switching	9
	The CCIE Written Exam	10
	The CCIE Hands-On Lab	10



Six Key Ingredients for CCIE Certification Success	10
Roadmap of This Book	11
Level One: Physical and Data-link Layer Configuration Tasks	12
Level One Topics Include	12
Level Two: Configuring IP Addressing, IP IGP Routing Protocols, and Redistribution	12
Level Two Topics Include	13
Level Three: Configuring IP Exterior Gateway Protocols	13
Level Three Topics Include	14
Level Four: Configuring non-IP Routing Protocols	14
Level Four Topics Include	14
Level Five: Configuring Nonroutable Protocols	15
Level Five Topics Include	15
Level Six: Managing Internetwork Traffic	15
Level Six Topics Include	16
Working Through the Six Levels and Working with the IOS	16
User Mode	16
Privileged Mode	17
Configuration Mode	17
A Warm Up “Issue Spotting” Scenario	18
Spotting Issues and Listing Configuration Steps	20
Summary	29

Chapter 2 Getting Started 31

A Rack of Routers and Switches Is Your Tabula Rasa....	31
The Cisco End-to-End Solution	32
Core, Distribution, and Access	33
The Cisco Hierarchical Internetworking Model	33
The Core-Level	35
The Distribution Level	36
The Access-Level	36
Scalability	37
Redundancy	37
Limit the Scope of Failure	37
Facilitates Traffic Control	37
Initial Inspection of Routers and Switches	38
Cisco Router and LightStream 1010 Boot-Up Process	39
Catalyst 5000 Boot-Up Process	41
Cisco Systems Console	41

Perform a Show Version on a Router	43
Record the IOS Loaded on the Router	44
Performing a Show Version on a Catalyst Switch	47
Remotely Connecting to a Router or Switch	49
Accessing a Router or Switch Via a TELNET Session	49
Accessing a Router or Switch Via an Asynchronous Modem Connection	50
Accessing a Router or Switch Via a Network Management Station	50
Accessing a Router or Switch Via a Terminal Server	51
Line Command Configuration	52
IP Address Configuration	52
Configuring IP Host Table	52
Troubleshooting the Terminal Server	55
Make Sure the Routers and Switches Have the Default Configurations Only	56
Assign Your Routers and Switches a Name	57
If No DNS Server Is Supplied, Disable DNS Lookups on the Routers	57
Cisco IOS Shortcuts	57
Summary	59
Professional Development Checklist	61
For Further Study	62
Can You Spot the Issues?	63

Chapter 3 General Guidelines for Cisco Router Interface and Catalyst Port Configuration 65

Introduction to Router Interfaces	66
The Taxonomy of Cisco Router Interfaces	66
Core-Level Routers	68
The Cisco 7500 Router Family	68
The Cisco 7200 Router Family	69
The Cisco 12000 Router Family	69
Cisco Catalyst 5000 Route Switch Module	70
Cisco Catalyst 8500 Layer Three Switch Router	70
Distribution-Level Routers	70
Access-Level Routers	71
Specialized Routers	72
Remote-Access Routers	72
<i>The Voice/Data Integration Routers</i>	72
Interface Overview Summary	73
Basic IOS Tools Used to Monitor Status	74
Default Router Interface Configuration	76



Overview of Router Interface States	76
Special Characteristics of Cisco Router LAN Interfaces Ethernet	77
Fast-Ethernet	78
Token-Ring	78
WAN Interfaces	79
<i>Synchronous Serial Interfaces</i>	79
<i>Determining DTE and DCE Interfaces</i>	80
Other WAN Interfaces	81
<i>ATM Interfaces</i>	81
<i>ISDN Interfaces</i>	81
Asynchronous Interfaces	82
Virtual Interfaces	82
Subinterfaces	82
Subinterfaces and Frame-Relay	82
Subinterfaces and ATM	83
Subinterfaces and Fast Ethernet/ISL	83
Changing Existing Subinterfaces	83
Channelized T-1 and T-3 Interfaces	84
Loopback Interfaces	86
Dialer Interfaces	87
Tunnel Interfaces	87
Bridge Virtual Interface	87
Null Interfaces	87
<i>Using the Cisco Discovery Protocol</i>	88
<i>Mapping Network Layer Addresses to Data-Link Addresses</i>	89
Manual Map Statements	91
Dialer Map	91
Frame-Relay Map	91
Map-Lists	92
Dynamic Mapping Protocols	92
Ports and Interfaces on a Catalyst 5000	92
Summary	100
Professional Development Checklist	103
For Further Study	104
Can You Spot the Issues?	105
 Chapter 4	
Configuring Frame-Relay: "To Map or Not to Map? That is the Question...."	107
Configuring Frame-Relay on a Cisco Router	110
The Minimum Frame-Relay Configuration: Encapsulation Frame-Relay and Inverse ARP	110



A Word of Caution About Inverse ARP	111
A Frame-Relay Configuration Supporting Multiple Sites	112
<i>Headquarters</i>	112
<i>Satellite Office One</i>	112
<i>Satellite Office Two</i>	113
<i>The Limitations of Inverse ARP</i>	114
<i>Solutions to the Limitations of Inverse ARP</i>	114
<i>Adding a PVC Between the Two Spokes: The Full-Mesh Solution</i>	115
Using Frame-Relay Map Statements	116
<i>Satellite One Configuration</i>	117
<i>Satellite Two Configuration</i>	117
A Word of Caution When Using Frame-Relay Map Statements	118
Configuring Frame-Relay Point-to-Point Subinterfaces	118
<i>Satellite One</i>	119
<i>Satellite Two</i>	119
<i>General Rules of Frame-Relay Subinterfaces</i>	121
<i>Point-to-Point Subinterfaces</i>	121
<i>Multipoint Subinterfaces</i>	121
<i>The "Frame-Relay Interface DLCI" Statement</i>	121
<i>Routing over Frame-Relay</i>	122
<i>Distance Vector Routing Protocols and Split-Horizon</i>	122
<i>OSPF and Network Type Mismatches</i>	123
<i>Survey the Primary Combinations</i>	126
All Physical Interfaces	126
<i>Configuring a Hub and Spoke Frame-Relay Configuration with Frame-Relay Map Statements and No Frame-Relay Subinterfaces Revisited</i>	126
<i>SPOKE-1</i>	129
<i>SPOKE-2</i>	130
<i>HQ</i>	130
<i>SUMMARY</i>	130
<i>All Subinterfaces Using Frame-Relay Interface DLCI Statements Only</i>	131
<i>SPOKE-1</i>	131
<i>SPOKE-2</i>	131
<i>HQ</i>	131
<i>Physical Interface at the Hub and Point-to-Point Subinterfaces at the Spoke</i>	133
<i>SPOKE-1</i>	133
<i>SPOKE-2</i>	133
<i>HQ</i>	133
<i>Multipoint Subinterface at the Hub and Physical Interfaces at the Spokes</i>	134



<i>SPOKE-1</i>	134
<i>SPOKE-2</i>	134
<i>HQ</i>	134
<i>Point-to-Point Subinterfaces at the Hub</i>	135
<i>Frame-Relay Interface DLCI vs Frame-Relay Map</i>	135
Configuring a Router as a Frame-Relay Switch	136
<i>Full-Mesh Frame-Relay Switch Configuration Script</i>	137
<i>Hub and Spoke Frame-Relay Switch Configuration Script</i>	138
<i>Checking Status of DLCIs on a Frame-Relay Switch</i>	139
<i>LMI</i>	140
<i>Show Frame-Relay LMI</i>	141
<i>Cisco IOS vs 11.2 LMI Auto-Sensing</i>	142
<i>Suggested Configuration Strategies for Frame-Relay</i>	142
Other Frame-Relay Topics to Review	144
Summary	145
Professional Development Checklist	147
For Further Study	148
Can You Spot the Issues?	149

Chapter 5 **Configuring ISDN and Dial-on-Demand Routing** 151

ISDN Overview	152
ISDN Components	153
ISDN Layers	154
Dial-on-Demand Routing Overview	154
Configuring ISDN on Cisco Routers	155
ISDN Syntax Overview	155
Selecting the ISDN Switch-Type	156
ISDN PRI Interface Configuration	157
ISDN Interface Configuration Commands	159
ISDN SHOW Commands	159
ISDN Debug Commands	160
Call Setup	160
<i>Calling Party</i>	160
<i>Called Party</i>	160
<i>Call Teardown</i>	161
<i>Calling Party Disconnecting</i>	161
<i>Called Party Disconnecting</i>	161
<i>Line is Busy</i>	161
<i>No Channels Are Available</i>	162
<i>ISDN Configuration Summary</i>	162